https://www.biodiversitylibrary.org/

Bulletin /
Urbana,State of Illinois, Dept. of Registration and Education, Natural History Survey Division,1918-1985.
https://www.biodiversitylibrary.org/bibliography/14605

14 (1921-1923): https://www.biodiversitylibrary.org/item/53060

Article/Chapter Title: Bull 14 no VII
Page(s): Text, Text, Text, Text, Text, Page 220, Page 221, Page 222, Page 223, Page 224, Page 225, Page 226, Page 227, Page 228, Page 229, Page 230, Page 231, Page 232, Page 233, Page 234, Page 235, Page 236, Page 237, Page 238, Page 239, Page 240, Page 241, Page 242, Page 243, Page 244, Page 245, Page 246, Page 247, Page 248, Page 249, Page 250, Text, Illustration, Text, Page 251, Page 252, Text, Foldout, Text, Foldout, Text, Foldout, Text, Illustration, Foldout, Foldout, Text, Text, Foldout, Text, Foldout, Text, Text, Text, Foldout, Text, Text, Text, Foldout, Text, Foldout, Text, Illustration, Foldout, Text, Foldout, Text, Foldout, Text, Illustration, Foldout, Text, Foldout, Text, Foldout, Page 253, Page 254, Page 255, Page 256, Page 257, Page 258, Page 259, Page 260, Page 261, Page 262, Text, Foldout, Text, Foldout, Text, Text, Page 263, Page 264, Text, Illustration, Text, Illustration, Text, Illustration, Text, Page 265, Page 266, Foldout, Text, Page 267, Page 268, Text, Foldout, Text, Foldout, Text, Foldout, Page 269, Page 270, Text, Text, Illustration, Text, Illustration, Text, Page 271, Page 272, Foldout, Text, Page 273, Page 274, Foldout, Text, Page 275, Page 276, Text, Illustration, Illustration, Foldout, Foldout, Text, Page 277, Page 278, Page 279, Page 280, Foldout, Text, Page 281, Page 282, Page 283, Page 284, Text, Foldout, Page 285, Page 286, Page 287, Page 288, Page 289, Text

Holding Institution: University Library, University of Illinois Urbana Champaign

STATE OF ILLINOIS
DEPARTMENT OF REGISTRATION AND EDUCATION
DIVISION OF THE
NATURAL HISTORY SURVEY
STEPHEN A. FORBES, Chief

Vol. XIV. BULLETIN Article VII.

CODLING-MOTH INVESTIGATIONS OF THE STATE ENTOMOLOGIST'S OFFICE

1915, 1916, 1917

BY
PRESSLEY A. GLENN

PRINTED BY AUTHORITY OF THE STATE OF ILLINOIS

URBANA, ILLINOIS
August, 1922

STATE OF ILLINOIS

DEPARTMENT OF REGISTRATION AND EDUCATION

W. H. H. MILLER, *Director*

BOARD OF

NATURAL RESOURCES AND CONSERVATION

W. H. H. MILLER, *Chairman*

WILLIAM TRELEASE, *Biology*
JOHN M. COULTER, *Forestry*
ROLLIN D. SALISBURY, *Geology*
WILLIAM A. NOYES, *Chemistry*
JOHN W. ALVORD, *Engineering*
KENDRIC C. BABCOCK, *Representing the President of the University of Illinois*

THE NATURAL HISTORY SURVEY DIVISION

STEPHEN A. FORBES, *Chief*

(64922—1200—6-22)

PHILLIPS BROS.' PRINT.
SPRINGFIELD, ILLINOIS.

CONTENTS

	PAGE
Introductory statement	219
Definition of terms	219
General conclusions	221
Equipment and method of work	223
Large-cage series	227
Life-history series	228
Band-record series	231
Influence of climatic conditions on the egg, larva, and pupa of the codling-moth	231
Zones of temperature	232
General procedure in the study of temperature relations	233
Relation of temperature to development of the egg	234
Relation of temperature to development of the larva	239
Relation of temperature to development of the pupa	246
Conclusions from the foregoing discussion	252
Observations on the life history of the codling-moth in 1915, 1916, and 1917	253
Incubation period	254
Larval period:	
Transforming lavæ	254
Hibernating larvæ	255
Pupal period	256
Combined egg, larval, and pupal periods	256
Adult period	257
Total life-period	257
Oviposition	258
Relation of temperature to length of development period	258
Seasonal history of the codling-moth, 1915	259
Large-cage series	259
First generation, 1915	260
Second generation, 1915	261
Third generation, 1915	261
Band collections:	
Hibernating generation, 1914-1915	262
Collections made in 1915	262
Hibernation, 1915	263
Summary of the seasonal history, 1915	263
Records for other points than Olney	264
General remarks on the season	264

PAGE
Seasonal history of the codling-moth, 1916 265
Large-cage series 265
Hibernating generation, 1915-1916 265
First generation 265
Second generation 266
Third generation 266
Band-collections:
Hibernating generation, 1915-1916 267
Collections made in 1916 267
Hibernation, 1916 268
Summary of the seasonal history, 1916 269
Records for several localities 271
Seasonal history of the codling-moth, 1917 272
Large-cage series 272
First generation 272
Second generation 273
Third generation 273
Band collections:
Hibernating generation, 1916-1917 273
Collections made in 1917 (see Table 37) 273
Summary of the seasonal history, 1917 275
Relation of temperature to the seasonal history of the codling-moth 275
Method of forecasting dates when the different stages of the several generations may be expected to appear at any given place in a normal season. 281
How to compute effective day-degrees 282
Relation of temperature to time when larvæ hibernate 283
Relation of humidity and evaporation to the development of the codling-moth 284
Spray program for the codling-moth 288
Figures (8), Graphs (7), Tables (51), Charts (3).

ARTICLE VII.—*Codling-moth Investigations of the State Entomologist's Office, 1915, 1916, and 1917.* BY P. A. GLENN, Chief Inspector of the Division of Plant Industry, State Department of Agriculture.

INTRODUCTORY STATEMENT

To secure accurate data in regard to the life history and the seasonal history of the codling-moth in Illinois, and the relation of climatic conditions to the rate of development and the time of appearance of the various stages of the insect, an investigation was begun in the spring of 1915 under the direction of Doctor S. A. Forbes, then State Entomologist. The principal station was established at Olney in charge of the writer, at that time and during the whole period of this investigation on the staff of the Entomologist.* Other stations were at Ozark, about 80 miles south and 45 miles east of Olney, in charge of Mr. L. M. Smith; and at Plainview, 40 miles north and 100 miles west of Olney, and at Springfield, 70 miles north and 90 miles west of Olney, in charge of Mr. W. P. Flint.

The station at Olney was equipped with large, screen-wire cages covering entire trees, a field laboratory and all necessary small cages for the observation of individual insects in all their stages, a self-recording thermograph, a self-recording hygrograph, a Livingston porous cup atmometer for measuring evaporation and a rain gage (Fig. 8, p. 230), standard maximum and minimum thermometers, and a sling psychrometer for checking daily the records of the self-recording instruments. The other stations were provided with instruments for keeping a record of climatic conditions.

At Olney a continuous daily record was kept of the history of all the stages of the insect. At the other stations band records and other data were recorded such as would enable us to follow the main features of the seasonal history of the insect.

DEFINITION OF TERMS

To avoid confusion resulting from a misunderstanding of terms, the following definitions are given:

The term "stages of the codling-moth" refers to the four distinct periods in the life of the insect: the egg, the larva, the pupa, and the adult.

---

* As a consequence of the passage of the Civil Administrative Code in 1917, the writer was transferred to the State Department of Agriculture, and the major part of this report has been written since he became a member of this department, the State Entomologist's office having been by the same law merged in the Natural History Survey of the State, with Dr. Forbes as its chief. This double relation has not, however, affected the character of this report, which has been prepared under the supervision of Dr. Forbes, and with a view to its publication as a survey bulletin.

The term "generation" is used to designate a group of insects in all the four stages from egg to adult, all equally removed by descent from a given insect or group of insects, except that the term "hibernating generation" is used for all the insects which hibernate, regardless of the generations to which they belonged the preceding year.

The term "brood" is used to designate all the individuals of one of the stages of a generation, as, brood of eggs, brood of larvæ, etc. The terms "first brood", "second brood", and "third brood" are used to designate the eggs, larvæ, pupæ, or adults of successive generations.

The "theoretical zero of development" is the temperature at which development begins when the temperature is rising and at which it ceases when the temperature is falling.

The "degree of maximum rate of development" is the temperature at which development proceeds most rapidly.

The "day-degree" is the unit used for measuring accumulations of temperature, and is equivalent to a temperature of one degree maintained for 24 hours.

"Effective day-degrees" are day-degrees above the zero of development, after necessary corrections have been made for retardation due to temperatures above the degree of maximum rate of development. This correction is made by subtracting twice the day-degrees above the degree of maximum rate from the total day-degrees above the zero of development.

The codling-moth passes the winter in the larval stage. The overwintering larvæ belong principally to the second and third generations of the preceding year, but for convenience in discussing the seasonal history we designate them as the hibernating generation. The generations which descend from the hibernating generation are designated as the "first generation", the "second generation", etc. In accordance with the foregoing definitions we have the following relations of generations and broods:

The hibernating generation, consisting of
the hibernating larvæ,
the first brood of pupæ, and
the first brood of adults.

The first generation, consisting of
the first brood of eggs,
the first brood of larvæ,
the second brood of pupæ, and
the second brood of adults.

The second generation, consisting of
the second brood of eggs,
the second brood of larvæ,
the third brood of pupæ, and
the third brood of adults.

The third generation, consisting of
the third brood of eggs,
the third brood of larvæ, etc.

In the case of insects which pass the winter as adults, the number of the broods will agree with the number of the generations to which they belong, but in the case of those that pass the winter in the egg, larval, or pupal stage, these numbers will not agree in all the broods.

General Conclusions

The following conclusions have been reached as the results of this investigation:

There are normally in the southern half of the state one complete generation, a nearly complete second generation, and a partial third generation of the codling-moth each year. In the northern part of the state there are but two generations.

In the latitude of Olney, larvæ of the first generation normally begin to enter the fruit about May 19; larvæ of the second generation, July 4; and larvæ of the third generation, August 12.

The data at hand are not sufficient to enable us to say definitely just how much allowance must be made in the time of appearance of the broods for differences of latitude, but in general, the first pupæ, moths, eggs, and young larvæ appear two or three days earlier at Ozark and two or three days later at Springfield than at Olney; and second and third broods of larvæ appear about a week earlier at Ozark and a week later at Springfield than at Olney.

The pupal period varies from 8 to 46 days, depending mainly upon the temperature. The period of the first brood is much longer than that of the second and third broods. The first brood period averages 30 days, the second 10.2 days, and the third 11.4 days.

The life of the male adult in confinement varies from 3 days to 24 days, the average being 10.5 days; the life of the female adult in confinement varies from 2 days to 27 days, the average being 13.4 days.

The female moth begins to lay eggs in from one to five days after emergence, the majority of the eggs being laid between the second and the fifth days, and oviposition is usually completed within ten days.

The egg period varies from 4 to 15 days, depending mainly upon the temperature. The average was 8.1 days for the 4956 eggs under observation.

The larval period varies from 18 to 47 days for transforming larvæ and from 244 to 302 for hibernating larvæ, the former averaging 26.4 days and the latter 264.8 days. The feeding period varies from 14 to 43 days for transforming larvæ and from 16 to 54 for hibernating larvæ, the average for the former being 24.7 and for the latter 29.3. The larval period in the cocoon varies for transforming larvæ from one to eleven days, and for hibernating larvæ from 206 to 275 days, the average for transforming larvæ being 4.2 and for hibernating larvæ 206.1 days.

The total life-period varies from 41 to 70 days for individuals whose larvæ transform, the average being 54.2, and from 287 to 332 days for individuals whose larvæ hibernate, the average being 313 days.

Larvæ begin to go into hibernation about August 1, and during the month the percentage of maturing larvæ which hibernate increases more or less rapidly, depending upon temperatures, until September 1, after which practically all larvæ hibernate.

Temperature is the predominating factor, so far as weather conditions are concerned, in determining the rate of development and the time of the appearance of the various stages.

Development begins in the spring as soon as the temperature in the warmer parts of the day rises above 52 degrees F., and the rate of development increases as the temperature rises,* until the degree of the maximum rate of development is reached, which for the egg is about 88, for the larva 85, and for the pupa 87 degrees F. The pupa will not develop at temperatures below 52 degrees, but the egg and larva will develop at temperatures above 50.

Temperatures above the degree of maximum rate of development retard development, and the retardation appears to be proportional to the number of degrees above the degree of the maximum rate, so that the rate of development at one, two, three, etc., degrees above the degree of the maximum rate is the same as one, two, three, etc., degrees below that degree.

There is a fairly constant relation between the accumulation of effective day-degrees and the time of appearance of the different broods. For practical purposes, 50 degrees F. may be used as the zero of development and 86 degrees as the degree of maximum rate of development, and the effective day-degrees for any day may be determined by finding the average temperature above 50 degrees and subtracting from it twice the average temperature above 86 degrees.

It requires an average of 163, 673, and 265 effective day-degrees to complete the development of the egg, larval, and pupal stages, respectively, and an average of 1101 for the development of an individual through the three stages when 50 is taken as the zero of development and 88, 85, and 87 as the degrees of maximum rate of development for the egg, larva, and pupa, respectively. The number of effective day-degrees which accumulate from a certain stage in the development of one generation to the same stage in the development of the succeeding generation varies in round numbers from about 1000 to 1600, the average being about 1195, when 50 is taken as the zero and 86 as the degree of maximum rate.

The first larvæ of the first, second, and third generations enter the fruit when the accumulations of effective day-degrees have reached about 550, 1550, and 2550 day-degrees, respectively.†

The seasonal history of the codling-moth for a normal year may be determined approximately in any locality by ascertaining the normal total accumulation of effective day-degrees for each day in the season in that locality.

---

* This statement is not strictly true, for with each unit of change in temperature, the rate of development is affected more at temperatures near the zero of development, and less at temperatures near the degree of maximum rate of development than at intermediate temperatures, but these variations from the rule are so slight that they may be disregarded for the purposes of this paper.

---

† The statements with regard to temperature relations may possibly not apply to places differing widely in latitude or altitude from Olney, Illinois.

The actual accumulation for any date during different seasons may vary widely from the normal accumulation.

By comparing the actual accumulation at any date during a given season with the normal accumulation for that date, the approximate number of days which development has been retarded or hastened on that date may be determined; and, by keeping track of the number of effective day-degrees that accumulate as the season advances, one may foretell, approximately, several days in advance, the dates when the larvæ of the different generations will begin to enter the fruit.

Equipment and Methods of Work

Aside from the large cages and the weather instruments previously mentioned, cages were devised for observing pupation of larvæ, emergence of moths, oviposition, and length of life of adults.

For observing pupation, cages such as those illustrated in Figures 1 and 2, were found to be most satisfactory. They consisted of two blocks of wood and a strip of celluloid, each 4¾ inches long and 2½ inches wide. On the face of one of the blocks, strips of wood or heavy paper about ⅛ inch thick were tacked along the end and longitudinally through the middle of the block, to hold the blocks far enough apart to permit the larvæ to crawl in between them. A strip of corrugated strawboard split through the middle so as to leave half of the corrugations on each face was placed, with the split surface up, on the block on each side of the center strip so as to cover the remaining face of the block. The other block was placed on the top of this with a strip of celluloid between, and the blocks were held together by small hooks and eyes fastened to the edges of the block, or by rubber bands—the latter proving the more satisfactory. There was room in each cage for about 50 larvæ. Smaller cages for single larvæ or a small number of larvæ were made on the same principle without blocks of wood.

When it was desired to determine the dates of pupation of larvæ collected from bands, they were confined in a lantern globe with one or more of the larger pupa-cages. Thus enclosed, the larvæ crawled into the little cells and spun their cocoons, and were thus arranged in very convenient order for further observation. By the use of sandpaper, the celluloid was roughened longitudinally through the center of the block, and after the larvæ were settled the number of each was entered on the celluloid beside it. (Fig. 2.)

Usually, transforming larvæ spun so thin a web on the exposed side of the cocoon that pupation could be observed without disturbing them, but hibernating larvæ spun a thicker web, and to observe them it was necessary to tear away a part of the web next to the celluloid every time an observation was made. The most convenient instrument for doing this was a steel crochet-needle with the hook ground away so as to leave only a small part of the barb. The cages above described will be referred to as pupa cages.

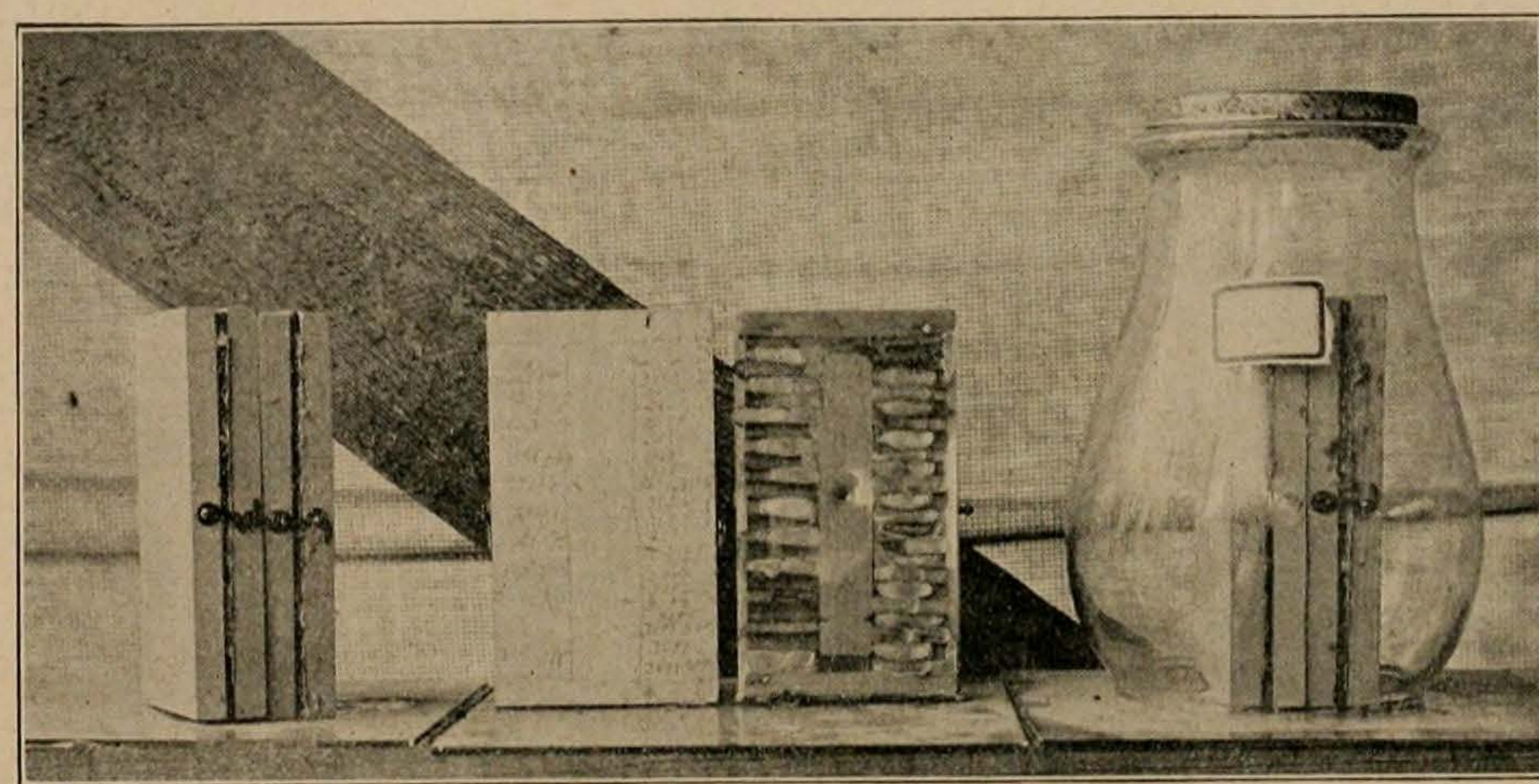


Fig. 1. Pupa cages: two at the left closed; one in the center open; and two in lantern globe.

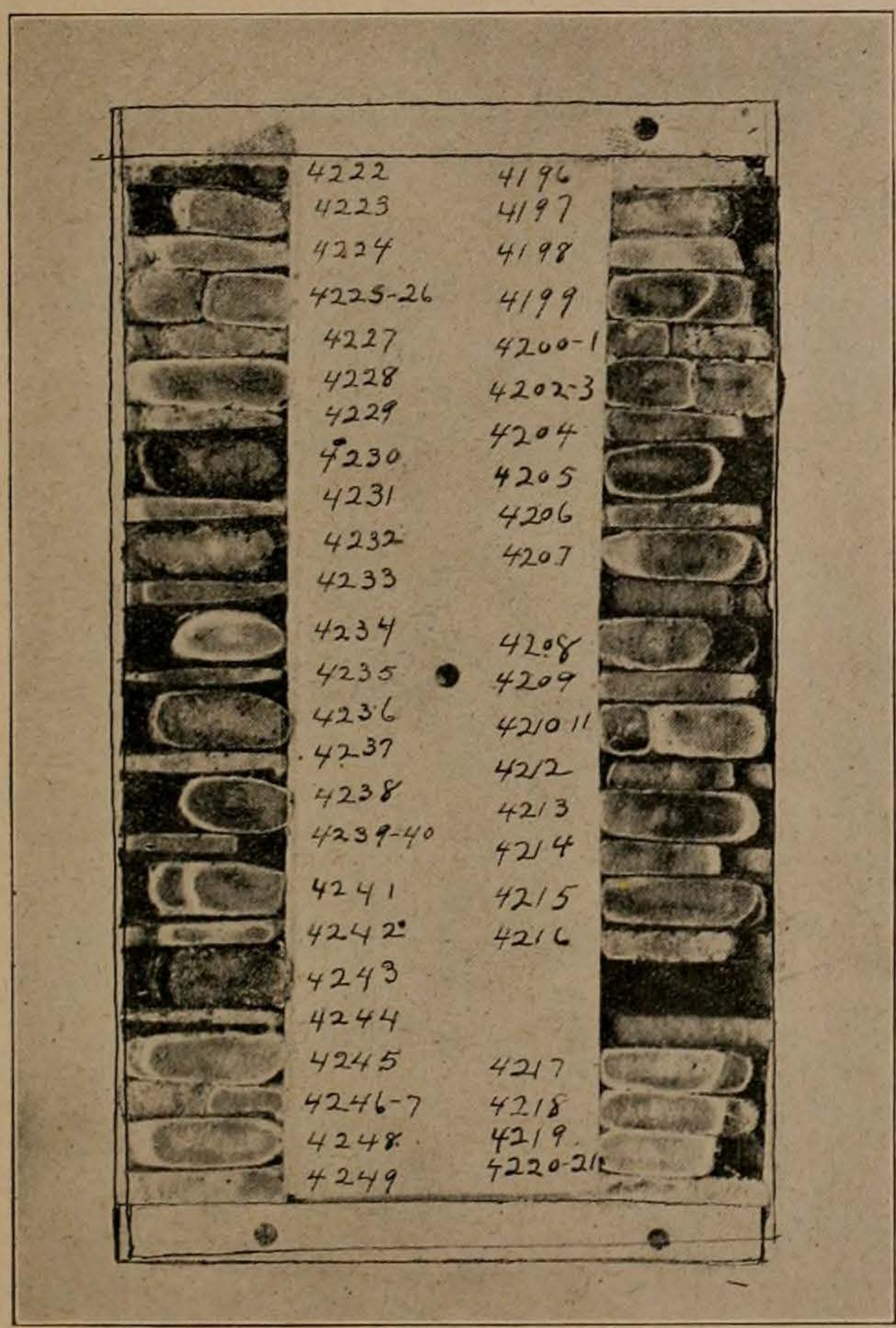


FIG. 2. Pupa cage open, showing arrangement of larvæ and method of numbering.

When it was desired to observe only the emergence of moths, larvæ were placed in a 4-oz. condiment jar containing a bundle of strips of strawboard. (Fig. 3.) These cages will be designated as emergence cages.

Fig. 3. Emergence cages. Strips of strawboard removed from jars to show arrangement of cocoons and pupa cases.

To secure eggs and note length of life of adults, pairs of moths were confined in cages consisting of a cylinder of screen-wire closed at one end with screen-wire and at the other end with an apron of cheese-cloth which permitted the cage to be fastened over the top of a branch of a tree. (Fig. 4.) These will be called oviposition cages.

The experiments were carried on in three series, kept as nearly independent as possible so that each would serve as a check on the others. I shall designate them as the *large-cage series,* the *life-history series,* and the *band-record series.*

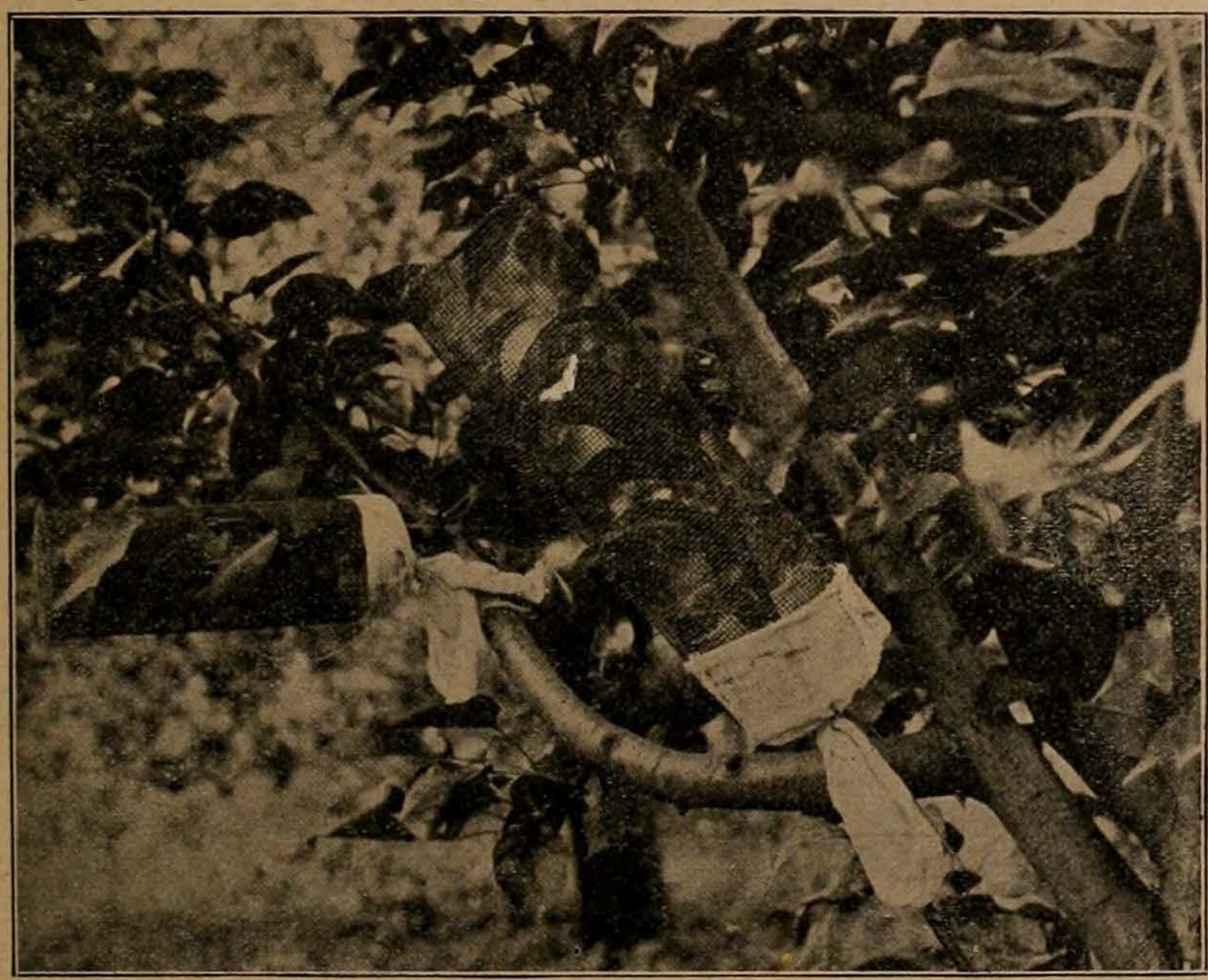


FIG. 4. Two oviposition cages in place on tree.

LARGE-CAGE SERIES

Cages used in this series were large enough to cover entire trees, the largest cages being 18 feet square and 18 feet high. (Fig. 5, 6, and 7.) The plan was to use two cages each for the first and the second generations and one cage for the third generation—if a third generation appeared.

The framework of the cages, consisting of 2×4 scantling, was erected over the trees before they were in bloom, and wire cloth, 12 wires to the inch, was tacked over the frame as soon as the time of full bloom was past. Each of the cages had a tight-fitting screen-door provided with hasp and padlock.

The trees thus screened in were examined very carefully for larvæ and two inches of the soil in each cage was removed.

The first moths to emerge from the hibernating larvæ were placed in cage No. 1, and the last moths to emerge in cage No. 2, to rear the first and the last individuals of the first generation; the first moths reared

in cage No. 1 were liberated in cage No. 3 and the last moths reared in cage No. 2 were liberated in cage No. 4, to rear the first and the last individuals of the second generation; and the moths reared in cage No. 3 were liberated in cage No. 5, to rear the third generation. In this way it was possible to ascertain approximately the dates when each generation began and ended.

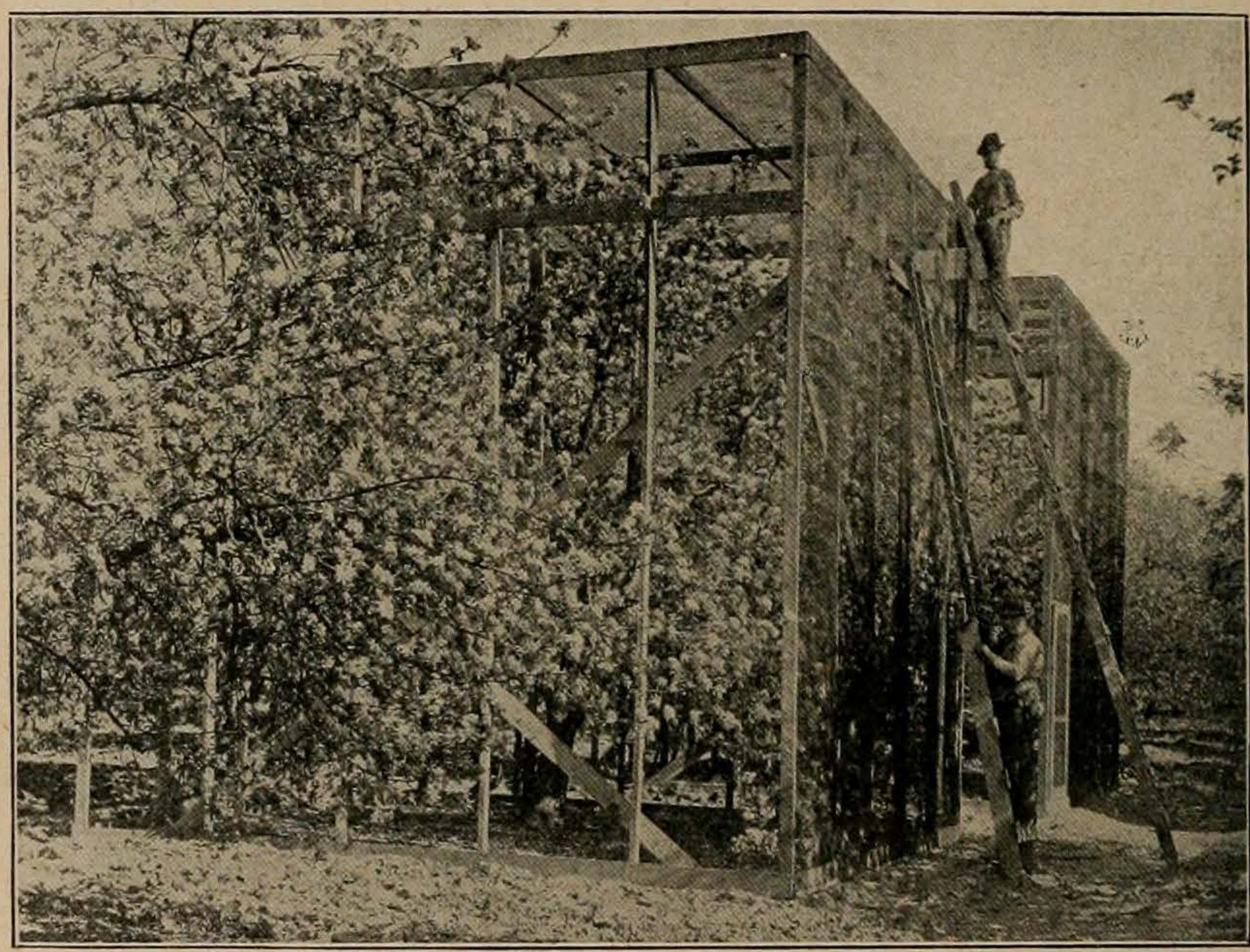


Fig. 5. Large screen-cage in course of construction.

LIFE-HISTORY SERIES

In the life-history series, pairs of adults of each of the broods were enclosed in oviposition cages (Fig. 4), and the number of eggs laid daily by each female and the dates of the death of the adults were noted.

The eggs obtained were numbered and allowed to remain on the trees until the black spot appeared. They were then removed to small vials on the bits of leaf or bark on which they had been laid, and, as they hatched, the larvæ were transferred to apples with a camel-hair brush, some to apples on the trees and others to picked fruit. The apples were tagged and each was given a number corresponding to that of the egg, and when they showed conspicuous signs of worminess they were transferred to jars, in which were placed strips of corrugated strawboard or small pupal cages in which the larvæ might spin up. The dates were noted when the larvæ left the apple, when they pupated, and when the adults emerged.

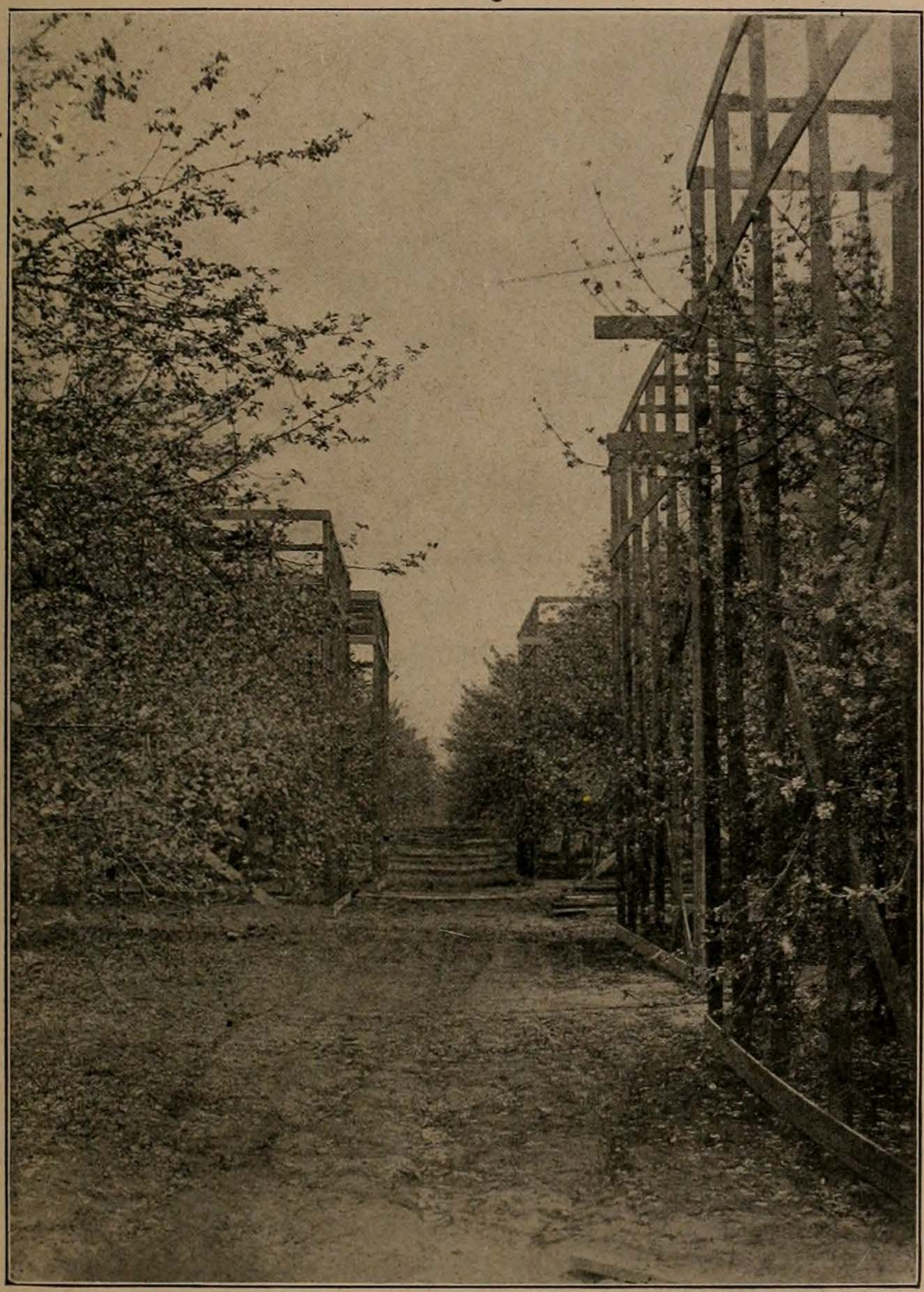


FIG. 6. View of orchard showing screened trees.

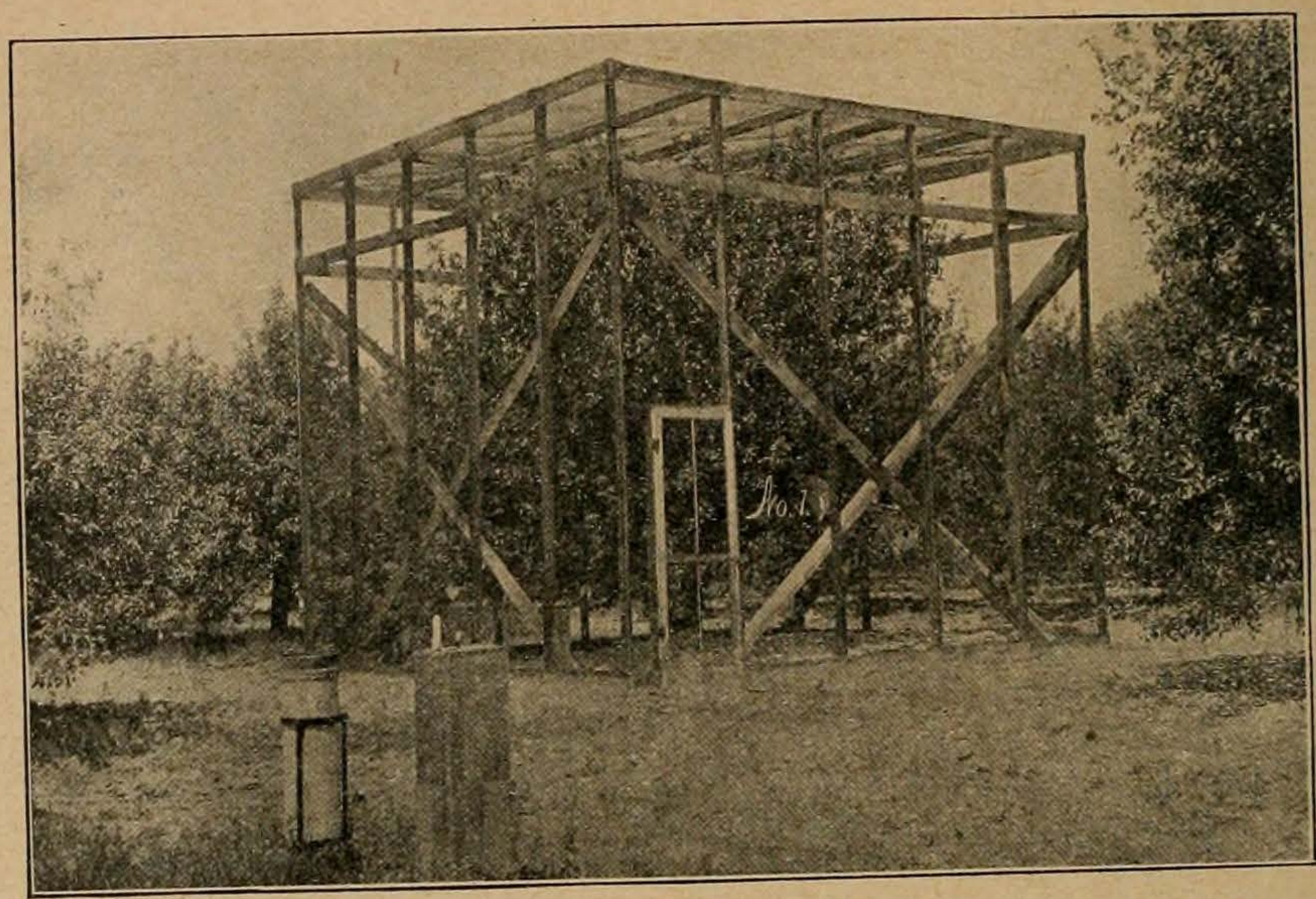


FIG. 7. Large cage completed. Rain-gage and atmometer in foreground.

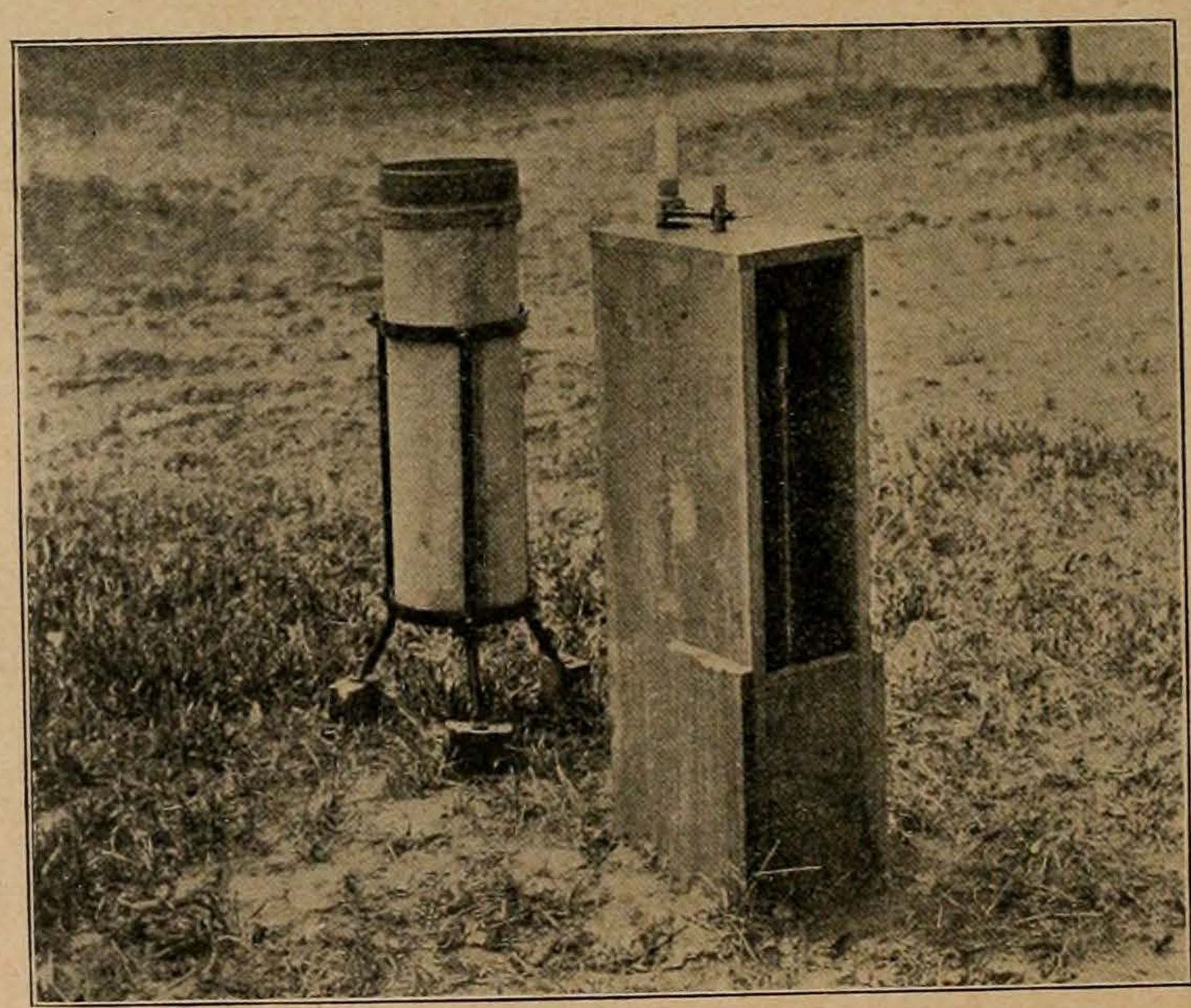


FIG. 8. Rain-gage (left), and atmometer (right) for determining rate of evaporation.

BAND-RECORD SERIES

A number of trees were banded each year at each of the places where observations were made, both sprayed and unsprayed trees being usually included. The bands used were mostly two or three-ply burlap, about 4 inches wide. They were placed on the trees about June 1 and examined every day until the first larvæ were found; and after that every third day. A record was kept of the number of male and female larvæ collected. All the larvæ collected were placed either in pupal cages or emergence cages for further observation, and a partial record of pupation and a complete record of the emergence of moths were kept at Olney. In cases where both pupation and emergence were noted the pupal periods of those under observation were determined, and the data thus obtained were used in connection with studies on the influence of climatic conditions on the development of the pupa.

No attempt will be made to record all the details of each of these series, but the combined results of all of them have been used in our studies on climatic relations, life history, and seasonal history. Since a knowledge of the influence of climatic relations will assist in interpreting our life-history and seasonal-history data, a discussion of the climatic influence will be taken up first.

Influence of Climatic Conditions on the Egg, Larva, and Pupa of the Codling-moth

We ascertained by observations during 1915, 1916, and 1917, that the incubation period varied from 4 to 15 days, the pupal period from 7 to 46 days, and the larval period from 18 to 45 days, and that the time of the appearance of the first brood of larvæ may vary as much as 19 days, and of the second brood 7 or 8 days in different seasons in the same locality, and that the variation in the time of the same events in various parts of the state in the same season may be as much as 20 or 25 days. These variations in length of the periods and dates of appearance of the broods are due principally to climatic conditions, and especially to temperature. It is the purpose of the present study to ascertain the relation of climatic conditions to the rate of development and to the time of the appearance of the broods and, as far as possible, to suggest methods by which these relations may be turned to practical account.

Under out-of-door conditions, temperature is the predominating factor in determining rate of development of the codling-moth. Evaporation and humidity have so little influence that they may be disregarded, except, perhaps, in seasons when there are prolonged periods of extremely high or low humidity.

The influence of temperature will be considered first.

The fact that a certain degree of warmth is necessary for development of animal and vegetable life and that the rate of development is hastened by warm weather and retarded by cool weather has apparently always been known, but it is only within recent years that efforts have been made to ascertain the relative effects of different degrees of temperature.

ZONES OF TEMPERATURE

The entire range of temperature may be divided into six zones with respect to life and development, as shown below:

Zone 6	Fatal temperatures; fatality due to heat.
Minimum high fatal degree	
Zone 5	Estivation temperatures; not fatal, but unfavorable for development.
Zero of estivation	
Zone 4	Temperatures stimulating development, the rate of development decreasing as the temperature rises.
Degree of maximum rate of development	
Zone 3	Temperatures stimulating development, the rate of development increasing as the temperature rises.
Zero of development	
Zone 2	Hibernating temperatures; not fatal, but unfavorable for development.
Maximum low fatal degree	
Zone 1	Fatal temperatures; fatality due to lack of heat.

The limits of these zones differ for different species, for different stages of the same species, and for different phases of the same stage of the same species.

The limits of the zones of temperature of a species will be affected by the latitude to which it is acclimated, and it is possible that they will vary for individuals of the same species which are acclimated to different latitudes. Generally speaking, the limiting temperatures of the zones of species in low latitudes may be expected to be higher than of species in higher latitudes. The temperature at which an insect comes out of hibernation is in many cases quite different from that at which it becomes dormant in the latter part of the season, because heredity has an important influence in determining the time when insects begin the dormant period which lasts through the winter.

The temperatures on which these studies are based fall within zones 2, 3, and 4, the purpose being to determine for the codling-moth the zero of development, or the point at which development begins in spring as

the temperature rises; the degree at which development proceeds most rapidly; and to find a temperature constant for each of the stages and for the whole period of development which will apply to all temperatures, and a method by which that constant can be determined.

Before proceeding very far it was discovered that the character of the climatic data obtained under field conditions was not well suited to studies of this kind, because the temperature varied constantly throughout the day, and consequently the deductions had to be made from averages of widely varying degrees of temperature. Early in the season the temperature during part of the day was in the zone of hibernating temperatures and during the remaining time in the zone of temperatures which stimulated development, and later in the season the temperatures during part of the day were in the zone in which the rate of development increased as the temperature rises and during the remainder of the day in the zone in which the rate of development decreased as the temperature rises. For scientific accuracy it is of interest to determine the relative effects of each degree of temperature, but from data of the kind here used this could not be undertaken.

It has already been pretty well established that the rate of development increases, approximately at least, as the temperature rises above the zero of development, until the temperature at which the rate of development is at its maximum is reached; and our studies have led us to conclude that as the temperature rises above the degree of the maximum rate of development the rate of development decreases directly as the temperature rises.

The day has been used as the unit of time, and the day-degree as the unit of accumulated temperatures; and it has been assumed that, within certain limits of temperature, the period expressed in days multiplied by the average daily day-degrees above the zero of development will approximate a constant, or at least that the average products of a large number of observations will approximate a constant.

GENERAL PROCEDURE IN THE STUDY OF TEMPERATURE RELATIONS

The first step taken was to prepare temperature tables from the thermographic records, showing the mean daily temperatures. In computing the mean daily temperatures, the day was regarded as beginning and ending at 5 o'clock p. m., that being the hour when observations for the day usually ended. All mean daily temperatures were ascertained by dividing the sums of the temperature readings for the even hours of the day by 12. Mean temperatures above 50, 52, 85, 86, 87, and 88 degrees were computed in the same way.

The second step was to tabulate in detail all the data relative to the length of the egg, pupal, and larval periods, tabulating the data for each generation and year separately and arranging the data in chronological order with respect to dates when the periods began and ended.

The average mean daily temperatures and the length of the periods were determined for each observation. In all the groups of eggs, larvæ, and pupæ which began their periods on the same date there was a considerable variation in the recorded length of the period of individuals, due, no doubt, partly to the fact that individuals differ somewhat in respect to the amount of time required for them to develop even under identical conditions as to heat, light, moisture, and environment; and partly to errors of observation due for the most part, especially in case of eggs and pupæ, to the use of the day as the unit of time, on account of which the recorded period may, if the observations are made at the same hour each day, be almost a day longer or shorter than the true period, and, if the observations are not made at the same hour, the recorded period may be more than a day longer or shorter than the true period.

To avoid these variations the observations beginning on the same dates were thrown into groups, and the average period and average mean daily temperature were determined for each group. These smaller groups were then thrown into larger groups, using the mean daily temperature as the basis, all those passing through the period at an average mean daily temperature of 60 and 61 degrees or fraction thereof forming one group, and those passing through the period at temperatures of 62 and 63 degrees or fraction thereof forming another group, etc. The mean daily temperatures and the average length of the periods of these groups were then computed. All averages are weighted and all periods were averaged harmonically.

The detailed tables which it was necessary to prepare for the purpose of making the computations are voluminous and would not be of special interest. Only summaries made as above indicated will be given.

The reciprocal curve was used, with the mean daily temperature for the horizontal axis and the reciprocals of the periods for the vertical axis, to help locate approximately the zero of development and the degree of maximum rate of development; but this had to be supplemented by other methods on account of the displacement of points at the upper and lower ends of the line because of temperatures above the degree of the maximum rate of development and temperatures below the theoretical zero.

RELATION OF TEMPERATURE TO DEVELOPMENT OF THE EGG

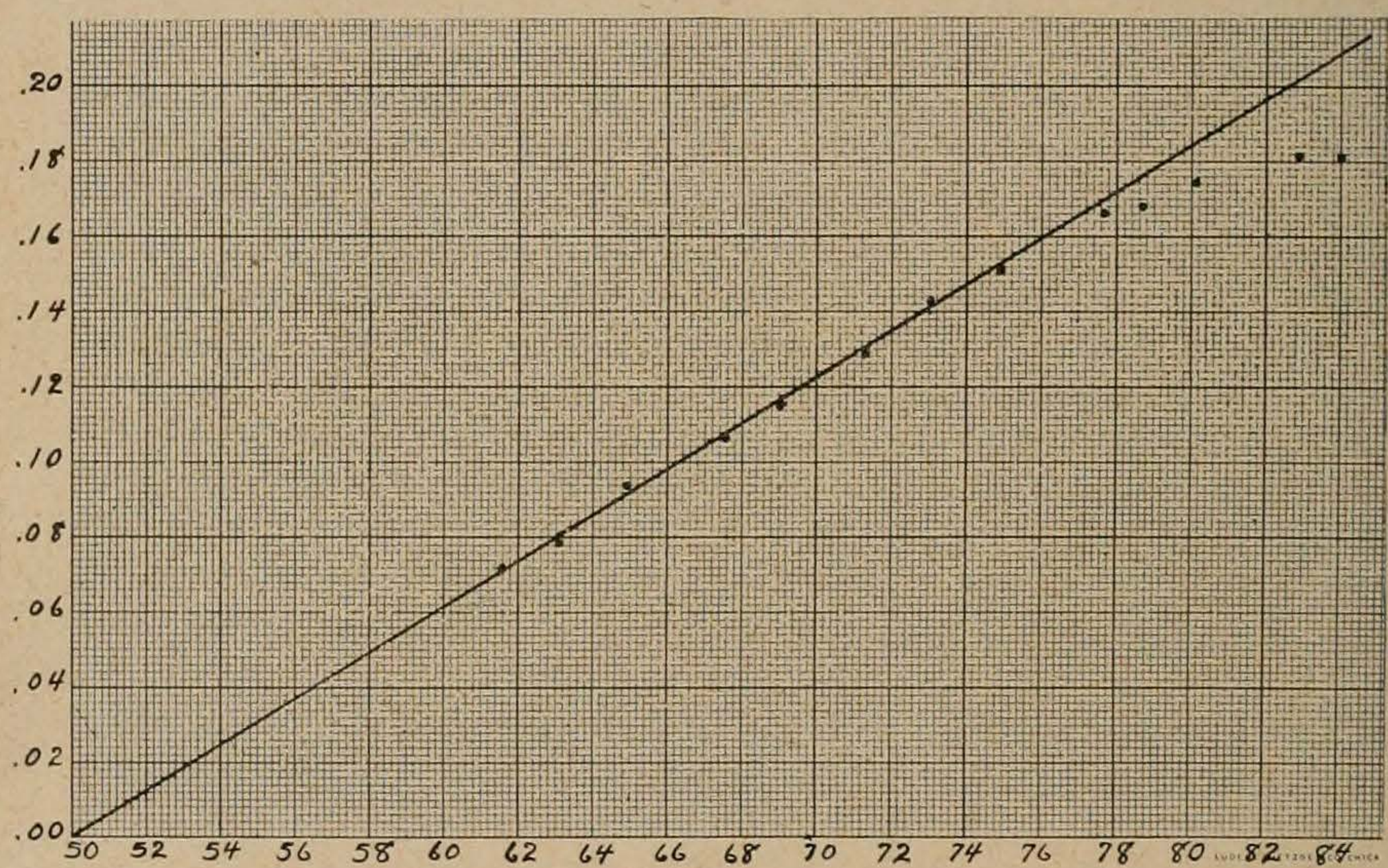
The eggs used for observation were obtained from pairs of moths isolated on branches of trees in small wire cages. These cages were examined morning and evening. The day was used as the unit of time. Eggs found in the cages in the morning were recorded as having been laid the preceding day and those found in the afternoon were recorded as having been laid the same day. It is possible, therefore, that in some cases the recorded length of the period may be either almost a day longer or shorter than the actual period, but the averages of a large number of observations should approximate the true period very closely.

TABLE 1—INCUBATION PERIOD AT OLNEY, ILLINOIS. SUMMARY OF DATA ON RELATION OF TEMPERATURE TO DEVELOPMENT OF EGG

Temp. range, deg. Fah.	Number of observations	Harmonic average of periods in days	Reciprocals of periods	Mean daily temperature	Average daily day-degrees			Total day-degrees	
					(50+)	2(88+)	(50+)—2(88+)	50+	(50+)—2(88+)
60–61	46	14.00	.0714	61.60	12.30		12.30	172	172
62–63	229	12.67	.0788	63.11	13.31		13.31	170	170
64–65	622	10.66	.0938	64.94	15.13		15.13	161	161
66–67	305	9.35	.1069	67.48	17.47		17.47	163	163
68–69	595	8.67	.1154	69.01	19.01		19.01	165	165
70–71	515	7.72	.1295	71.33	21.33		21.33	165	165
72–73	572	7.00	.1425	73.12	23.12	.01	23.11	162	162
74–75	335	6.60	.1513	74.86	24.86	.45	24.41	164	161
76–77	232	6.02	.1663	77.43	27.43	.96	26.47	165	159
78–79	249	5.95	.1679	78.71	28.71	.96	27.25	171	165
80–81	288	5.71	.1750	80.14	30.14	1.93	28.21	172	161
82–83	141	5.52	.1813	82.86	32.86	3.74	29.12	181	161
84–85	46	5.53	.1807	84.00	34.00	4.66	29.34	188	162
60–85	4175	7.67	.1304		21.70		21.33	166	163

Table 1 is a final summary of the data on the relation of temperature to development of the egg. For the present we are concerned only with columns 4 and 5—the reciprocals of the periods and the average mean daily temperatures.

In preparing Graph 1, convenient fractional parts were laid off on the vertical axis corresponding to the reciprocals of the periods and divisions were made on the horizontal axis corresponding to the mean daily temperatures, and the one was plotted against the other.



Graph 1. Incubation period. Reciprocals of the periods plotted against average mean daily temperatures.

The points below 76 degrees fall approximately in a straight line, those above 76 are displaced to the right because for part of the time during the periods the temperature was above the degree of maximum rate of development. The reciprocal curve determined by the points below 76 degrees crosses the temperature axis at 49.32 degrees. Since it is probable that some of these points used are somewhat displaced, the upper ones somewhat to the right on account of temperatures higher than the degree of maximum rate of development, the lower ones to the left on account of temperatures below the zero of development, this line is probably a little too flat and the true line will cross the temperature axis above 49.32° rather than below it. Fifty degrees was taken as the approximate zero and was found to be nearly correct.

The average daily day-degrees above 50 degrees were computed for the different groups, and the results are recorded in column 6 of Table 1. Next, the averages in column 6 were multiplied by the length of the

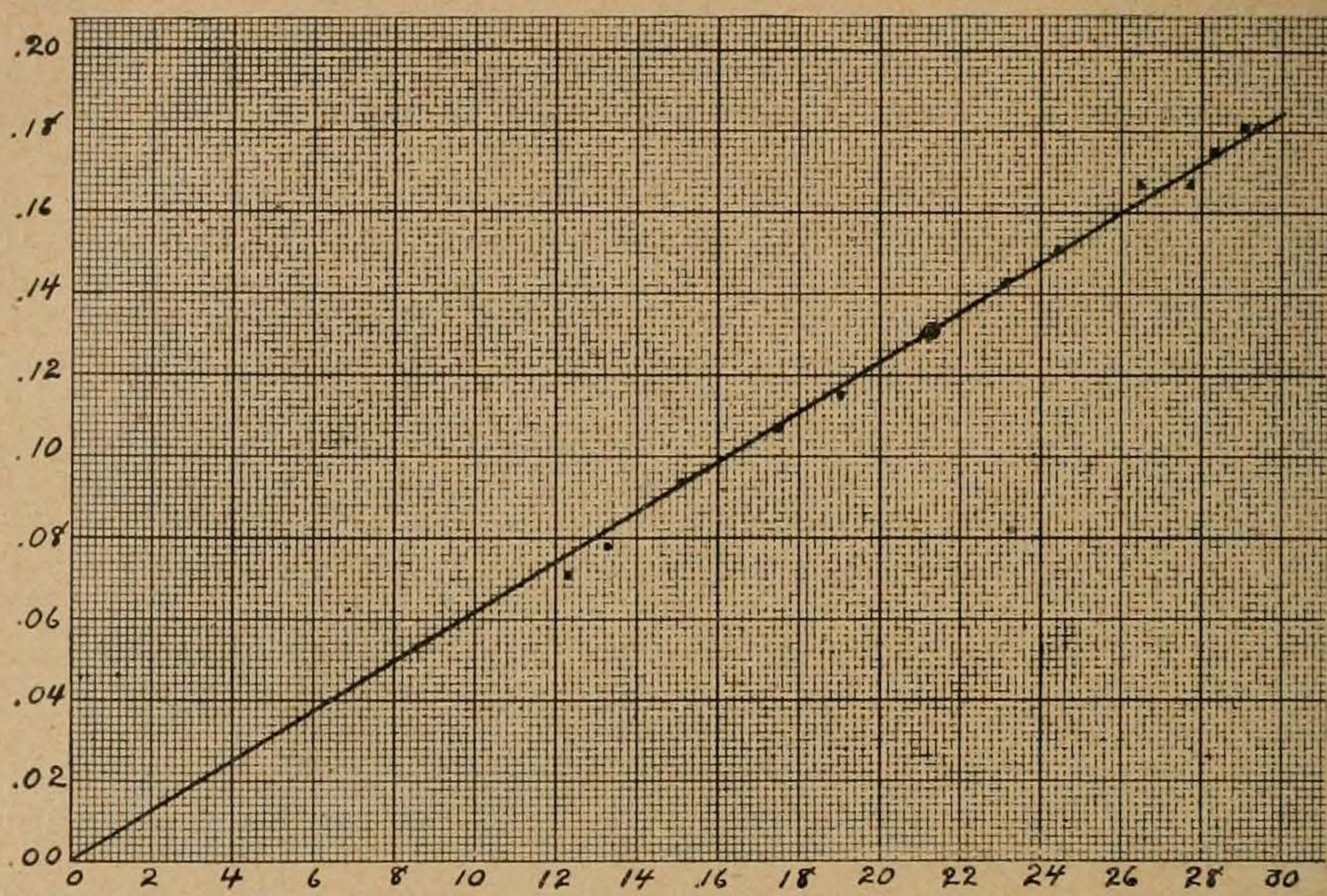
various periods (column 3) in order to get the total accumulation of day-degrees. These are recorded in column 9. If, in column 9, we disregard the accumulations for the first two groups at the top of the table, the accumulations are fairly constant till the 78-79 group is reached. Below this the accumulations rapidly increase, owing to the fact that the averages in column 6 contain some temperatures that are above the degree of the maximum rate of development and so retard development. It was necessary, therefore, to ascertain the degree of maximum rate of development, and to make the necessary corrections in the daily day-degrees column, so as to get only the *effective* day-degrees. In determining this point and making the correction, it was assumed that the products obtained by multiplying the average daily effective day-degrees by the periods would be nearly the same for all temperatures. It will not be necessary to give the details of the process by which the degree of maximum rate of development and the effects of temperatures above this point were determined. Suffice it to say that they were found by making guesses and testing the guesses out. It was found in this way that if 88 degrees were taken as the degree of maximum rate of development and twice* the number of day-degrees above this point (column 7) were subtracted from the average day-degrees above 50 degree, values for the daily effective day-degrees (column 8) were secured which when multiplied by the periods gave products that very nearly filled the conditions, giving about the same accumulation of effective day-degrees for the high temperatures as for the low.

By plotting the average daily day-degrees obtained in column 8 against the reciprocals of the periods, the points all fall somewhere near the established line (Graph 2). The average accumulation of effective day-degrees for the incubation period is, therefore, about 163.

No good reason can be assigned why the accumulations for the 60-61 and the 62-63 groups should be higher than the average unless it may have been that in assuming in 1915 that eggs found in the forenoon of one day were laid the previous evening, too long a period was assigned to many of them. The weather during the early part of 1915 was very cloudy and a larger per cent. of the eggs were laid during the daytime than in the other seasons.

---

* Twice the number of day-degrees above the degree of maximum rate of development is subtracted from the total day-degrees above the zero of development because one degree rise in temperature above the degree of maximum rate of development retards the rate of development at approximately the same rate as does one degree fall in temperature below this point.



GRAPH 2. Incubation period. Reciprocals of the periods plotted against average daily effective day-degrees.

TABLE 2—DISTRIBUTION OF THE EGGS AS TO NUMBER OF THE TOTAL EFFECTIVE DAY-DEGREES ACCUMULATED DURING THE OBSERVED PERIOD

Number of eggs	Range of effective day-degrees
35	119-128
29	129-138
1030	149-158
2163	159-168
745	169-178
171	179-188
2	189-198

The variations in the total of effective day-degrees in the cases of individuals shown in the above table arises from several causes. Some of the extreme variations resulted, no doubt, from inaccuracies in observations; but for the most part they resulted from the use of the day as the unit, from which cause the recorded period may exceed or fall short of the true period by almost a day. Since in midsummer the daily accumulations may reach 27 effective day-degrees, the variations from this cause alone may be from 136 to 190. The variations from this source are so large that they overshadow all the lesser ones and make it impossible to estimate the errors which probably arise from them. This source of error might have been avoided by using a smaller unit of time. There is also a difference in eggs as to the length of time required for the incubation period. Moisture, evaporation, and light also may have a slight influence on the rate of development.

It is probably true that variations arising from individual differences are comparatively slight and that the wide variations shown in the tables are due to the first two causes above mentioned. The extreme variations may therefore be regarded as of little significance and the average of the large number of observations may be relied upon as being approximately the true heat factor.

RELATION OF TEMPERATURE TO DEVELOPMENT OF THE LARVA

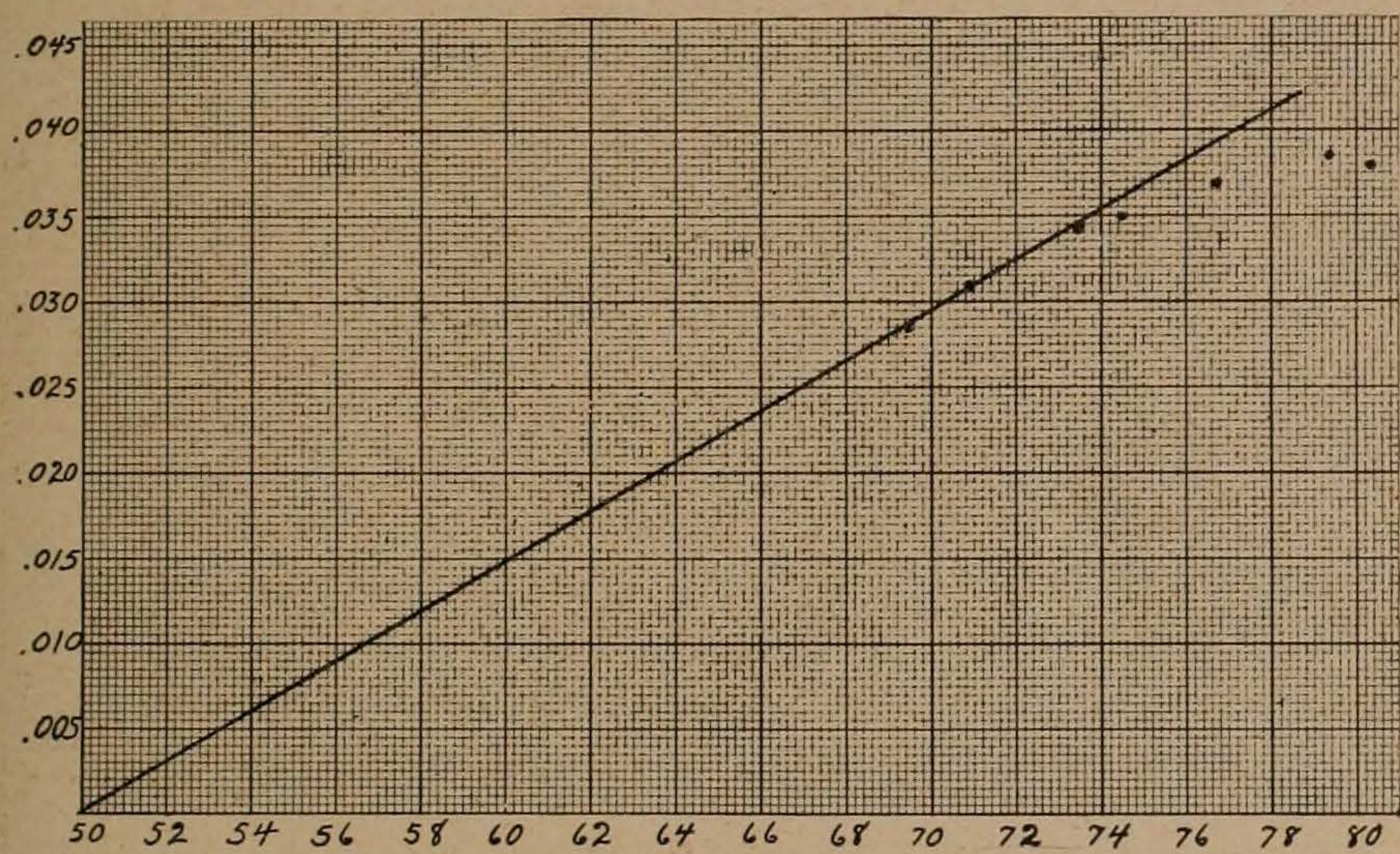
The conclusions arrived at are based upon observations made on 344 larvæ reared in apples on the tree and 214 larvæ reared in picked apples. It was found that larvæ reared in picked apples had a shorter period relative to the temperature than those reared in apples on the tree.

These data were first tabulated in detail and the periods and mean daily temperatures averaged for each of the observations, then for groups of larvæ which began the period on the same day, and lastly for groups arranged according to average mean daily temperatures. A summary of the results thus obtained from the observations on larvæ reared in apples on the tree is given in Table 3.

TABLE 3—LARVAL PERIOD. SUMMARY OF DATA ON RELATION OF TEMPERATURE TO DEVELOPMENT. LARVAE REARED IN APPLES ON TREE.

Temp. range, deg. Fah.	Number of observations	Harmonic average of periods in days	Reciprocals of periods	Mean daily temperature	Daily day-degrees			Total day-degrees	
					50+	2(85+)	(50+)—2(85+)	50+	(50+)—2(85+)
68-69	32	35.57	.028531	69.45	19.45	.34	19.11	692	680
70-71	122	32.29	.03091	70.88	20.88	.30	20.58	674	665
72-73	45	29.20	.03424	73.48	23.48	.72	22.76	686	665
74-75	33	28.62	.03495	74.53	24.53	.74	23.79	702	681
76-77	14	27.14	.03684	76.74	26.74	1.40	25.34	726	688
78-79	20	25.93	.03855	79.39	29.39	3.62	25.77	762	668
80-81	78	26.33	.03798	80.30	30.30	4.36	25.94	798	683
68-81	344	29.07	.0338	74.31	24.31	1.56	22.75	719	673

In Graph 3, fractional parts corresponding to the reciprocals of the periods (Table 3) were laid off on the vertical axis, and divisions were marked on the horizontal axis corresponding to the mean daily temperatures. Points were then plotted, using the reciprocals of the periods and the mean daily temperatures as the coordinates.



GRAPH 3. Larval period. Reciprocals of the periods plotted against mean daily temperatures. Larvæ reared in apples on tree.

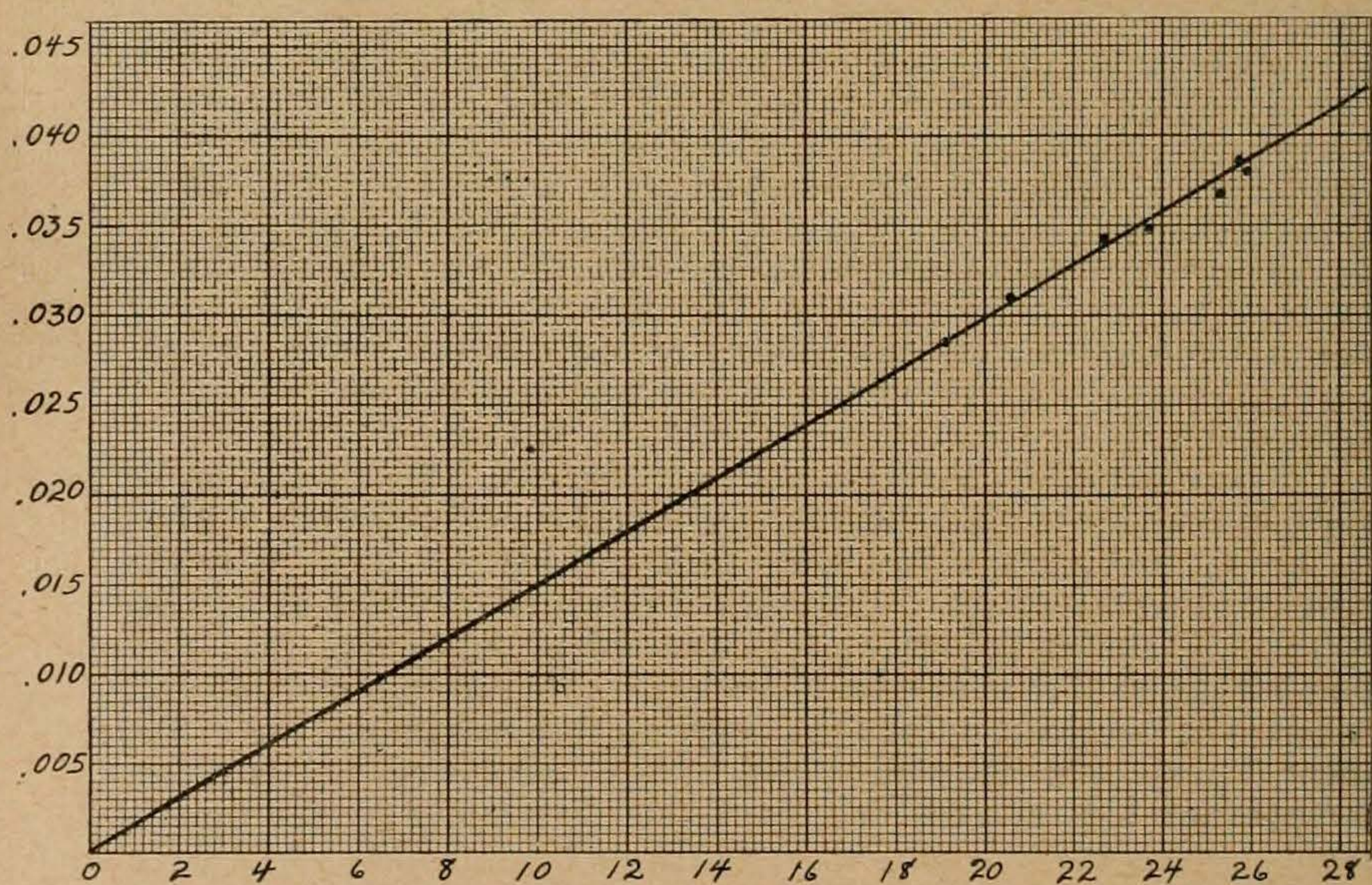
These points do not lie in a straight line, and hence can not be used for the purpose of establishing the reciprocal curve accurately. The points do not lie in a straight line because in making the mean daily averages temperatures were used which are not effective or which retard development. The lower points are less affected by this cause than the other points because they represent temperatures that are intermediate between the zero of development and the degree of the maximum rate of development. A straight line determined by the two lowest points crosses the temperature axis at 52+ degrees, a line determined by the three lowest points crosses the axis at 47+. All points between 47 and 52 were tried out as to which best fulfilled the condition as the zero of development and 50 was selected as the one which did so most nearly.

The daily day-degrees above 50 degrees were computed and the results were entered in column 6 of Table 3. The figures in this column multiplied by the number of days in the periods gave the total accumulations of day-degrees above 50 degrees, shown in column 9 of Table 3. An examination of these results as well as the position of the upper points in Graph 3 leads us to conclude that the gradual increase in the accumulations and the deviation to the right of the points from the line at the

higher temperatures were due to retarding temperatures or temperatures above the degree of maximum rate of development. To find this point guesses were made and tried out to test their correctness. It was found that by using 85 as the degree of the maximum rate of development, and subtracting twice the average day-degrees above 85 (column 7) from the day-degrees above 50, we got a temperature factor (column 8) for each of the temperature groups which when multiplied by the period expressed in days gave the most nearly constant products (column 10) for the different groups, the average for all groups being 673.

This average may be taken as the approximate average of accumulations of effective day-degrees for the larval period of larvæ reared in apples on the tree.

In Graph 4, the average daily effective day- degrees as recorded in column 8 of Table 3 were plotted against the reciprocals of the periods, with the result that the points in the upper part of the graph were brought nearly into line with the other points.



GRAPH 4. Larval period. Reciprocals of the periods plotted against mean daily effective day-degrees. Larvæ reared in apples on tree.

The data secured from observations made on 214 larvæ reared in picked apples were treated in the same manner as the data for larvæ reared in apples on the tree. A summary of the results is shown in Table 4.

TABLE 4—LARVAL PERIOD. SUMMARY OF DATA ON RELATION OF TEMPERATURE TO DEVELOPMENT. LARVAE REARED IN PICKED APPLES

Temp. range, deg. Fah.	Number of observations	Harmonic average of periods in days	Reciprocals of periods	Average mean daily temperature	Average daily day-degrees			Total day-degrees	
					50+	2(85+)	(50+)—2(85+)	50+	(50+)—2(85+)
66-67	1	34.00	.02941	67.90	17.90	.20	17.70	608	601
68-69	15	33.11	.03020	68.38	18.38	.26	18.12	609	600
70-71	63	28.94	.03456	71.25	21.25	.46	20.79	615	602
72-73	43	26.68	.03748	72.47	22.47	.50	21.97	599	586
74-75	27	22.84	.04378	74.82	24.82	.84	23.98	567	548
76-77	25	23.86	.04107	77.25	27.25	1.72	25.53	650	609
78-79	16	22.01	.04543	79.08	29.08	3.00	26.08	640	573
80-81	24	21.54	.04643	80.75	30.75	3.90	26.85	662	578
66-81	214	25.69	.03892	74.08	24.08	1.22	22.86	619	587

In computations for Table 4, 50 was taken as the zero of development and 85 as the degree of maximum rate of development. The results indicate that 52 degrees would have more nearly satisfied the conditions; but as the main interest in this table is that it gives an opportunity for comparing the rate of development of larvæ in apples on the tree and in picked apples, in order to have the same units of accumulation in both cases 50 was used as the zero. The average accumulation of effective day-degrees required to develop larvæ in picked apples was 587, or 86 day-degrees less than for larvæ in apples on the tree (Table 3).

The variations in the length of the larval period are very great for individuals even when subjected to the same conditions. The following example will illustrate the extent of the variations. Of 19 larvæ hatched July 20, 1916, one pupated in 20 days, two in 23 days, three in 25 days, one in 27 days, three in 28 days, four in 29 days, three in 30 days, one in 31 days, and one in 34 days, giving a variation of 14 days in the length of the period. Individual variations are also shown by the varying number of effective day-degrees which accumulated during the larval period.

Tables 5 and 6 show the distribution of larvæ as to accumulated effective day-degrees.

TABLE 5—DISTRIBUTION OF LARVAE REARED IN APPLES ON THE TREE WITH REFERENCE TO ACCUMULATED EFFECTIVE DAY-DEGREES DURING THE PERIOD

Number of larvæ	Range of effective day-degrees
8	456-499
18	500-549
39	550-599
65	600-649
64	650-699
58	700-749
29	750-799
26	800-849
16	850-899
6	900-949
1	950-969

The variations above 900 and below 500 are possibly due to errors in observations. The smaller variations are due in part to the use of the day as the period unit, and in part, no doubt, to the various temperatures

to which larvæ in different parts of the tree are simultaneously subjected, to variations in the character of food, and to individual differences. How much of the variations are attributable to each of these causes can not be accurately determined from the data at hand.

The use of the day as the unit will take account of a variation of 27 day-degrees each way from the average. If we assume that variations below 500 and above 900 are due to errors of observation and make a correction of 27 on account of the use of the day as the unit, it still leaves a variation of from 527 to 873 to be attributed to other causes. Since there is no way of eliminating these causes in practical operations, we must expect under natural conditions that some larvæ will complete their period when the effective day-degrees have reached 527 and that others will not complete it until 873 effective day-degrees have accumulated, the average accumulation being 673.

Table 6 shows the distribution of larvæ reared in picked apples as to total effective day-degrees required for their development.

TABLE 6—DISTRIBUTION OF LARVAE REARED IN PICKED APPLES WITH REFERENCE TO ACCUMULATIONS OF EFFECTIVE DAY-DEGREES DURING THE PERIOD

Number of larvæ	Range of effective day-degrees
3	400-449
16	450-499
41	500-549
59	550-599
40	600-649
22	650-699
12	700-749
5	750-799
1	800-849

Following the same course of reasoning with these data as with the preceding, the variations arising from factors which can not be eliminated under field conditions, range from 477 to 722, the average being 587.

These results are not very satisfactory for practical use. The averages are, no doubt, approximately correct; but the variations from the average are too great and the limits of the variations due to unpreventable causes are a little too uncertain to render the data entirely satisfactory for the purpose of forecasting life-history events. However, these are the nearest approximations to the actual accumulation of effective

day-degrees for the larva and the variations therefrom that we have at the present time, and with similar data for the egg and pupa they will serve as a fairly satisfactory basis for forecasting events in the seasonal history of the codling-moth.

RELATION OF TEMPERATURE TO DEVELOPMENT OF THE PUPA

Observations were made on a total of 4348 pupæ of the codling-moth. The data were tabulated, grouped, and averaged in the same manner as those for the other stages. A summary of the results is given in Table 7.

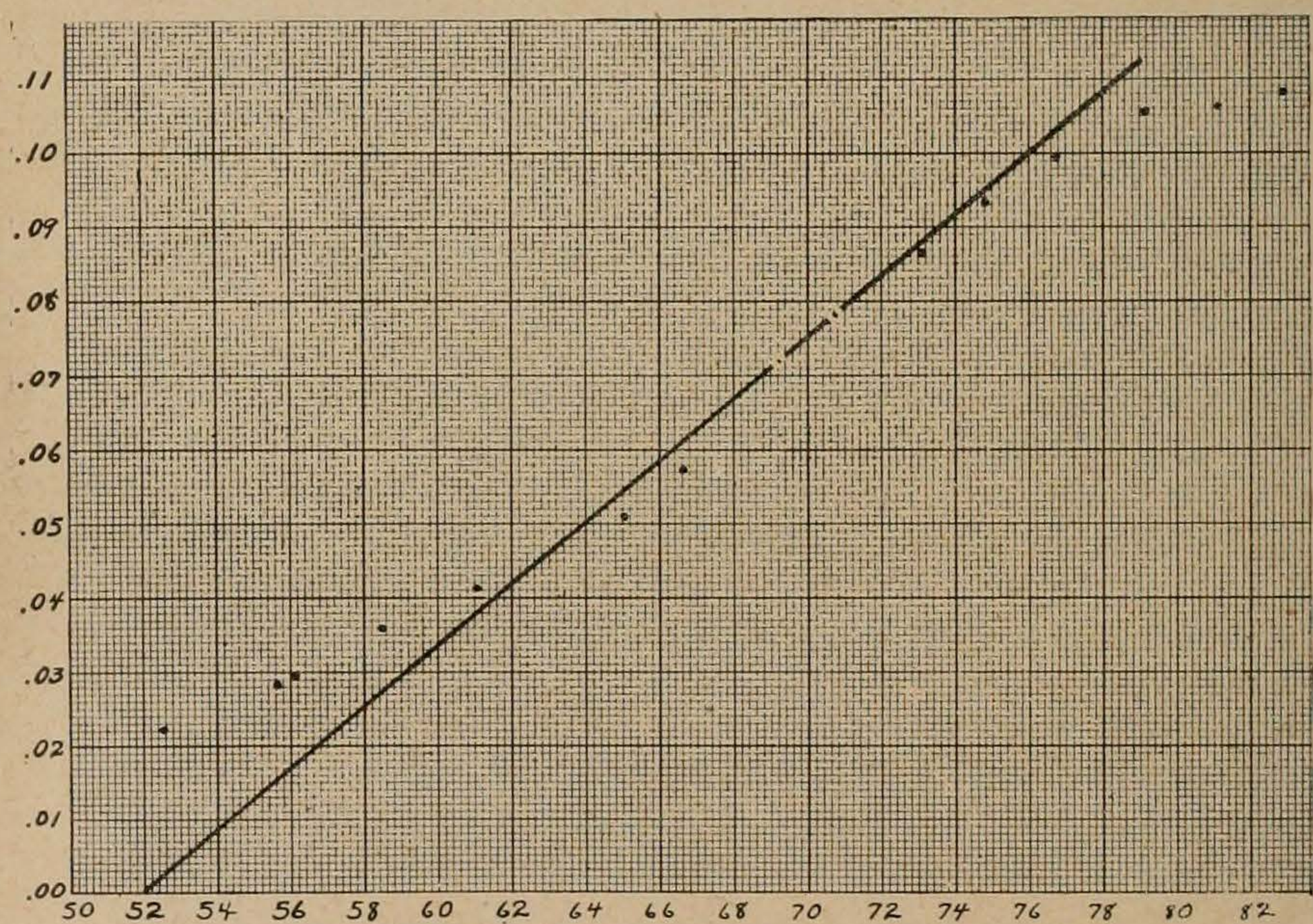
TABLE 7—PUPAL PERIOD, OLNEY, ILLINOIS. SUMMARY OF DATA ON RELATION OF TEMPERATURE TO DEVELOPMENT

Temp. range, deg. Fah.	Number of observations	Harmonic average of periods in days	Reciprocals of periods	Average mean daily temperatures	Average daily day-degrees					Total day-degrees			
					50+	52+	2(87+)	(50+)—2(87+)	(52+)—2(87+)	50+	52+	(50+)—2(87+)	(52+)—2(87+)
52.53	2	45.50	.0220	52.60	6.19	5.19		6.19	5.19	281.6	236.0	281.6	236.0
54-55	348	35.20	.0284	55.70	7.85	6.80		7.85	6.80	276.3	237.9	276.3	237.9
56-57	976	34.01	.0294	56.15	8.24	7.08		8.24	7.08	280.2	240.8	280.2	240.8
58-59	243	27.77	.0360	58.50	9.92	8.69		9.92	8.69	275.5	241.3	275.5	241.3
60-61	72	24.08	.0416	61.13	11.75	10.39		11.75	10.39	282.9	250.2	282.7	250.2
62-63	148	22.21	.0450	62.75	13.12	11.56		13.12	11.56	291.4	256.7	291.4	256.7
64-65	212	19.57	.0511	65.02	15.46	13.66		15.46	13.66	302.6	267.3	302.6	267.3
66-67	99	17.41	.0574	66.59	16.90	15.15		16.90	15.15	294.2	263.8	294.2	263.8
68-69	218	13.80	.0724	69.28	19.27	17.31		19.27	17.31	265.9	238.9	265.9	238.9
70-71	175	12.70	.0787	70.79	20.79	18.79	.04	20.75	18.75	264.0	238.6	263.5	238.1
72-73	221	11.51	.0868	73.11	23.11	21.11	.24	22.87	20.87	266.0	242.8	263.2	240.2
74-75	247	10.73	.0932	74.92	24.92	22.92	.42	24.50	22.50	267.4	245.9	262.9	241.4
76-77	517	10.02	.0997	76.77	26.77	24.77	.88	25.89	23.89	268.2	248.2	259.4	239.4
78-79	481	9.44	.1059	79.14	29.13	27.13	1.63	27.50	25.50	275.0	256.1	259.6	240.7
80-81	133	9.43	.1062	80.88	30.88	28.88	3.52	27.36	25.36	291.1	272.2	257.9	239.0
82-83	256	9.24	.1082	82.68	32.68	30.68	4.12	28.56	26.56	302.0	283.5	263.9	245.4
52-83	3817	14.49	.0690		19.03	17.38	.77	18.26	16.61	275.6	251.8	264.6	240.7

N. B.—The totals and averages of this table do not include the data given for 60°-67° inclusive. The pupæ noted at those temperatures being a part of the hibernating generation which pupated late, were disturbed by daily examinations which resulted in a prolongation of the normal pupal period.

Graph 5 was prepared by plotting the reciprocals of the periods against the mean daily temperatures (columns 4 and 5, Table 7).

No three of the points in this graph appear to lie in a straight line. The points at the lower end of the line are too far to the left because in computing the mean daily temperatures temperatures below the zero of development were included, which prolongs the temperature axis too far to the left. Points at the upper end of the line are too far to the right because in computing the mean daily temperatures temperatures were included which were above the degree of the maximum rate of development and which, therefore, retarded development. The use of the mean daily degrees in this part of the graph prolonged the temperature axis too far to the right.



GRAPH 5. Pupal period. Reciprocals of the periods plotted against average mean daily temperatures.

The points from 60 to 68 degrees are lower than they should be normally because these represent the portion of the hibernating generation which did not pupate until from two to six weeks after pupation began in the spring, and were consequently disturbed daily until they pupated by having their cocoons torn open to make observations possible. The energy expended in repairing their cocoons daily seems to have devitalized them somewhat, on account of which a relatively longer period was required. Those which pupated last and hence were disturbed the most had the longest periods relative to the temperature. These points should, therefore, be disregarded.

Because all the points seem to be displaced more or less on account of using ineffective and retarding temperatures in the temperature axis, they afford no means of determining the true reciprocal curve. The two points that are least affected are the middle points from 68 to 72 degrees. The line determined by these two points cuts the temperature axis at 51.92 degrees. By using 50, 51, 52, and 53 degrees in turn as the possible zero of development it was found that 52 degrees more nearly satisfied the conditions than any other of the points.

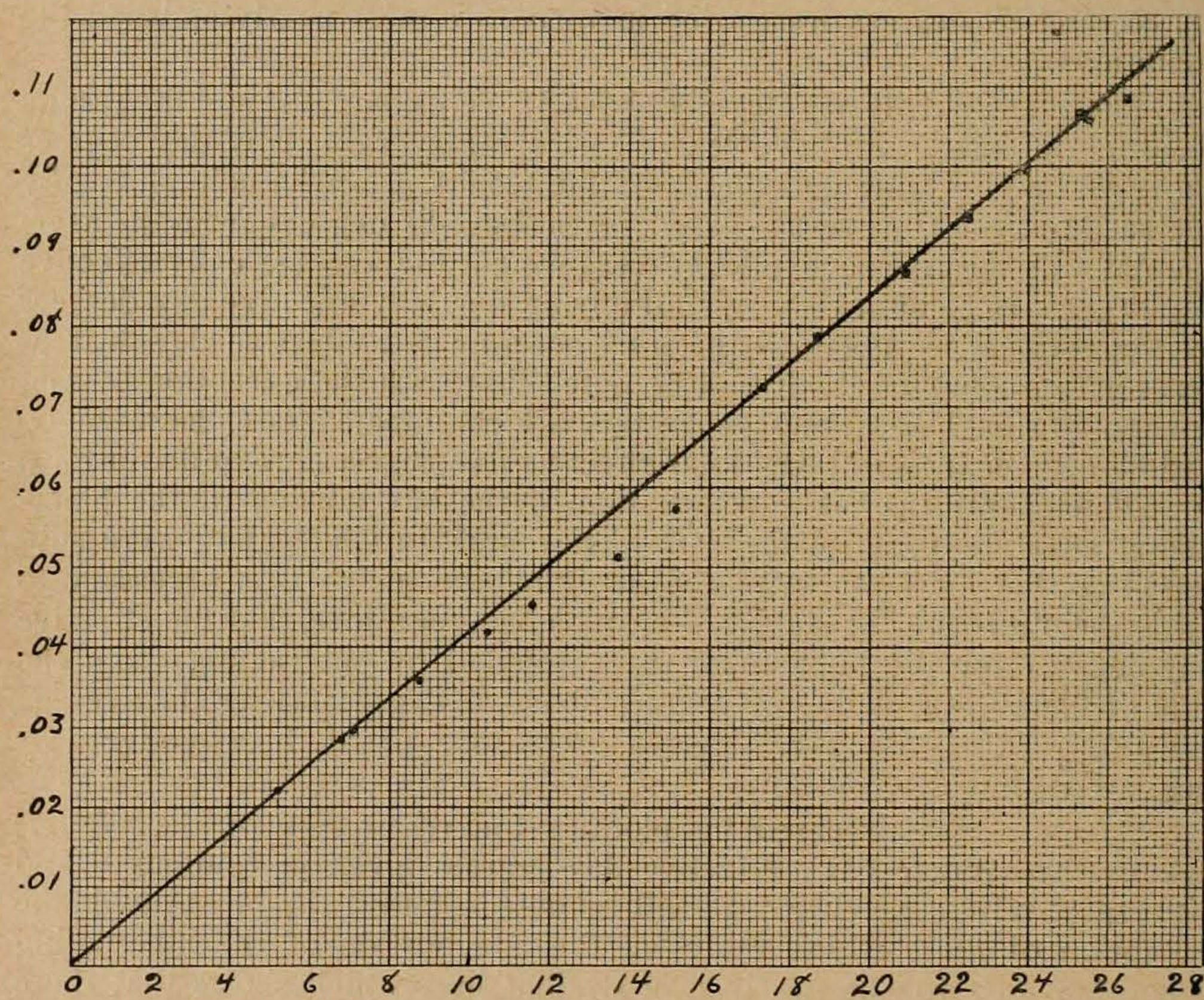
To ascertain the degree of the maximum rate of development 86, 87, 88, and 89 degrees were tried in turn. 87 most nearly satisfied the conditions.

The average daily day-degrees above 52 were computed and the results recorded in column 7 of Table 7. Twice the average daily day-degrees above 87 degrees were computed and the results placed in column 8. By subtracting twice the average day-degrees above 87 degrees from the average daily day-degrees above 52 degrees we got the average daily effective day-degrees in column 10. By multiplying the daily effective day-degrees by the periods, we obtained the total accumulated effective day-degrees recorded in column 14. It will be noted that with the exception of that portion of the hibernating generation which pupated late, between 60 and 67 degrees inclusive, the total effective day-degrees are quite uniform for all temperatures. The retardation of the late portion of the hibernating generation due to the daily disturbance to which they were subjected is shown by the increased accumulation which was necessary to bring them through the stage. We concluded, therefore, that the effective day-degrees for the pupa might be computed by subtracting from the sum of the average daily day-degrees above 52 degrees, twice the average daily day-degrees above 87 degrees. The average of the effective day-degrees as thus determined is 240.7.

Graph 6 was prepared by plotting the reciprocals of the periods against the average daily effective day-degrees given in columns 4 and 10 respectively of Table 7. It will be noted that all the points with the exception of those which represent the late portion of the hibernating generation (10–16) lie nearly in a straight line, which shows that there is a quite constant relation between the average daily effective day-degrees as above determined, and the rate of development.

Observations on the pupal period were made at such a wide range of temperatures that the data exemplify very nicely the hyperbolic form of the curve of development formed by plotting the periods against the average daily effective day-degrees. Graph 7 has been prepared to show the different positions of the points occasioned by the use of different factors as coordinates and also the curve of development.

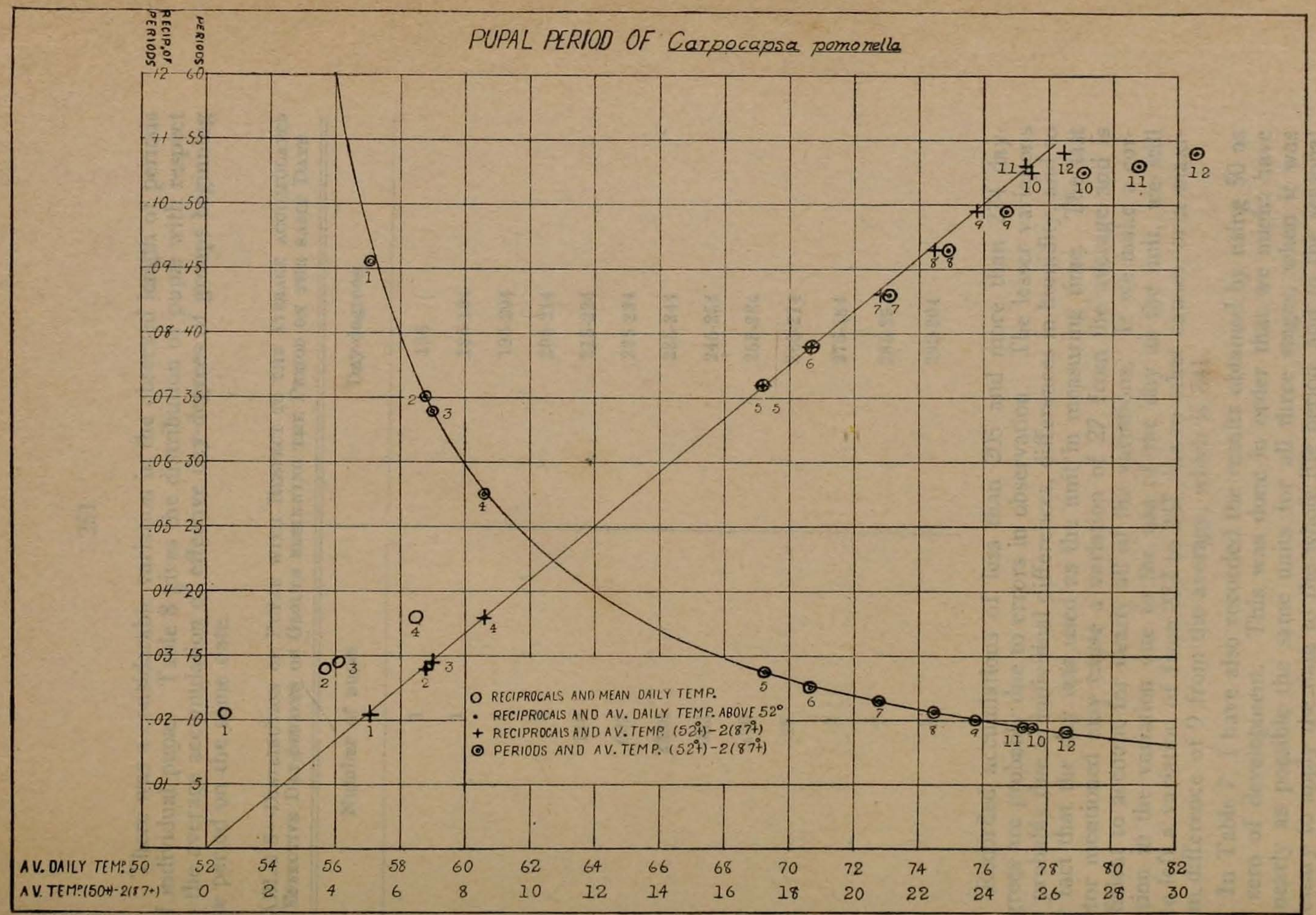
Graph 7 combines Graphs 5 and 6, and also shows the curve of development. The circles show the position of the points when the reciprocals of the periods (Table 7, column 4) are plotted against the average mean daily temperature (column 5); the dots show the position of the points when the reciprocals of the periods are plotted against the average day-degrees above 52° (column 7); the dots with crosses show the position of the same points when the average daily effective



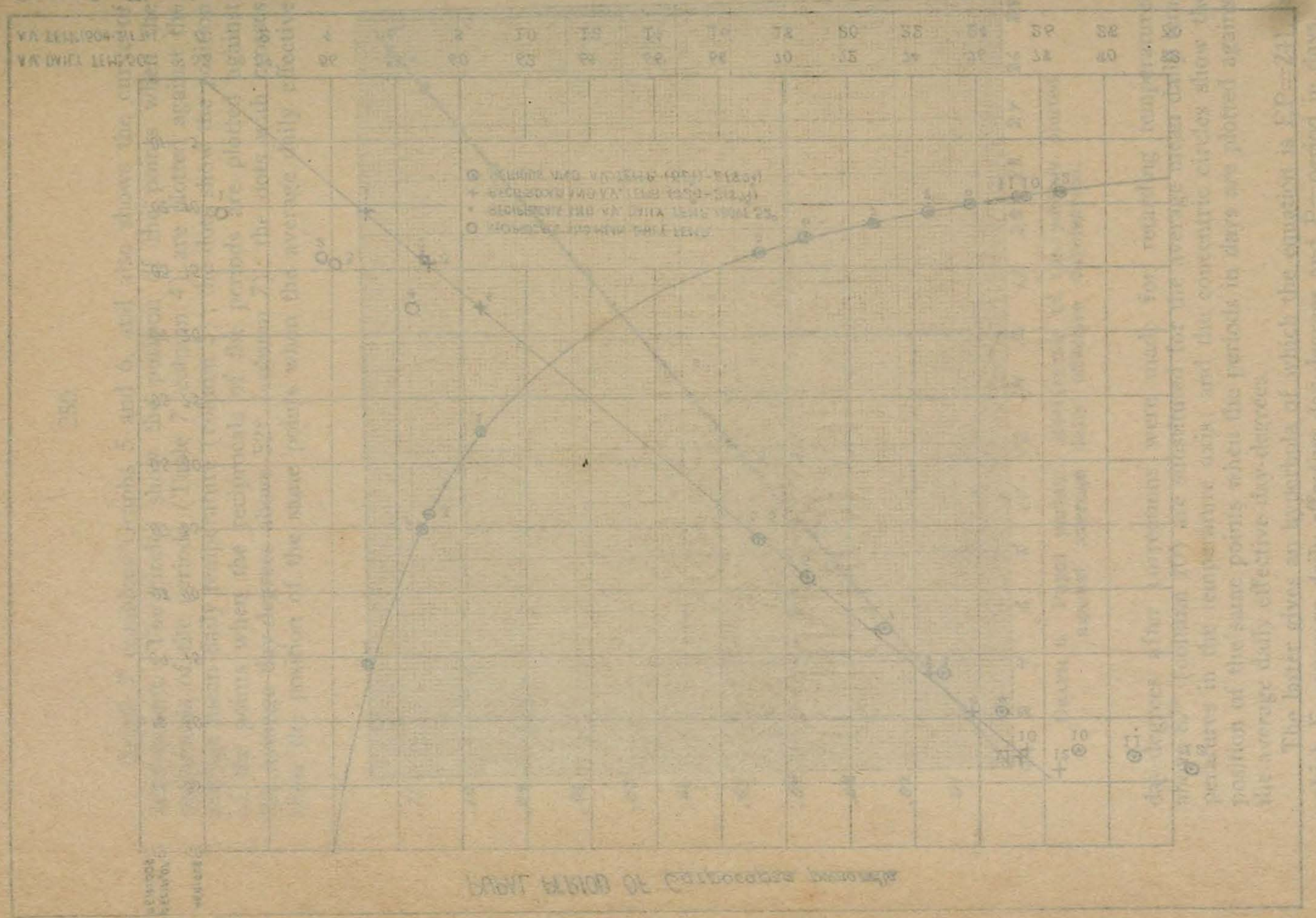
GRAPH 6. Pupal period. Reciprocals of the periods plotted against average daily effective day-degrees.

day-degrees after corrections were made for retarding temperatures above 87° (column 10) are substituted for the average mean daily temperatures in the temperature axis; and the concentric circles show the position of the same points when the periods in days are plotted against the average daily effective day-degrees.

The latter gives an hyperbola of which the equation is EP=241, in which E=average daily effective day-degrees and P=period in days.



GRAPH 7. The time-temperature curve, reciprocal curve and different positions of points resulting from the use of different factors as coordinates, as indicated by the numerals under points.



There was a considerable variation in the observed length of periods of individual pupæ. Table 8 gives the distribution of pupæ with respect to the average accumulation of effective day-degrees of groups beginning the period on the same date.

TABLE 8—DISTRIBUTION OF PUPAE WITH RESPECT TO THE AVERAGE ACCUMULATED EFFECTIVE DAY-DEGREES OF GROUPS BEGINNING THE PERIOD ON THE SAME DATE

Number of pupæ	Day-degrees
1	166
1	185-194
4	195-204
3	205-214
110	215-224
602	225-234
2238	235-244
353	245-254
170	255-264
18	265-274
7	275-284
7	285-294
2	295-304

Recorded accumlations of less than 205 and more than 274 day-degrees are probably due to errors in observation. The lesser variations are probably due to individual differences, differences in humidity, and to the fact that the day was used as the unit in measuring time. The last factor mentioned may cause a variation of 27 from the average and is sufficient to account for nearly all of the variations. If we make a correction in the variation due to the use of the day as the unit, we still have left a variation of from 232 to 247 due to other causes, or a maximum difference of 9 from the average, which is 241.

In Table 7, I have also recorded the results obtained by using 50 as the zero of development. This was done in order that we might have as nearly as possible the same units for all three stages, when it was necessary to apply the data to the whole life period, and to the seasonal history. The average accumulation of effective day-degrees using 50 as

the zero of development is 265, and the variation due to causes other than the use of the day as the unit gives 256 as the minimum and 274 as the maximum.

CONCLUSIONS FROM THE FOREGOING DISCUSSION

1. There is a fairly constant relation between temperature and the rate of development of different stages of the codling-moth.

2. Only temperatures above the zero of development are effective.

3. The rate of development increases as the temperature rises above the zero of development until a temperature is reached at which the maximum rate of development takes place.

4. For the first few degrees, at least, above the degree of the maximum rate of development the rate of development decreases approximately as the temperature rises above this point.

5. The average daily effective day-degrees are found by subtracting from the average daily day-degrees above the zero of development twice the average daily day-degrees above the degree of maximum rate of development.

6. The product obtained by multiplying the average daily effective day-degrees by the period, expressed in days, or other convenient unit, is fairly constant for all temperatures.

7. Variations in the total accumulation of day-degrees recorded for individuals from the average accumulation, may result from the following causes:—1. Use of too large a unit of time. 2. Differences in humidity. 3. Individual differences. 4. Errors in observation. 5. Slight differences of temperature between the individual under observation and the recording instrument, due to difference of locality. 6. Abnormal environment and treatment of the individual.

8. The zero of development for the egg stage is about 50 degrees F. and the degree of the maximum rate of development is about 88. The equation of the curve of development is $PE = 163$, in which $P =$ period in days, and $E =$ average daily effective day-degrees.

9. The zero of development for the larva is about 50 degrees and the degree of the maximum rate of development is about 85 degrees. The equation of the curve of development for larvæ reared in apples on the tree is $PE = 673$; that for larvæ reared in picked applies is $PE = 587$.

10. The zero of development for the pupa is about 52 and the degree of maximum rate of development is about 87 degrees. The equation of the curve of development is $PE = 241$. For practical purposes it will be more convenient to use 50 as the zero of development for the pupa when applying the data to the whole life cycle, and the error that will result from so doing will amount to only a fraction of a day in the length of the period. The equation when 50 degrees is used, is $PE = 265$.

TABLE 9—LIFE-HISTORY DATA ON FIRST GENERATION, OLNEY, 1915. LARVAE REARED IN APPLES ON TREE

Sex.	Egg laid.	Larva hatched.	Larva left apple.	Larva pupated.	Adult emerged.	Life periods in days.						Total effective day-degrees.				
						Egg	Larva in apple.	Larva in cocoon.	Total larval period.	Pupa.	Egg, larva, pupa.	Egg (50+)—2(88+)	Larva (50+)—2(85+)	Pupa (50+)—2(87+)	Egg, larva, pupa.	Egg, larva, and pupa (50+)—2(86+)
F.	May 21	June 3	June 29	June 30	July 13	13	26	1	27	13	53	174	559	255	988	989
M.	" 21	" 3	" 29	July 1	" 14	13	26	2	28	13	54	174	580	264	1018	1017
F.	" 21	" 3			" 14	13					54	174			1018	1017
M.	" 21	" 3		" 3	" 16	13			30	13	56	174	621	284	1079	1078
F.	" 21	" 3	" 29	" 4	" 16	13	26	5	31	12	56	174	636	269	1079	1078
M.	" 21	" 3	" 30	" 5	" 16	13	27	5	32	11	56	174	648	258	1080	1078
F.	" 21	" 3	July 1	" 7	" 18	13	28	6	34	11	58	174	682	284	1140	1138
F.	" 21	" 2	" 5	" 10	" 18	12	33	5	38	8	58	157	759	225	1141	1138
F.	" 21	" 3		" 9	" 19	13			36	10	59	174	719	274	1167	1165
F.	" 21	" 3	June 30	" 9	" 19	13	27	9	36	10	59	174	719	274	1167	1165
F.	" 21	" 3	July 6	" 12	" 22	13	33	6	39	10	62	174	787	271	1232	1229
M.	" 22	" 3	June 30	" 4	" 17	12	27	4	31	13	56	159	636	299	1094	1093
F.	" 22	" 3	July 7	" 12	" 21	12	34	5	39	9	60	159	787	252	1198	1195
M.	" 23	" 4		" 9	" 19	12			35	10	57	169	698	274	1141	1139
M.	" 23	" 4	" 4	" 10	" 20	12	30	6	36	10	58	169	720	279	1168	1165
F.	" 23	" 4	" 10	" 14	" 25	12	36	4	40	11	63	169	821	277	1267	1267
F.	" 31	" 9	June 30	" 4	" 15	9	21	4	25	11	45	159	525	238	922	921
M.	" 31	" 10		" 7	" 17	10			27	10	47	174	556	253	983	982
M.	" 31	" 10		" 8	" 18	10			28	10	48	174	575	265	1014	1011
M.	" 31	" 8		" 10	" 19	8			32	9	49	148	641	252	1041	1034
F.	" 31	" 7	July 7	" 12	" 20	7	30	5	35	8	50	139	695	233	1067	1065
M.	" 31	" 8		" 10	" 20	8			32	10	50	148	641	279	1068	1065
F.	" 31	" 9		" 10	" 20	9			31	10	50	159	630	279	1068	1065
M	" 31	" 7	" 6	" 11	" 21	7	29	5	34	10	51	139	671	276	1086	1084
M.	" 31	" 9	" 6	" 11	" 21	9	27	5	32	10	51	159	652	276	1087	1084
F.	" 31	" 9	" 7	" 12	" 22	9	28	5	33	10	52	159	676	271	1106	1103
M.	" 31	" 9		" 13	" 23	9			34	10	53	159	703	264	1126	1123
F.	" 31	" 9		" 13	" 23	9			34	10	53	159	703	264	1126	1123
M.	" 31	" 9	" 13	" 16	" 27	9	34	3	37	11	57	159	789	269	1217	1220
F.	" 31	" 8	" 12	" 16	" 28	8	34	4	38	12	58	149	801	296	1246	1244
M.	" 31	" 9	" 14	" 18	" 29	9	35	4	39	11	59	159	848	264	1271	1275
F.	June 1	" 11	June 29	" 3	" 15	10	18	4	22	12	44	182	472	254	908	906
F.	" 1	" 10	July 3	" 8	" 18	9	23	5	28	10	37	159	575	265	999	996
M.	" 1	" 11	" 3	" 8	" 18	10	22	5	27	10	47	182	552	265	999	996
M.	" 1	" 11		" 11	" 21	10			30	10	50	182	614	276	1072	1069
F.	" 1	" 11		" 14	" 25	10			33	11	54	182	693	278	1153	1152
F.	" 1	" 11		" 14	" 25	10			33	11	54	182	693	278	1153	1152
F.	" 1	" 10	" 17	" 21	Aug. 1	9	37	4	41	12	62	159	906	280	1345	1345
M.	June 2	June 11		July 4	July 16	9			23	12	44	166	488	269	923	921
M.	" 2	" 11	" 6	" 12	" 22	9	25	6	31	10	50	166	638	271	1075	1072
F.	" 2	" 11		" 12	" 22	9			31	10	50	166	638	271	1075	1072
M.	" 2	" 11	" 8	" 13	" 23	9	27	5	32	10	51	166	665	262	1093	1093
F.	" 2	" 11	" 12	" 14	" 25	9	31	2	33	11	53	166	693	278	1137	1136
F.	" 2	" 11	" 14	" 16	" 29	9	33	2	35	13	57	166	752	325	1243	1244
F.	" 2	" 11	" 14	" 18	" 29	9	33	4	37	11	57	166	810	264	1240	1244
F.	" 2	" 11	" 14	" 19	" 30	9	33	5	38	11	58	166	838	266	1270	1273
F.	" 2	" 11		" 20	" 31	9			39	11	59	166	864	270	1300	1303
M.	" 2	" 11	" 24	" 28	Aug. 8	9	43	4	47	11	67	166	1043	264	1473	1475
M.	" 3	" 12		June 30	July 13	9			18	13	40	174	386	255	815	814
F.	" 3	" 12	" 2	July 7	" 17	9	20	5	25	10	44	174	509	253	936	934
M.	" 3	" 12		" 9	" 19	9			25	10	44	174	546	274	994	991
M.	" 3	" 12	" 5	" 10	" 20	9	23	5	28	10	47	174	568	279	1021	1017
F.	" 3	" 12	" 11	" 14	" 24	9	29	3	32	10	51	174	669	256	1099	1097
F.	" 3	" 11	" 8	" 14	" 25	8	27	6	33	11	52	149	693	278	1120	1119
F.	" 3	" 12	" 10	" 14	" 25	9	28	4	32	11	52	174	669	278	1121	1119
F.	" 3	" 12	" 12	" 15	" 25	9	30	3	33	10	52	174	698	247	1119	1119
F.	" 3	" 11	" 12	" 15	" 25	8	31	3	34	10	52	149	722	247	1118	1119
F.	" 3	" 12		" 16	" 27	9			34	11	54	174	727	269	1170	1172
F.	" 3	" 12		" 16	" 28	9			34	12	55	174	727	296	1197	1198
F.	" 3	" 12	" 16	" 19	" 29	9	34	3	37	10	56	174	813	237	1224	1227
M.	" 3	" 11	" 14	" 18	" 30	8	35	4	39	12	59	149	810	293	1252	1256
F.	" 3	" 13		" 19	" 31	10			36	12	58	201	786	297	1284	1286
F.	" 3	" 12	" 18	" 22	Aug. 1	9	36	4	40	9	58	174	877	260	1311	1313
F.	" 3	" 12	" 19	" 23	" 2	9	37	4	41	9	59	174	897	266	1337	1340
F.	" 3	" 12		" 23	" 2	9			41	9	59	174	897	266	1337	1341
F.	" 3	" 12		" 25	" 4	9			43	10	62	174	941	263	1378	1381
F.	" 3	" 12	" 21	" 26	" 6	9	39	5	44	11	64	174	967	272	1413	1415
F.	" 4	" 12			July 18	8					44	153			942	941
M.	" 4	" 12	" 8	" 12	" 21	8	26	4	30	9	47	153	613	252	1018	1013
F.	" 5	" 13	" 8	" 12	" 22	8	25	4	29	10	47	157	586	271	1015	1008
M.	" 5	" 13		" 14	" 24	8			31	10	49	157	642	255	1054	1049
F.	" 5	" 13		" 16	" 26	8			33	10	51	157	700	242	1099	1092
F.	" 5	" 14	" 12	" 18	" 27	9	28	6	34	9	52	179	737	208	1124	1119
M.	" 5	" 14	" 26	" 28	Aug. 9	9	42	2	44	12	55	179	970	290	1439	1433

SUMMARY OF TABLE 9

Sex.	Egg.		Larva in fruit.		Larva in cocoon.		Larva.		Pupa.		Egg, larva, and pupa.			
													Total effective day-degrees.	
	No.	Period in days.	No.	Period in days.	No.	Period in days.	No.	Period in days.	No.	Period in days.	No.	Period in days.	Sum for stages.	(50+)—2(86+).
M.	28	9.6	16	28.3	16	4.3	28	31.9	28	10.7	28	51.9	1096	1095
F.	46	9.7	36	28.9	31	4.4	44	34.6	44	10.5	46	54.3	1154	1154
M. & F.	74	9.7	52	28.7	47	4.4	72	33.5	72	10.6	74	53.4	1132	1131

TABLE 10—LIFE-HISTORY DATA ON FIRST GENERATION, OLNEY, 1916. LARVAE REARED IN APPLES ON TREE

Sex.	Egg laid.	Larva hatched.	Larva left apple.	Larva pupated.	Adult emerged.	Adult died.	Length of life periods.								Total effective day-degrees.				
							Egg	Larva in apple.	Larva in cocoon.	Total larval period.	Pupal period.	Egg, larva, pupa.	Adult period.	Total life period.	Egg (50+)—2(88+)	Larva (50+)—2(85+)	Pupa (50+)—2(87+)	Egg, larva, and pupa	Egg, larva, and pupa (50+)—2(86+)
F.	May 19	May 27	July 3	July 7	July 16	July 26	8	37	4	41	9	58	10	68	174	795	245	1214	1211
M.	" 20	" 27			" 9		7					50			160			1014	1007
M.	" 20	" 27	June 26	June 29	" 10	" 16	7	30	3	33	11	51	6	57	160	591	289	1040	1033
F.	" 20	" 27	" 27	" 29	" 10	" 20	7	31	2	33	11	51	10	61	160	591	289	1040	1033
F.	" 20	" 27	" 29	July 1	" 10	" 16	7	33	2	35	9	51	6	57	160	644	234	1038	1033
M.	" 20	" 27	" 29	" 2	" 10		7	33	3	36	8	51			160	670	207	1037	1033
M.	" 20	" 27	" 30	" 3	" 12	" 16	7	34	3	37	9	53	4	57	160	698	232	1090	1087
F.	" 20	" 27	" 28	" 1	" 13		7	32	3	35	12	54			160	644	314	1118	1112
M.	" 20	" 27	July 1	" 3	" 13		7	35	2	37	10	54			160	698	257	1115	1112
F.	" 20	" 27	" 1	" 4	" 14	" 19	7	35	3	38	10	55	5	60	160	723	260	1143	1140
M.	" 20	" 27	" 4	" 10	" 20	" 23	7	38	6	44	10	61	3	64	160	870	281	1311	1308
M.	" 21	" 28	June 27	June 30	" 10		7	30	3	33	10	50			165	597	263	1025	1019
M.	" 21	" 27	" 29	July 2	" 12	" 17	6	33	3	36	10	52	5	57	146	670	261	1077	1073
M.	" 21	" 27	" 28	" 1	" 12		6	32	3	35	11	52			146	644	289	1079	1073
F.	" 21	" 28			" 12	" 18	7					52	6	58	165			1079	1073
M.	" 23	" 30	" 28	" 1	" 11	" 18	7	29	3	32	10	49	7	56	159	589	262	1010	1005
M.	" 23	" 30	" 29	" 1	" 12	" 15	7	30	2	32	11	50	3	53	159	589	289	1037	1031
F.	" 23	" 31	" 29	" 3	" 14		8	29	4	33	11	52			173	629	285	1087	1084
F.	" 23	" 30	" 29	" 3	" 14	" 23	7	30	4	34	11	52	9	61	159	643	345	1087	1084
F.	" 23	" 30	" 30	" 4	" 14	" 16	7	31	4	35	10	52	2	54	159	668	260	1087	1084
M.	" 23	" 30	July 4	" 7	" 17	" 23	7	35	3	38	10	55	6	61	159	740	274	1173	1169
F.	" 23	" 30	" 4	" 8	" 17	" 26	7	35	4	39	9	55	9	64	159	764	247	1170	1169
F.	" 23	" 30		" 7	" 18	" 26	7			38	11	56	8	64	159	740	303	1202	1197
M.	" 23	" 30	" 5	" 8	" 18	" 23	7	36	3	39	10	56	5	61	159	764	276	1199	1197
F.	" 23	" 30	" 7	" 11	" 20	" 27	7	38	4	42	9	58	7	65	159	440	253	1252	1253
F.	" 23	" 30	" 7	" 11	" 20	" 27	7	38	4	42	9	58	7	65	159	440	253	1252	1253
M.	" 23	" 31	" 8	" 11	" 21	" 30	8	38		41	10	59	9	68	173	827	279	1279	1279
M.	" 24	" 31	June 25	June 28	" 8	" 11	7	25	3	28	10	45	3	48	151	498	263	912	905
M.	" 24	" 31			" 10	" 16	7					47	6	53	151			963	956
F.	" 24	" 31	" 29	July 2	" 12		7	29	3	32	10	49			151	601	261	1013	1010
M.	" 24	" 31	" 29	" 3	" 14	" 18	7	29	4	33	11	51	4	55	151	629	285	1065	1062
F.	" 24	June 1	July 2	" 6	" 15	" 23	8	31	4	35	9	52	8	60	168	684	241	1093	1091
F.	" 24	May 31	" 4	" 6	" 16	" 23	7	34	2	36	10	53	7	60	151	701	272	1124	1120
F.	" 24	June 1			" 16	" 23	8					53	7	60	168			1124	1120
M.	" 24	May 31	" 3	" 7	" 17		7	33	4	37	10	54			151	726	274	1151	1147
F.	" 24	June 1	" 5	" 8	" 17	" 25	8	34	3	37	9	54	8	62	168	734	247	1149	1147
F.	" 24	May 31	" 3	" 8	" 18		7	33	5	38	10	55			151	751	276	1178	1176
F.	" 24	" 31	" 3	" 8	" 18	" 26	7	33	5	38	10	55	8	63	151	751	276	1178	1176
M.	" 24	" 31	" 7	" 11	" 21	" 27	7	37	4	41	10	58	6	64	151	827	279	1257	1258
F.	" 24	" 31		" 11	" 21	" 29	7			41	10	58	8	66	151	827	279	1257	1258
F.	" 24	" 31	" 8	" 12	" 21	" 27	7	38	4	42	9	58	6	64	151	853	253	1257	1258
M.	" 24	" 31	" 8	" 13	" 23	" 28	7	38	5	43	10	60	5	65	151	878	278	1307	1307
F.	" 24	" 31	" 12	" 15	" 24	" 30	7	42	3	45	9	61	6	67	151	933	247	1331	1332
F.	" 24	" 31	" 9	" 15	" 25	Aug. 2	7	39	6	45	10	62	8	70	151	933	273	1357	1357
F.	" 25	June 2	June 24	June 28	" 8	July 17	8	22	4	26	10	44	9	53	166	457	263	886	880
F.	" 25	" 2	July 2	July 5	" 15	" 23	8	30	3	33	10	51	8	59	166	637	265	1068	1066
F.	" 25	" 2	" 8	" 9	" 18	" 26	8	36	1	37	9	54	8	62	166	734	250	1150	1151
M.	" 25	" 2	" 8	" 11	" 21	" 27	8	36	3	39	10	57	6	63	166	786	279	1231	1233
M.	" 25	" 2	" 9	" 13	" 24	" 28	8	37	4	41	11	60	4	64	166	837	303	1306	1307
M.	" 25	" 2	" 10	" 13	" 24	" 30	8	38	3	41	11	60	6	66	166	837	303	1306	1307
F.	" 26	" 4	" 3	" 6	" 15	" 16	9	29	3	32	9	50	1	51	167	630	241	1038	1038
M.	June 7	" 17	" 9	" 13	" 23	" 27	10	22	4	26	10	46	4	50	163	601	278	1042	1044
M.	" 7	" 17	" 9	" 13	" 23	" 27	10	22	4	26	10	46	4	50	163	601	278	1042	1044
F.	" 7	" 17	" 11	" 14	" 23	" 28	10	24	3	27	9	46	5	51	163	627	251	1041	1044
M.	" 7	" 17	" 14	" 17	" 27	" 30	10	27	3	30	10	50	3	53	163	710	271	1144	1148
F.	" 8	" 18	" 10	" 14	" 23	" 30	10	22	4	26	9	45	7	52	169	611	251	1031	1033
F.	" 8	" 18	" 13	" 16	" 26	" 30	10	25	3	28	10	48	4	52	169	667	270	1106	1110
M.	" 12	" 22	" 13		" 28	Aug. 2	10	21				46	5	51	177			1098	1103
F.	" 12	" 22	" 14	" 18	" 28	" 2	10	22	4	26	10	46	5	51	177	652	269	1098	1103
M.	" 12	" 22	" 15	" 18	" 28	" 1	10	23	3	26	10	46	4	50	177	652	269	1098	1103
M.	" 12	" 22	" 16	" 18	" 28	" 6	10	24	2	26	10	46	9	55	177	652	269	1098	1103
F.	" 12	" 22	" 13	" 19	" 29	" 5	10	21	6	27	10	47	7	54	177	680	269	1126	1130
F.	" 12	" 22	" 14	" 19	" 29		10	22	5	27	10	47			177	680	269	1126	1130
M	" 12	" 22	" 15	" 19	" 30		10	23	4	27	11	48			177	680	300	1157	1159
M.	" 12	" 22		" 24	Aug. 3	" 8	10			32	10	52	5	57	177	803	287	1267	1270

SUMMARY OF TABLE 10

Sex.	Egg.		Larva in fruit.		Larva in cocoon.		Larva.		Pupa.		Egg, larva, and pupa.				Adult.		Total life period.	
	No.	Period in days.	No.	Period in days.	No.	Period in days.	No.	Period in days.	No.	Period in days.	No.	Period in days.	Total effective day-degrees. Sum for stages.	Total effective day-degrees. (50+)—2(86+)	No.	Period in days.	No.	Per. in days.
M.	31	7.8	28	31.2	27	3.3	28	34.6	28	10.1	31	52.1	1127	1125	24	5.1	24	57.4
F.	34	7.8	30	31.0	30	3.6	32	35.1	32	9.8	34	52.7	1132	1131	29	6.9	29	59.8
M.& F.	65	7.8	58	31.1	57	3.5	60	34.9	60	9.9	65	52.4	1129	1128	53	6.1	53	58.7

TABLE 11—LIFE-HISTORY DATA ON FIRST GENERATION, OLNEY, 1917. LARVAE REARED IN APPLES ON TREE

Sex.	Egg laid.	Larva hatched.	Larva left apple.	Larva pupated.	Adult emerged.	Length of life periods.						Total effective day-degrees.				
						Egg	Larva in apple.	Larva in cocoon.	Total larval period.	Pupa.	Egg, larva, pupa.	Egg (50+)/2(88+)	Larva (50+)/2(85+)	Pupa (50+)/2(87+)	Egg, larva, pupa.	Egg, larva, and pupa (50+)/2(86+)
F.	May 24	June 4	June 30	July 3	July 15	11	26	3	29	12	52	153	600	276	1029	1033
F.	" 24	" 4	July 1	" 7	" 17	11	27	6	33	10	54	153	684	227	1064	1070
	" 24	" 4		" 7	" 18	11				11	55	153	684	249	1086	1093
F.	" 24	" 4	June 30	" 7	" 19	11	26	7	33	12	56	153	684	274	1111	1118
	" 24	" 4	July 5	" 9	" 21	11	31	4	35	12	58	153	735	275	1163	1174
F.	" 24	" 4	" 5	" 9	" 22	11	31	4	35	13	59	153	735	303	1191	1201
	" 24	" 4	" 5	" 11	" 24	11	31	6	37	13	61	153	778	315	1246	1258
M.	" 31	" 9	June 30	" 4	" 16	9	21	4	25	12	46	164	510	278	952	957
M.	" 31	" 9	" 30	" 5	" 16	9	21	5	26	11	46	164	531	257	952	957
F.	" 31	" 9	July 1	" 5	" 16	9	22	4	26	11	46	164	531	257	952	957
M.	" 31	" 9	" 1	" 5	" 17	9	22	4	26	12	47	164	531	276	971	976
M.	" 31	" 9	" 1	" 5	" 18	9	22	4	26	13	48	164	531	298	993	998
M.	" 31	" 9	" 1	" 7	" 18	9	22	6	28	11	48	164	579	249	992	998
M.	" 31	" 9	" 2	" 7	" 17	9	23	5	28	10	47	164	579	227	970	976
F.	" 31	" 9	" 5	" 8	" 19	9	26	3	29	11	49	164	605	247	1016	1024
M.	" 31	" 9	" 5	" 9	" 22	9	26	4	30	13	52	164	629	303	1096	1106
M.	" 31	" 9	" 6	" 10	" 22	9	27	4	31	12	52	164	652	279	1095	1106
F.	" 31	" 9	" 5	" 10	" 23	9	26	5	31	13	53	164	652	308	1124	1135
F.	" 31	" 9	" 6	" 11	" 24	9	27	5	32	13	54	164	672	315	1151	1163
F.	" 31	" 9	" 7	" 11	" 24	9	28	4	32	13	54	164	672	315	1151	1163
F.	" 31	" 9	" 7	" 12	" 24	9	28	5	33	12	54	164	697	290	1151	1163
F.	" 31	" 9	" 6	" 12	" 26	9	27	6	33	14	56	164	697	344	1205	1217
F.	" 31	" 9	" 11		" 26	9	32				56	164			1205	1217
	June 1	" 10	" 5	" 9	" 21	9	25	4	29	12	50	167	611	275	1056	1064
F.	" 3	" 11	" 6	" 8	" 20	8	25	2	27	12	47	159	567	273	1001	1005
M.	" 3	" 11	" 5	" 8	" 21	8	24	3	27	13	48	159	567	299	1025	1035
	" 3	" 11	" 6	" 9	" 21	8	25	3	28	12	48	159	591	275	1027	1035
F.	" 3	" 11	" 3	" 10	" 23	8	22	7	29	13	50	159	614	308	1081	1091
F.	" 3	" 11	" 7	" 10	" 23	8	26	3	29	13	50	159	614	308	1081	1091
M.	" 4	" 12	" 3	" 7	" 18	8	21	4	25	11	44	167	517	249	933	939
F.	" 4	" 12	" 4	" 8	" 20	8	22	4	26	12	46	167	544	273	984	991
F.	" 4	" 12	" 8	" 12	" 23	8	26	4	30	11	49	167	635	263	1065	1077
M.	" 4	" 12	" 8	" 12	" 24	8	26	4	30	12	50	167	635	290	1092	1105
M.	" 4	" 12	" 8	" 12	" 24	8	26	4	30	12	50	167	635	290	1092	1105
F.	" 4	" 12	" 9	" 14	" 25	8	27	5	32	11	51	167	679	271	1117	1131
F.	" 4	" 12	" 10	" 13	" 26	8	28	3	31	13	52	167	655	323	1145	1158
M.	" 4	" 12	" 11	" 13	" 28	8	29	2	31	15	54	167	655	380	1202	1215
M.	" 4	" 12	" 11	" 17	" 28	8	29	6	35	11	54	167	739	296	1202	1215
M.	" 4	" 12	" 12		" 29	8	30				55	167			1232	1243
M.	" 4	" 12	" 15	" 20	" 30	8	33	5	38	10	56	167	812	279	1258	1271
F.	" 7	" 16	" 5	" 9	" 20	9	19	4	23	11	43	150	522	248	920	928
F.	" 7	" 16	" 5	" 8	" 21	9	19	3	22	13	44	150	498	299	947	958
M.	" 7	" 16	" 7	" 10	" 22	9	21	3	24	12	45	150	545	279	974	985
	" 7	" 16	" 8	" 11	" 22	9	22	3	25	11	45	150	565	259	974	985
M.	" 7	" 17	" 7	" 10	" 22	10	20	3	23	12	45	160	535	279	974	985
M.	" 7	" 17	" 8	" 10	" 22	10	21	2	23	12	45	160	535	279	974	985
M.	" 7	" 16	" 7	" 11	" 23	9	21	4	25	12	46	150	565	288	1003	1014
F.	" 7	" 16	" 9	" 12	" 24	9	23	3	26	12	47	150	590	290	1030	1042
F.	" 7	" 16	" 9	" 12	" 24	9	23	3	26	12	47	150	590	290	1030	1042
F.	" 7	" 16	" 9	" 13	" 24	9	23	4	27	11	47	150	610	270	1030	1042
F.	" 7	" 16	" 9	" 13	" 24	9	23	4	27	11	47	150	610	270	1030	1042
F.	" 7	" 17	" 8	" 13	" 24	10	21	5	26	11	47	160	600	270	1030	1042
M.	" 7	" 17	" 9	" 13	" 24	10	22	4	26	11	47	160	600	270	1030	1042
F.	" 7	" 17	" 10	" 13	" 24	10	23	3	26	11	47	160	600	270	1030	1042
F.	" 7	" 17			" 24	10					47	160			1030	1042
F.	" 7	" 17	" 10	" 14	" 24	10	23	4	27	10	47	160	624	245	1029	1042
F.	" 7	" 17	" 11	" 16	" 25	10	24	5	29	9	48	160	665	230	1055	1068
M.	" 7	" 16	" 9	" 14	" 26	9	23	5	28	12	49	150	634	299	1083	1096
F.	" 7	" 16	" 10	" 15	" 26	9	24	5	29	11	49	150	657	276	1083	1096
F.	" 7	" 16	" 11	" 16	" 26	9	25	5	30	10	49	150	675	258	1083	1096
M.	" 7	" 16	" 11	" 17	" 26	9	25	6	31	9	49	150	694	239	1083	1096
M.	" 7	" 16	" 11	" 16	" 27	9	25	5	30	11	50	150	675	287	1112	1124
	" 7	" 16	" 13	" 17	" 27	9	27	4	31	10	50	150	694	268	1112	1124
M.	" 7	" 17	" 11	" 17	" 27	10	24	6	30	10	50	160	684	268	1112	1124
M.	" 7	" 17	" 12	" 17	" 27	10	25	5	30	10	50	160	684	268	1112	1124
M.	" 7	" 11	" 13	" 18	" 28	9	27	5	32	10	51	150	716	274	1140	1152
	" 7	" 16	" 14	" 19	" 28	9	28	5	33	9	51	150	741	248	1139	1152
F.	" 7	" 16	" 12	" 16	" 29	9	26	4	30	13	52	150	675	343	1168	1180
M.	" 7	" 17	" 10	" 16	" 29	10	23	6	29	13	52	160	665	343	1168	1180
M.	" 7	" 16	" 14	" 19	" 29	9	28	5	33	10	52	150	741	276	1167	1180
M.	" 7	" 16	" 14	" 19	" 29	9	28	5	33	10	52	150	741	276	1167	1180
F.	" 7	" 17	" 14	" 19	" 29	10	27	5	32	10	52	160	731	276	1167	1180
F.	" 7	" 16		" 20	" 29	9				9	52	150	767	250	1167	1180
F.	" 7	" 16	" 17	" 21	" 29	9	31	4	35	8	52	150	791	223	1164	1180
M.	" 7	" 17	" 10	" 20	" 30	10	23	10	33	10	53	160	756	279	1195	1208
F.	" 7	" 16	" 16	" 21	" 30	9	30	5	35	9	53	150	791	252	1193	1208
M.	" 7	" 17	" 18	" 22	Aug. 1	10	31	4	35	10	55	160	807	284	1251	1266
F.	" 7	" 16	" 21	" 24	" 1	9	35	3	38	8	55	150	873	228	1251	1261
M.	" 7	" 17	" 21	" 25	" 2	10	34	4	38	8	56	160	889	230	1279	1294
F.	" 7	" 16	" 22	" 25	" 2	9	36	3	39	8	56	150	900	230	1280	1294
M.	" 7	" 17	" 21	" 25	" 4	10	34	4	38	10	58	160	889	278	1327	1343
M.	" 8	" 19	" 12	" 16	July 27	11	23	4	27	11	49	175	626	287	1088	1101
F.	" 8	" 19	" 16	" 20	" 29	11	27	4	31	9	51	175	718	250	1143	1156
F.	" 8	" 19	" 14	" 21	" 30	11	25	7	32	9	52	175	742	252	1169	1184
M.	" 8	" 19	" 15	" 21	" 30	11	26	6	32	9	52	175	742	252	1169	1184
F.	" 10	" 21			" 26	11					46	180			1021	1035
	" 10	" 21	" 13	" 18	" 27	11	22	5	27	9	47	180	625	245	1050	1063
M.	" 10	" 21			" 29	11					49	180			1104	1119
M.	" 11	" 20	" 10	" 14	" 26	9	20	4	24	12	45	137	566	299	1002	1015
F.	" 11	" 20	" 12	" 16	" 28	9	22	4	26	12	47	137	607	315	1059	1071
M.	" 11	" 20	" 13	" 19	" 28	9	23	6	29	9	47	137	673	248	1058	1071
M.	" 11	" 20	" 13	" 19	" 28	9	23	6	29	9	47	137	673	248	1058	1071
F.	" 11	" 20	" 14	" 19	" 29	9	24	5	29	10	48	137	673	276	1086	1098
F.	" 11	" 21	" 15	" 20	" 29	10	24	5	29	9	48	160	676	250	1086	1098
F.	" 11	" 20	" 16	" 21	" 29	9	26	5	31	8	48	137	723	223	1083	1098
M.	" 11	" 20	" 15	" 21	" 30	9	25	6	31	9	49	137	723	252	1112	1126
M.	" 11	" 20	" 15	" 22	" 30	9	25	7	32	8	49	137	749	224	1110	1126
M.	" 11	" 20	" 19	" 23	" 31	9	29	4	33	8	50	137	777	225	1139	1156
M.	" 11	" 20	" 19		" 31	9	29				50	137			1139	1156
F.	" 11	" 21	" 19	" 23	Aug. 1	10	28	4	32	9	51	160	754	254	1168	1185
F.	" 11	" 21	" 17	" 21	" 2	10	26	4	30	12	52	160	700	340	1200	1213
F.	" 11	" 20	" 21		" 3	9	31				53	137			1224	1237
F.	" 11	" 20	" 22	" 26	" 4	9	32	4	36	9	54	137	858	251	1246	1262
F.	" 11	" 21	" 22	" 28	" 6	10	32	6	38	9	56	160	889	246	1295	1312

SUMMARY OF TABLE 11

Sex.	Egg.		Larva in fruit.		Larva in cocoon.		Larva.		Pupa.		Egg, larva, and pupa.			
													Total effective day-degrees.	
	No.	Period in days.	No.	Period in days.	No.	Period in days.	No.	Period in days.	No.	Period in days.	No.	Period in days.	Sum for stages.	(50+)/2(86+).
M.	44	9.2	43	25.1	41	4.7	41	29.6	41	10.9	44	49.8	1095	1107
F.	51	9.3	48	26.1	46	4.4	46	30.5	47	10.9	51	50.5	1104	1116
Und.	9	9.8	8	26.4	8	4.3	8	30.6	9	11.0	9	51.6	1095	1105
M. & F.	104	9.3	99	25.7	95	4.5	95	30.1	97	10.9	104	50.3	1100	1111

TABLE 12—LIFE-HISTORY DATA ON FIRST GENERATION, OLNEY, 1915. LARVAE REARED IN PICKED APPLES

Sex.	Egg laid.	Larva hatched.	Larva left apple.	Larva pupated.	Adult emerged.	Length of life periods.						Total effective day-degrees.				
						Egg	Larva in apple.	Larva in cocoon.	Total larval period.	Pupal period.	Egg, larva, pupa.	Egg period (50+)—2(88+)	Larval period (50+)—2(85+)	Pupal period (50+)—2(87+)	Egg, larva, pupa.	Egg, larva, and pupa (50+)—2(86+)
M.	June 5	June 13		July 8	July 18	8			25	10	43	157	501	265	923	919
M.	" 5	" 13		" 8	" 18	8			25	10	43	157	501	265	923	919
F.	" 5	" 13	July 3	" 8	" 18	8	20	5	25	10	43	157	501	265	923	919
M.	" 5	" 13	" 3	" 10	" 20	8	20	7	27	10	45	157	541	279	977	973
M.	" 5	" 13		" 11	" 21	8			28	10	46	157	563	276	996	991
M.	" 5	" 13		" 12	" 22	8			29	10	48	157	586	271	1014	1010
F.	" 5	" 13	" 8	" 12	" 22	8	25	4	29	10	47	157	586	271	1014	1010
F.	" 5	" 13	" 8	" 13	" 23	8	25	5	30	10	48	157	613	264	1034	1030
M.	" 5	" 13	" 11	" 14	" 24	8	28	3	31	10	49	157	642	256	1055	1052
M.	" 5	" 13	" 10	" 14	" 26	8	27	4	31	12	51	157	642	304	1103	1100
F.	" 5	" 13		" 18	" 28	8			35	10	53	157	759	235	1151	1153
M.	" 7	" 15	" 10	" 13	" 23	8	25	3	28	10	46	151	572	264	987	984
F.	" 13	" 22	" 13	" 16	" 29	9	21	3	24	13	46	195	505	325	1025	1026
M.	" 13	" 21		" 18	" 29	8			27	11	46	173	586	264	1023	1026
F.	" 13	" 20		" 18	" 29	7			28	11	46	148	610	264	1022	1026
F.	" 13	" 21	" 15	" 18	" 29	8	24	3	27	11	46	173	586	264	1023	1026
F.	" 13	" 21		" 19	" 30	8			28	11	47	173	613	266	1052	1055
M.	" 14	" 22		" 14	" 24	8			22	10	40	173	447	256	876	874
F.	" 14	" 21		" 16	" 27	7			25	11	43	151	527	269	947	949
F.	" 14	" 22		" 17	" 28	8			25	11	44	173	547	265	985	975
M.	" 14	" 22	" 16	" 18	" 30	8	24	2	26	12	46	173	576	293	1042	1033
F.	" 14	" 23		" 18	" 30	9			25	12	46	191	558	293	1042	1033
F.	" 14	" 22	" 16	" 19	" 30	8	24	3	27	11	46	173	591	266	1030	1033
F.	" 15	" 23	" 13	" 16	" 26	8	20	3	23	10	41	172	488	242	902	903
M.	" 15	" 23	" 15	" 18	" 29	8	22	3	25	11	44	172	558	264	984	985
F.	" 16	" 24	" 13	" 16	" 26	9	19	3	22	10	40	170	470	242	882	884
F.	" 16	" 23		" 18	" 28	7			25	10	42	153	558	235	946	937
M.	" 16	" 23		" 18	" 29	7			25	11	43	153	558	264	975	966
M.	" 16	" 24	" 22	" 26	Aug. 6	8	28	4	32	11	53	170	710	272	1152	1154
F.	" 16	" 23	" 16	" 19	July 30	7	23	3	26	11	44	153	573	266	992	996
F.	" 16	" 23		" 30	Aug. 10	7			37	11	55	153	837	259	1249	1248

SUMMARY OF TABLE 12

Sex.	Egg.		Larva in fruit.		Larva in cocoon.		Larva.		Pupa.		Egg, larva, and pupa.			
													Total effective day-degrees.	
	No.	Period in days.	No.	Period in days.	No.	Period in days.	No.	Period in days.	No.	Period in days.	No.	Period in days.	Sum for stages.	(50+)—2(86+).
M.	14	8.0	7	24.9	7	3.7	14	27.2	14	10.6	14	45.9	1002	999
F.	17	7.8	9	22.4	9	3.6	17	27.1	17	10.8	17	45.7	1013	1012
M. & F.	31	7.9	16	23.5	16	3.6	31	27.1	31	10.7	31	45.8	1008	1006

Sex.	Egg laid.	Larva hatched.	Larva left apple.	Larva pupated.	Adult emerged.	Adult died.	Life periods in days.								Total effective day-degrees.				
							Egg	Larva in apple.	Larva in cocoon.	Total larval period	Pupa.	Egg, larva, pupa.	Adult	Total life period.	Egg (50+)—2(88+)	Larva (50+)—2(85+)	Pupa (50+)—2(87+)	Egg, larva, pupa.	Egg, larva, pupa. (50+)—2(86+)
M.	May 21	May 28	June 24	June 28	July 8	July 12	7	27	4	31	10	48	4	52	165	548	263	976	968
F.	" 21	" 28	" 24	" 28	" 8	" 16	7	27	4	31	10	48	8	56	165	548	263	976	968
F.	" 21	" 28	" 24	" 29	" 9		7	27	5	32	10	49			165	573	263	1001	993
M.	" 21	" 28		" 30	" 10		7			33	10	50			165	597	263	1025	1019
M.	" 21	" 28			" 11	" 16	7					51	5	56	165			1050	1047
F.	" 21	" 28	" 27	July 1	" 12	" 18	7	30	4	34	11	52	6	58	165	625	289	1079	1073
M.	" 28	June 7	" 29	" 3	" 13	" 18	10	22	4	26	10	46	5	51	164	515	257	936	937
F.	" 28	" 7	July 1	" 5	" 15	" 23	10	24	4	28	10	48	8	56	164	564	268	996	992
M.	" 28	" 7	" 2	" 6	" 15	" 19	10	25	4	29	9	48	4	52	164	587	241	992	992
F.	" 28	" 7	" 3	" 7	" 17	" 23	10	26	4	30	10	50	6	56	164	612	274	1050	1049
M.	" 28	" 7	" 2	" 7	" 18	" 25	10	25	5	30	11	51	7	58	164	612	303	1079	1077
M.	" 28	" 7	" 3	" 8	" 18	" 19	10	26	5	31	10	51	1	52	164	637	276	1077	1077
M.	" 28	" 7	" 3	" 8	" 18	" 26	10	26	5	31	10	51	8	59	164	637	276	1077	1077
F.	" 28	" 7	" 5		" 18	" 23	10	28				51	5	56	164			1077	1077
F.	" 30	" 10	June 30	" 3	" 12	" 19	11	20	3	23	9	43	7	50	165	477	230	872	875
F.	" 30	" 10	July 1	" 4	" 14		11	21	3	24	10	45			165	502	260	927	927
M.	" 30	" 9	" 1	" 4	" 15	" 16	10	22	3	25	11	46	1	47	150	518	289	957	956
F.	" 30	" 10	June 30	" 4	" 15		11	20	4	24	11	46			165	502	289	956	956
M.	" 30	" 10	July 2	" 4	" 15	" 23	11	22	2	24	11	46	8	54	165	502	289	956	956
F.	" 30	" 10	" 1	" 5	" 15	" 19	11	21	4	25	10	46	6	52	165	526	265	956	956
F.	" 30	" 10	" 2	" 6	" 16	" 27	11	22	4	26	10	47	11	58	165	549	272	986	985
M.	" 30	" 10	" 2	" 6	" 16	" 23	11	22	4	26	10	47	7	54	165	549	272	986	985
F.	" 30	" 10	" 3	" 7	" 17	" 26	11	23	4	27	10	48	9	57	165	574	274	1013	1012
M.	" 30	" 10	" 4	" 8	" 18	" 22	11	24	4	28	10	49	4	53	165	599	276	1040	1041
F.	" 30	" 10	" 4	" 9	" 20	" 27	11	24	5	29	11	51	7	58	165	624	307	1096	1095
F.	" 30	" 9	" 3	" 11	" 21	" 30	10	24	8	32	10	52	9	61	150	690	281	1121	1123
M.	" 31	" 10	June 30	" 5	" 16	" 21	10	20	5	25	11	46	5	51	152	526	296	974	972
M.	" 31	" 10	July 2	" 6	" 17	" 23	10	22	4	26	11	47	6	53	152	549	298	999	999
M.	" 31	" 10	" 2	" 7	" 17		10	22	5	27	10	47			152	574	274	1000	999
F.	" 31	" 10	" 3	" 7	" 18	" 25	10	23	4	27	11	48	7	55	152	574	303	1029	1027
F.	June 1	" 12	June 30	" 3	" 13		11	18	3	21	10	42			169	443	257	869	870
M.	" 1	" 12	July 3	" 6	" 16	" 19	11	21	3	24	10	45	3	48	169	515	274	958	955
F.	" 1	" 12	" 2	" 6	" 16	" 21	11	20	4	24	10	45	5	50	169	515	274	958	955
F.	" 1	" 12	" 3	" 6	" 16	" 23	11	21	3	24	10	45	7	52	169	515	274	958	955
M.	" 1	" 12	" 8	" 9	" 17	" 26	11	26	1	27	8	46	9	55	169	589	222	980	982
F.	" 1	" 12	" 2	" 7	" 18	" 22	11	20	5	25	11	47	4	51	169	540	303	1012	1010
F.	" 1	" 12	" 4	" 8	" 18	" 19	11	22	4	26	10	47	1	48	169	565	276	1010	1010
F.	" 1	" 12	" 3	" 9	" 20	" 23	11	21	6	27	11	49	3	52	169	589	307	1065	1066
M.	" 1	" 12	" 4	" 9	" 20	" 27	11	22	5	27	11	49	7	56	169	589	307	1065	1066
M.	" 1	" 12	" 4	" 9	" 20		11	22	5	27	11	49			169	589	307	1065	1066
F.	" 1	" 12	" 3	" 11	" 21		11	21	8	29	10	50			169	641	279	1089	1092
M.	" 1	" 12			" 23	" 25	11					52	2	54	169			1140	1141
M.	" 2	" 11	" 1	" 5	" 17	" 20	9	20	4	24	12	45	3	48	127	510	324	961	958
M	" 2	" 14			" 18	" 25	12					46	7	53	186			991	986
M.	" 2	" 12	" 3	" 8	" 19	" 28	10	21	5	26	11	47	9	56	145	565	305	1015	1015
M.	" 7	" 15	" 6	" 9	" 18	" 20	8	21	3	24	9	41	2	43	134	528	251	913	912
F.	" 11	" 19	" 6	" 10	" 20	" 26	8	17	4	21	10	39	6	45	142	490	281	913	915
F.	" 11	" 20	" 7	" 11	" 20	" 23	9	17	4	21	9	39	3	42	161	498	253	912	915
M.	" 11	" 20	" 6	" 11	" 21		9	16	5	21	10	40			161	498	279	938	941
M.	" 11	" 20	" 8	" 11	" 21	" 28	9	18	3	21	10	40	7	47	161	498	279	938	941
M.	" 11	" 20	" 8	" 12	" 21	" 25	9	18	4	22	9	40	4	44	161	523	253	937	941
F.	" 11	" 20	" 8	" 12	" 21	" 28	9	18	4	22	9	40	7	47	161	523	253	937	941
F.	" 11	" 20	" 8	" 12	" 21	" 30	9	18	4	22	9	40	9	49	161	523	253	937	941
F.	" 11	" 20	" 6	" 12	" 22	Aug. 1	9	16	6	22	10	41	10	51	161	523	279	963	965
F.	" 11	" 19	" 7	" 12	" 22	July 29	8	18	5	23	10	41	7	48	143	542	279	964	965
F.	" 11	" 19	" 9	" 13	" 22	" 29	8	18	4	22	9	41	7	48	143	567	252	962	965
M.	" 11	" 20	" 9	" 13	" 23	" 29	9	19	4	24	10	42	6	48	161	549	278	988	990
F.	" 11	" 20	" 9	" 13	" 23	" 30	9	19	4	23	10	42	7	49	161	549	278	988	990
F.	" 11	" 20	" 9	" 13	" 23	" 29	9	19	4	23	10	42	6	48	161	549	278	988	990
F.	" 11	" 20	" 9	" 13	" 23	" 28	9	19	4	23	10	42	5	47	161	549	278	988	990
F.	" 11	" 20	" 10	" 14	" 24	" 28	9	20	4	24	10	43	4	47	161	575	276	1012	1015
M.	" 11	" 20	" 6	" 15	" 25		9	16	9	25	10	44			161	603	273	1037	1040
F.	" 11	" 19	" 10	" 15	" 27	Aug. 4	8	21	5	26	12	46	8	54	142	622	328	1092	1094
M.	" 11	" 20	" 8	" 17	" 27	July 31	9	18	9	27	10	46	4	50	161	658	278	1097	1094
F.	" 12	" 22	" 12	" 14	" 23	" 29	10	20	2	22	9	41	6	47	177	541	251	969	972
F.	" 13	" 22	" 9	" 12	" 21	" 27	9	17	3	20	9	38	6	44	158	489	253	900	903
F.	" 13	" 22	" 15	" 16	" 24	" 30	9	23	1	24	8	41	6	47	158	597	217	972	977
M.	" 13	" 24	" 12	" 16	" 24	" 30	11	18	4	22	8	41	6	47	204	553	217	974	977
F.	" 13	" 22	" 9	" 15	" 25	" 30	9	17	6	23	10	42	5	47	158	569	275	1002	1002
F.	" 13	" 23	" 13	" 17	" 26	Aug. 1	10	20	4	24	9	43	6	49	181	601	244	1026	1029
F.	" 13	" 22	" 12	" 16	" 27	" 4	9	20	4	24	11	44	8	52	158	597	304	1059	1055
M.	" 13	" 24	" 16	" 24	Aug. 3	" 11	11	22	8	30	10	51	8	59	204	759	281	1244	1250
M.	" 13	" 24	" 12	" 17	July 27		11	18	5	23	10	44			204	579	271	1054	1055
F.	" 13	" 24	" 13	" 17	" 27	July 30	11	19	4	23	10	44	3	47	204	579	271	1054	1055
F.	" 14	" 24	" 12	" 17	" 28	Aug. 1	10	18	5	23	11	44	4	48	183	579	299	1061	1061
F	" 18	" 26	" 12	" 16	" 26	July 30	8	16	4	20	10	38	4	42	156	512	275	943	941
F	" 18	" 26	" 12	" 16	" 27	Aug. 6	8	16	4	20	11	39	10	49	156	512	297	965	968
F.	" 18	" 26	" 12	" 19	" 29	" 6	8	16	7	23	10	41	8	49	156	595	270	1021	1022
M.	" 18	" 26			" 29	July 30	8					41	1	42	156			1021	1022
M.	" 18	" 27	" 16	" 21	" 30	Aug. 3	9	19	5	24	9	42	4	46	183	620	246	1049	1051
F	" 18	" 26	" 13	" 21	Aug. 1	" 6	8	17	8	25	11	44	5	49	156	647	309	1112	1108
F.	" 18	" 26	" 13	" 24	" 2		8	17	11	28	9	45			156	718	257	1131	1136
F.	" 18	" 26	" 16	" 24	" 3	" 8	8	20	8	28	10	46	5	51	156	718	285	1159	1163
F.	" 18	" 26	" 21	" 24	" 4	" 8	8	25	3	28	11	47	4	51	156	718	314	1188	1191
M.	" 18	" 26	" 17	" 25	" 5	" 17	8	21	8	29	11	48	12	60	156	742	318	1216	1219
M.	" 20	" 28	" 14	" 18	July 28		8	16	4	20	10	38			171	517	269	957	959
F.	" 20	" 28	" 14	" 18	" 28	" 6	8	16	4	20	10	38	9	47	171	517	269	957	959

SUMMARY OF TABLE 12A

Sex.	Egg.		Larva in fruit.		Larva in cocoon.		Larva.		Pupa.		Egg, larva, and pupa.				Adult.		Total life period.	
	No.	Period in days.	No.	Period in days.	No.	Period in days.	No.	Period in days.	No.	Period in days.	No.	Period in days.	Total effective day-degrees. Sum for stages.	Total effective day-degrees. (50+)—2(86+)	No.	Period in days.	No.	Per. in days.
M.	37	9.7	32	21.2	32	4.6	33	26.0	33	10.1	37	46.0	1018	1018	30	5.3	30	51.6
F.	50	9.4	50	20.4	49	4.6	49	24.8	49	10.0	50	44.4	1005	1006	44	6.4	44	50.5
M. & F.	87	9.5	82	20.7	81	4.6	82	25.3	82	10.1	87	45.1	1011	1013	74	5.9	74	50.9

TABLE 13—OVIPOSITION AND LIFE PERIOD OF ADULTS OF FIRST GENERATION, OLNEY, 1915, AND WEATHER DURING FIRST TEN DAYS AFTER EMERGENCE OF FEMALE

Emerged.		Died.		Days lived.		Number of eggs laid daily 1 to 9 days after emergence.										Av. mean daily temp.	Av. daily rainfall.
Male.	Female.	Male.	Female.	Male.	Fem.	1	2	3	4	5	6	7	8	9	Total		
July 1	June 28	July 8	July 7	7	9	.....		.....	55	....	25	....	....	....	80	68.8	.291
" 2	" 3	" 15	" 15	13	12	.....		.....	....	43	....	....	....	....	43	68.9	.40
" 4	" 4	.....	" 14	....	10	.....	7	27	3	....	....	....	....	....	37	70.2	.346
" 4	" 5	" 9	" 14	5	9	.....		35	....	....	....	....	....	....	35	72.3	.346
" 7	" 7	" 13	" 15	6	8	.....	4	.....	5	....	....	....	....	....	9	75.4	.314
" 9	" 9	" 12	.....	3	.....	24		.....	....	....	....	....	....	....	24	77.6	.285
" 11	" 11	" 16	" 16	5	5	.....	77	.....	....	....	....	....	....	....	77	78.2	.181
" 11	" 11	.....	" 21	....	10	.....	21	24	....	....	....	....	....	....	45	78.2	.181
" 13	" 13	" 17	" 18	4	5	1		.....	....	....	....	....	....	....	1	77.0	.106
" 15	" 15	" 20	" 20	5	5	.....	87	4	....	....	....	....	....	....	91	75.2	.106
" 17	" 17	" 21	" 22	4	5	.....		25	....	....	....	....	....	....	25	73.9	.043
" 18	" 18	.....	" 23	....	5	2		.....	....	....	....	....	....	....	2	73.5	.062
" 18	" 18	" 26	" 28	8	10	.....		.....	9	....	....	....	....	....	9	73.5	.063
" 20	" 20	" 26	" 26	6	6	.....		.....	48	....	....	....	....	....	48	73.8	.059
" 20	" 20	" 30	" 26	10	16	1		.....	....	....	....	....	....	....	1	73.8	.059
" 22	" 22	" 26	" 26	4	4	100		.....	....	....	....	....	....	....	100	75.9	.116
" 23	" 23	Aug. 3	Aug. 3	11	11	.....	32	.....	....	....	....	....	....	....	32	76.7	.120
" 27	" 27	" 3	" 1	7	6	.....	78	.....	....	....	....	....	....	....	78	75.8	.130
" 28	" 28	" 3	" 3	6	6	11		.....	....	....	....	....	....	....	11	74.2	.110
" 29	" 29	" 4	" 2	6	4	93	74	.....	....	....	....	....	....	....	167	73.8	.110
Aug. 5	Aug. 5	" 9	" 13	4	8	1		.....	....	....	....	....	....	....	1	70.9	.164
" 5	" 5	" 12	" 14	7	9	.....		40	....	4	1	....	....	....	45	70.9	.164
" 7	" 7	" 18	" 17	11	10	1		.....	....	....	....	....	....	....	1	72.4	.321
" 7	" 7	" 14	" 10	7	3	4		.....	....	....	....	....	....	....	4	72.4	.321
" 9	" 9	" 23	" 14	14	5	.....		2	....	....	....	....	....	....	2	71.0	.362
" 11	" 11	" 23	" 23	12	12	.....		2	....	....	....	....	....	....	2	69.6	.599
" 11	" 11	" 17	" 18	6	7	.....	42	.....	....	....	....	....	....	....	42	69.6	.599
" 13	" 13	" 22	" 22	9	9	.....	7	.....	....	....	....	....	....	....	7	69.4	.599
" 14	" 13	.....	" 28	....	15	.....		.....	....	....	....	....	....	84	84	69.4	.599
" 21	" 21	" 28	" 28	7	7	42	18	17	....	....	....	....	....	....	67	64.5	.016
			Totals..	....	.....	280	447	166	120	47	26			84	1170		

SUMMARY OF TABLE 13

Items.	Max.	Min.	Av.
Length of life of male moth in days	14	3	7.2
Length of life of female moth in days	15	2	7.6
Number of days from emergence till egg-laying began	9	1	2.3
Number of days from emergence till egg-laying ceased	10	2	3.8
Egg-laying period in days	4	1	1.5
Number of eggs laid by one female	167	1	39
Average mean daily temperature			73
Average daily rainfall in inches			.24

TABLE 14—OVIPOSITION AND LIFE PERIOD OF ADULTS OF FIRST GENERATION, OLNEY, 1916, AND WEATHER DURING FIRST TEN DAYS AFTER EMERGENCE OF FEMALE

Moths emerged.		Moths died.		Adult period in days.		Number of eggs laid daily 1 to 9 days from date of emergence.										Av. mean daily temp.	Av. daily hum.	Av. daily evap.	Av. daily rainfall.
Male.	Female.	Male.	Female.	Male.	Fem.	1	2	3	4	5	6	7	8	9	Total.				
July 4	July 5	July 9	July 12	5	7	.....	11	.....	.....	.....	.....	.....	.....	.....	11	77.	74	16.3	.113
" 8	" 8	" 12	" 16	4	8	.....	25	.....	.....	.....	.....	.....	.....	.....	25	78.5	77	16.1	.113
" 10	" 10	" 16	" 20	6	10	.....	.....	.....	.....	82	.....	.....	26	.....	108	79.2	79	15.6	.113
" 12	" 12	" 17	.....	5	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	1	78.9	78	17.2	.048
" 12	" 12	" 15	" 18	3	6	.....	67	18	21	.....	.....	.....	.....	.....	106	78.9	78	17.2	.048
" 15	" 14	" 19	" 19	4	5	.....	.....	.....	2	.....	.....	.....	.....	.....	2	78.9	77	21.3	.015
" 14	" 14	" 18	" 23	4	7	.....	.....	8	.....	.....	.....	.....	.....	.....	8	78.9	77	21.3	.015
" 15	" 15	" 19	" 19	4	4	.....	31	8	.....	.....	.....	.....	.....	.....	39	78.8	76	23.3	.015
" 16	" 16	" 21	" 23	5	7	.....	1	2	.....	.....	.....	.....	.....	.....	3	77.6	77	23.9	.015
" 16	" 16	" 23	" 23	7	7	.....	73	.....	.....	.....	.....	.....	.....	.....	73	78.8	75	23.9	.015
" 17	" 16	" 23	" 26	6	10	.....	.....	.....	.....	9	.....	.....	.....	.....	9	78.8	75	23.9	.015
" 17	" 16	" 20	" 23	3	7	.....	33	34	.....	29	.....	.....	.....	.....	96	78.8	75	23.9	.015
" 17	" 17	" 23	" 23	6	6	.....	.....	.....	.....	.....	6	.....	.....	.....	6	79.1	75	24.7	.015
" 17	" 17	" 23	" 26	6	9	.....	42	.....	.....	.....	.....	.....	.....	.....	42	79.1	75	24.2	.015
" 18	" 18	" 23	" 23	5	5	31	.....	3	.....	.....	.....	.....	.....	.....	34	79.3	74	25.4	.015
" 18	" 18	" 25	" 26	7	8	.....	38	52	33	.....	39	.....	.....	.....	162	79.3	74	25.4	.015
" 20	" 20	" 27	" 27	7	7	.....	19	.....	2	.....	.....	.....	.....	.....	8	80.5	73	26.4	.015
" 21	" 20	" 27	" 27	6	7	.....	6	.....	2	.....	.....	.....	.....	.....	8	81.5	73	26.4	.015
" 21	" 21	" 27	" 27	6	6	.....	8	.....	.....	.....	.....	.....	.....	.....	8	81.5	72	26.9	.0
" 21	" 21	" 27	" 30	6	9	.....	.....	.....	.....	12	.....	.....	.....	.....	12	81.5	72	26.9	.0
" 21	" 21	" 30	" 30	9	9	.....	.....	17	1	66	.....	.....	.....	.....	84	81.5	72	26.9	.0
" 21	" 21	" 28	" 28	7	7	.....	.....	48	.....	.....	.....	.....	.....	.....	48	81.5	72	26.9	.0
" 21	" 21	" 27	" 29	6	8	.....	.....	11	.....	.....	.....	.....	.....	.....	11	81.5	72	26.9	.0
" 22	" 22	" 27	" 28	5	6	.....	23	.....	.....	.....	.....	.....	.....	.....	23	81.7	73	26.7	.010
" 24	" 23	" 29	" 29	5	4	.....	.....	29	.....	23	.....	.....	.....	.....	52	81.7	73	26.4	.010
" 24	" 23	" 28	" 28	4	5	.....	53	.....	.....	.....	.....	.....	.....	.....	53	81.7	73	26.4	.010
" 27	" 27	.....	Aug. 4	.....	8	.....	40	.....	.....	.....	.....	.....	.....	.....	40	83.1	73	26.7	.010
" 28	" 28	Aug. 1	" 1	4	4	62	.....	.....	.....	.....	.....	.....	.....	.....	62	83.1	73	27.1	.010
" 28	" 28	" 2	" 2	5	5	.....	51	.....	.....	.....	.....	.....	.....	.....	51	83.1	73	27.1	.010
Aug. 9	Aug. 9	" 17	" 17	8	8	66	21	.....	.....	.....	.....	.....	.....	.....	87	77.1	82	13.7	.351
" 9	" 9	" 15	" 17	6	8	.....	.....	59	.....	.....	.....	.....	.....	.....	59	77.1	82	13.7	.351
" 8	" 8	" 19	" 19	11	11	.....	74	.....	.....	.....	.....	18	4	12	108	76.6	83	14.2	.353
" 9	" 9	" 17	" 17	8	8	.....	.....	.....	.....	3	.....	.....	.....	.....	3	77.1	82	13.7	.351
" 9	" 9	" 17	" 17	8	8	39	75	28	.....	13	17	.....	.....	.....	172	77.1	82	13.7	.351
" 10	" 10	" 19	" 19	9	9	49	22	.....	.....	.....	.....	.....	.....	.....	71	77.3	82	12.2	.351
" 10	" 10	.....	.....	.....	.....	.....	.....	4	.....	.....	.....	.....	.....	.....	4	77.3	82	12.2	.351
			Totals..	.....	...	248	713	321	61	237	62	18	30	12	1702				

SUMMARY OF TABLE 14

Items.	Max.	Min.	Av.
Length of life of male adult in days	11	3	5.88
Length of life of female adult in days	11	4	7.2
Number of days from emergence to laying of first egg	6	1	2.5
Number of days from emergence to laying of last egg	9	1	3.6
Egg-laying period, in days	8	1	2.1
Number of eggs laid by one female	172	1	47.3
Average mean daily temperature	83.1	76.6	79.5
Average daily humidity	83	72	75.9
Average daily evaporation in c.c.	27.1	12.2	21.8
Average daily rainfall in inches	.353	0	.087

TABLE 15—LIFE-HISTORY DATA ON PORTION OF SECOND GENERATION WHOSE LARVAE TRANSFORMED, OLNEY, 1915. LARVAE REARED IN APPLES ON TREE

Sex.	Egg laid.	Larva hatched.	Larva left apple.	Larva pupated	Adult emerged.	Length of life periods.						Total effective day-degrees.				
						Egg.	Larva in apple.	Larva in cocoon.	Total larval period.	Pupa.	Egg, larva, and pupa.	Egg (50+)—2(88+).	Larva (50+)—2(85+).	Pupa (50+)—2(87+).	Egg, larva, and pupa.	Egg, larva, and pupa (50+)—2(86+).
	July 2	July 11	July 31	Aug. 5		9	20	5	25			161	628			
F.	" 7	" 14	Aug. 3	" 8	Aug. 19	7	20	5	25	11	43	162	616	231	1009	1009
M.	" 7	" 14	" 7	" 10	" 24	7	24	3	27	14	48	162	664	273	1099	1099
F.	" 7	" 13	" 9	" 13	" 27	6	27	4	31	14	51	132	750	257	1139	1140
M.	" 7	" 14			" 21	7					45	162			1041	1041
F.	" 7	" 14	" 5	" 10	" 23	7	22	5	27	13	47	162	664	250	1076	1076
M.	" 7	" 14	" 4	" 10	" 24	7	21	6	27	14	48	162	664	273	1099	1099
F.	" 7	" 14	" 9	" 13	" 27	7	26	4	30	14	51	162	721	257	1140	1140
M.	" 7	" 14	" 14	" 17	Sept. 4	7	31	3	34	18	59	162	815	277	1254	1253
F.	" 8	" 14	" 2	" 3	Aug. 16	6	19	1	20	13	39	144	520	270	934	934
M.	" 8	" 14			" 22	6					45	144			1039	1039
F.	" 8	" 14	" 9	" 16	" 27	6	26	7	33	11	50	144	791	188	1123	1122
F.	" 8	" 14	" 13	" 17	Sept. 2	6	30	4	34	16	56	144	815	238	1197	1197
F.	" 10	" 17	" 14	" 17	Sept. 3	7	28	3	31	17	55	196	727	255	1178	1175

SUMMARY OF TABLE 15

Sex.	Egg.		Larva in fruit.		Larva in cocoon.		Larva.		Pupa.		Egg, larva, and pupa.			
													Total effective day-degrees.	
	No.	Period in days.	No.	Period in days.	No.	Period in days.	No.	Period in days.	No.	Period in days.	No.	Period in days.	Sum for stages.	(50+)—2(86+)
M.	5	6.8	3	25.3	3	4.0	3	29.3	3	15.3	5	49	1106	1106
F.	8	6.5	8	24.8	8	4.1	8	29.0	8	13.6	8	49	1100	1099
Und.	1	9.0	1	20.0	1	5.0	1	25.0	0		0			
M.& F.	14	6.8	12	24.5	12	4.2	12	28.7	11	14.1	13	49	1102	1102

TABLE 16—LIFE-HISTORY DATA ON PORTION OF SECOND GENERATION WHOSE LARVAE TRANSFORMED, OLNEY, 1916
LARVAE REARED IN APPLES ON TREE

Sex.	Egg laid.	Egg hatched.	Larva left apple.	Larva pupated.	Moth emerged.	Adult died.	Length of life periods.								Total effective day-degrees.				
							Egg.	Larva in apple.	Larva in cocoon.	Total larval period.	Pupa.	Egg, larva, and pupa.	Adult.	Total life period.	Egg (50+)—2(88+).	Larva (50+)—2(85+).	Pupa (50+)—2(87+).	Egg, larva, pupa.	Egg, larva, and pupa (50+)—2(86+).
M.	July 6	July 12	July 31	Aug. 3	Aug. 12	Sept. 1	6	19	3	22	9	37	20	57	160	575	263	998	1009
M.	" 6	" 12	" 31	" 4	" 13	" 5	6	19	4	23	9	38	23	61	160	602	257	1019	1032
M.	" 6	" 12			" 14	Aug. 27	6					39	13	52	160			1033	1046
M.	" 6	" 12	Aug. 1	" 5	" 15	" 31	6	20	4	24	10	40	16	56	160	630	263	1053	1066
F.	" 7	" 13	" 5	" 9	" 20	Sept. 1	6	23	4	27	11	44	12	56	159	718	287	1164	1183
	" 7	" 14	" 4	" 7	" 18		7	21	3	24	11	42			186	633	284	1103	1124
F.	" 7	" 14	" 8	" 12	" 23	" 2	7	25	4	29	11	47	10	57	186	774	273	1233	1255
F.	" 14	" 19	" 10	Aug. 14	" 25	" 10	5	22	4	26	11	42	16	56	149	672	278	1099	1113
F.	" 14	" 19	" 11	" 14	" 25	" 4	5	23	3	26	11	42	10	52	149	672	278	1099	1113
F.	" 14	" 19	" 11	" 16	" 26		5	23	5	28	10	43			149	720	251	1120	1134
F.	" 14	" 19	" 15	" 18	" 26	" 5	5	27	3	30	8	43	10	53	149	772	195	1116	1134
F.	" 14	" 19	" 15	" 18	" 29	" 5	5	27	3	30	11	46	7	53	149	772	239	1160	1177
	" 14	"20	" 9	" 12	" 22		6	20	3	23	10	39			176	609	253	1038	1051
M.	" 14	" 20	" 13	" 17	" 29	" 4	6	24	4	28	12	46	6	52	176	718	268	1162	1177
F.	" 14	" 20	" 15	" 18	" 31	" 5	6	26	3	29	13	48	5	53	176	746	273	1195	1212
F.	" 14	" 20			Sept. 1	" 10	6					49	9	58	176			1214	1231
F.	" 15	" 20			Aug. 20	Aug. 27	5					36	7	43	146			954	971
M.	" 15	" 20			" 22		5					38			146			1008	1023
F.	" 15	" 20	" 9	" 14	" 23	Sept. 3	5	20	5	25	9	39	11	50	146	646	236	1028	1043
M.	" 15	" 21	" 10	" 14	" 23	" 2	6	20	4	24	9	39	10	49	173	620	236	1029	1043
M.	" 15	" 21	" 10	" 14	" 23	" 5	6	20	4	24	9	39	13	52	173	620	236	1029	1043
M.	" 15	" 20	" 10	" 14	" 24	" 2	5	21	4	25	10	40	9	49	146	646	255	1047	1062
F.	" 15	" 20	" 10	" 14	" 24	" 7	5	21	4	25	10	40	14	54	146	646	255	1047	1062
F.	" 15	" 21	" 10	" 14	" 24	Aug. 27	6	20	4	24	10	40	3	43	173	620	255	1048	1062
F.	" 15	" 21	" 11	" 15	" 24	Sept. 6	6	21	4	25	9	40	13	53	173	641	235	1049	1062
F.	" 15	" 20	" 12	" 16	" 26	" 5	5	23	4	27	10	42	10	52	146	693	251	1091	1105
M.	" 15	" 21	" 12	" 16	" 26	" 4	6	22	4	26	10	42	9	51	173	668	251	1092	1105
F.	" 15	" 21	" 13	" 17	" 27	" 5	6	23	4	27	10	43	9	52	173	692	241	1106	1122
F.	" 15	" 20	" 13	" 17	" 28	" 21	5	24	4	28	11	44	24	68	146	718	255	1119	1136
M.	" 15	" 22	" 13	" 17	" 28	" 5	7	22	4	26	11	44	8	52	198	679	255	1122	1136
M.	" 15	" 20	" 13	" 18	" 30	" 3	5	24	5	29	12	46	4	50	146	746	254	1146	1164
F.	" 15	" 20	" 13	" 18	" 30		5	24	5	29	12	46			146	746	254	1146	1164
F.	" 15	" 20	" 12	" 18	" 30	" 10	5	23	6	29	12	46	11	57	146	746	254	1146	1164
F.	" 15	" 21	" 14	" 18	" 30	" 9	6	24	4	28	12	46	10	56	173	720	254	1147	1164
M.	" 15	" 20	" 12		Sept. 1	" 10	5	25				48	9	57	146			1185	1202
M.	" 15	" 20	" 13	" 19	" 2		5	24	6	30	14	49			146	774	283	1203	1223
F.	" 15	" 21	" 13	" 16	" 2	" 14	6	23	3	26	17	49	12	61	173	668	369	1210	1223
M.	" 15	" 20	" 17	" 23	" 5		5	28	6	34	13	52			146	874	253	1273	1295
F.	" 16	" 21	" 9	" 12	Aug. 23	" 10	5	19	3	22	11	38	18	56	142	583	273	998	1014
M.	" 16	" 21	" 10	" 14	" 24	Aug. 27	5	20	4	24	10	39	3	42	142	621	254	1017	1032
M.	" 16	" 21	" 12	" 16	" 25	" 30	5	22	4	26	9	40	5	45	142	669	230	1041	1055
M.	" 18	" 24		" 14	" 24	Sept. 5	6			21	10	37	12	49	161	549	255	965	977
M.	" 18	" 24	" 10	" 14	" 25	" 5	6	17	4	21	11	38	11	49	161	549	277	987	998
M.	" 18	" 23	" 10	" 15	" 25	" 5	5	18	5	23	10	38	11	49	135	593	257	985	998
F.	" 18	" 24	" 11	" 15	" 26		6	18	4	22	11	39			161	569	278	1008	1020
M.	" 18	" 24	" 12	" 16	" 26	" 13	6	19	4	23	10	39	18	57	161	596	251	1008	1020
F.	" 18	" 24	" 12	" 17	" 28	" 10	6	19	5	24	11	41	13	54	161	621	255	1037	1051
F.	" 18	" 24	" 15	" 18	" 29		6	22	3	25	11	42			161	649	239	1049	1064
M.	" 18	" 24	" 13	" 18	" 30	" 3	6	20	5	25	12	43	4	47	161	649	254	1064	1078
F.	" 18	" 24	" 15	" 19	" 31	" 7	6	22	4	26	12	44	7	51	161	677	243	1081	1098
M.	" 18	" 23	" 15	" 19	Sept. 2		5	23	4	27	14	46			135	701	283	1119	1138
M.	" 18	" 24	" 14	" 20	" 2		6	21	6	27	13	46			161	705	253	1119	1138
F.	" 18	" 24	" 17	" 20	" 3	" 10	6	24	3	27	14	47	7	54	161	705	275	1141	1160
M.	" 18	" 24	" 17	" 20	" 4		6	24	3	27	15	48			161	705	297	1163	1182
F.	" 18	" 24	" 26	" 31	" 13		6	33	5	38	13	57			161	917	291	1369	1388
F.	" 19	" 25	" 11	" 14	Aug. 23		6	17	3	20	9	35			158	525	236	919	929
F.	" 19	" 25	" 13	" 17	" 27	" 5	6	19	4	23	10	39	9	48	158	597	241	996	1009
M.	" 19	" 25	" 15	" 18	" 29	" 5	6	21	3	24	11	41	7	48	158	625	239	1022	1035
F.	" 19	" 25	" 13	" 18	" 31	" 10	6	19	5	24	13	43	10	53	158	625	274	1057	1070
M.	" 19	" 25	" 14	" 18	" 31	" 5	6	20	4	24	13	43	5	48	158	625	274	1057	1070
F.	" 19	" 25	" 16	" 19	" 31	" 9	6	22	3	25	12	43	9	52	158	653	243	1054	1070
M.	" 19	" 25	" 16	" 19	Sept. 1	" 4	6	22	3	25	13	44	3	47	158	653	262	1073	1089
F.	" 19	" 25	" 18	" 21	" 4	" 19	6	24	3	27	14	47	15	62	158	708	268	1134	1154
M.	" 19	" 25	" 17	" 22	" 5	" 11	6	23	5	28	14	48	6	54	158	733	273	1164	1182
F.	" 19	" 25	" 17	" 22	" 5		6	23	5	28	14	48			158	733	273	1164	1182
M.	" 19	" 25	" 19	" 23	" 7		6	25	4	29	15	50			158	753	309	1220	1237
M.	" 19	" 25	" 20	" 24	" 7		6	26	4	30	14	50			158	772	290	1220	1237
F.	" 19	" 25	" 21	" 26	" 8		6	27	5	32	13	51			158	815	268	1241	1258
F.	" 19	" 25	" 21	" 27	" 11		6	27	6	33	15	54			158	831	310	1299	1317
F.	" 20	" 26	" 16	" 19	" 1		6	21	3	24	13	43			159	628	262	1049	1062
M.	" 20	" 26	" 16	" 20	" 2	" 11	6	21	4	25	13	44	9	53	159	656	253	1070	1083
F.	" 20	" 27	" 18	" 21	" 5		7	22	3	25	15	47			187	660	298	1145	1159
M.	" 20	" 27	" 19	" 23	" 6	" 15	7	23	4	27	14	48	9	57	187	705	282	1174	1182
F.	" 20	" 27	" 19	" 26	" 6	" 14	7	23	7	30	11	48	8	56	187	767	219	1173	1182
F.	" 20	" 26	" 20	" 27	" 9	" 20	6	25	7	32	13	51	11	62	159	807	269	1235	1249
F.	" 20	" 27	" 26	" 31	" 13	" 21	7	30	5	35	13	55	8	63	187	845	291	1323	1332
F.	" 21	" 27	" 15	" 18	Aug. 29		6	19	3	22	11	39			161	577	239	977	982
M.	" 21	" 27	" 15	" 18	" 30		6	19	3	22	12	40			161	577	254	992	997
F.	" 21	" 28	" 16	" 19	Sept. 1	" 5	7	19	3	22	13	42	4	46	190	579	262	1031	1036
F.	" 21	" 27			" 3		6					44			161			1074	1079
F.	" 21	" 27	" 18	" 22	" 4	" 11	6	22	4	26	13	45	7	52	161	685	244	1090	1100
M.	" 21	" 27	" 17	" 22	" 5		6	21	5	26	14	46			161	685	273	1119	1129
F.	" 21	" 29	" 22	" 26	" 8		8	24	4	28	13	49			220	714	268	1202	1205
F.	" 21	" 27	" 23	Sept. 1	" 13	" 24	6	27	9	36	12	54	11	65	161	864	272	1297	1306
F.	" 22	" 28	" 14	Aug. 17	Aug. 26		6	17	3	20	9	35			164	523	225	912	914
F.	" 22	" 28	" 15	" 19	" 31	" 5	6	18	4	22	12	40	5	45	164	579	243	986	992
M.	" 22	" 28	" 16	" 20	Sept. 3		6	19	4	23	14	43			164	608	275	1047	1054
F.	" 22	" 28	" 19	" 22	" 5	" 20	6	22	3	25	14	45	15	60	164	659	273	1096	1104
F.	" 22	" 28	" 20	" 26	" 9		6	23	6	29	14	49			164	741	286	1191	1198
F.	" 22	" 29	" 21	" 26	" 9	" 19	7	23	5	28	14	49	10	59	195	714	286	1195	1198
F.	" 22	" 28	" 20	" 27	" 11	" 21	6	23	7	30	15	51	10	62	164	758	310	1232	1239
F.	" 22	" 28	" 27	Sept. 3	" 17	" 25	6	30	7	37	14	57	8	65	164	881	268	1313	1320

SUMMARY OF TABLE 16

Sex.	Egg.		Larva in fruit.		Larva in cocoon		Larva.		Pupa.		Egg, larva, and pupa.				Adult.		Total life period.	
	No.	Period in days.	No.	Period in days.	No.	Period in days.	No.	Period in days.	No.	Period in days.	No.	Period in days.	Total effective day-degrees. Sums for stages.	Total effective day-degrees. (50+)—2(86+).	No.	Period in days.	No.	Period in days.
M.	36	5.8	33	21.6	32	4.2	33	26.0	33	11.8	36	43.0	1084	1098	25	9.7	25	51.3
F.	54	6.0	51	22.9	51	4.3	51	27.2	51	12.0	54	44.9	1119	1133	38	10.2	38	55.1
Und.	2	6.5	2	20.5	2	3.0	2	23.5	2	10.5	2	40.5	1071	1088				
M.&F.	92	6.0	86	22.3	85	4.2	86	26.4	86	11.9	92	44.1	1106	1118	63	10.0	63	53.6

TABLE 17—OVIPOSITION AND LIFE PERIOD OF ADULTS OF SECOND GENERATION, OLNEY, 1915, AND WEATHER DURING FIRST TEN DAYS AFTER EMERGENCE OF MOTH

Emerged.		Died.		Days lived.		Number of eggs laid daily 1 to 8 days after emergence.									Av. mean daily temp.	Av. daily rainfall.
Male.	Female.	Male.	Female.	Male.	Female.	1	2	3	4	5	6	7	8	Total.		
Aug. 17	Aug. 16	Aug. 23	Aug. 25	6	9	.....	....	....	.....	.....	78	8	.....	86	66.7	.5375
" 21	" 20	" 30	Sept. 3	9	14	.....	....	10	62	65	.....	6	.....	143	64.6	.347
" 23	" 23	" 30	Aug. 30	7	7	56	....	9	.....	.....	.....	.....	.....	65	63.5	.0105
" 27	" 27	Sept. 2	Sept. 3	6	7	4	5	....	.....	.....	.....	.....	.....	9	65.6	.008
" 27	" 27	" 3	" 8	7	12	.....	....	....	.....	.....	.....	.....	.....	.....	65.6	.008
" 27	" 27	*	" 12	.....	16	.....	....	....	50	31	35	.....	23	139	65.6	.008
Sept. 5	.....	Sept. 12	.....	7	.....	.....	....	....	.....	.....	.....	.....	.....	.....	.....	
Sept. 2	Sept. 2	" 8	" 8	6	6	.....	....	....	.....	.....	.....	.....	.....	.....	74.1	.038
" 7	" 7	†	" 15	.....	8	.....	....	....	.....	32	26	.....	.....	58	78.0	.0067
" 9	" 9	Sept. 14	" 14	5	5	.....	30	....	.....	.....	.....	.....	.....	30	76.8	.0367
" 12	" 12	" 15	" 25	3	13	.....	1	....	.....	.....	.....	.....	.....	1	70.3	.0727
					Total	60	36	19	112	128	139	14	23	531		

* Killed Sept. 5, by larva of lacewing fly. † Escaped.

SUMMARY OF TABLE 17

Items.	Max.	Min.	Av.
Length of life of male moth in days	9	3	6.1
Length of life of female moth in days	16	5	9.9
Number of days from emergence till egg-laying begins	7	2	3.7
Number of days from emergence till egg-laying ceases	9	3	5.4
Egg-laying period in days	5	1	2.6
Number of eggs laid by one female	143	1	66.3

TABLE 18—Oviposition and Life Period of Adults of Second Generation, Olney, 1916, and Weather during first ten Days after Emergence of Female

Emerged.		Died.		Adult period.		Number of eggs laid daily 1 to 12 days from date of emergence.													Av. mean daily temp.	Av. daily humid.	Av. daily evap.	Av. daily rainfall.
Male.	Female.	Male.	Female.	M.	F.	1	2	3	4	5	6	7	8	9	10	11	12	Total				
Aug. 16	Aug. 16	Aug. 20	Aug. 26	4	10	....	73	....	....	...	...	...	...	...	...	...	....	73	76.5	80	14.8	.245
" 22	" 22	" 31	" 31	9	9	....	....	....	....	...	...	...	2	...	...	...	....	2	68.0	79	13.2	.182
" 24	" 24	Sept. 2	Sept. 6	9	13	....	64	....	28	...	...	...	...	...	...	...	....	92	68.3	81	11.1	.195
" 24	" 24	" 5	" 7	12	14	....	....	15	46	12	5	5	...	...	17	10	10	120	68.3	81	11.1	.195
" 25	" 25	" 5	" 4	11	10	32	....	....	....	...	...	...	...	...	...	...	....	32	68.3	81	10.7	.195
" 26	" 26	" 4	" 5	9	10	....	....	....	....	...	...	...	6	9	...	...	....	15	69.1	81	11.8	.204
" 27	" 27	Aug. 31	" 5	4	9	....	....	....	....	...	...	...	20	...	...	...	....	20	70.2	80	13.6	.151
" 28	" 28	Sept. 5	" 21	8	24	....	....	....	....	...	24	...	...	...	...	...	....	24	71.6	81	13.1	.241
" 29	" 29	" 5	" 5	7	7	....	....	55	20	...	...	...	...	...	...	...	....	75	72.5	82	12.3	.283
" 30	" 30	" 3	" 10	4	11	....	....	....	....	...	...	5	10	...	...	...	....	15	72.7	83	12.2	.283
" 30	" 30	" 3	" 9	4	10	....	....	....	....	19	...	...	...	...	...	...	....	19	72.7	83	12.2	.283
" 31	" 31	" 5	" 5	5	5	....	54	....	....	...	...	...	...	...	...	...	....	54	72.5	83	11.8	.283
" 31	" 31	.....	.....	...	..	....	....	27	....	...	...	...	...	...	...	...	....	27	72.5	83	11.8	.283
Sept. 5	Sept. 5	Sept. 11	Sept. 20	6	15	....	....	....	....	5	...	16	1	1	...	...	....	23	70.2	79	13.6	.142
" 6	" 6	" 15	" 14	9	8	....	....	....	57	...	...	...	...	...	...	...	....	57	67.4	78	13.5	.142
" 9	" 9	" 12	" 19	3	10	....	....	1	....	6	...	...	41	...	...	...	....	48	62.2	74	15.2	.000
" 11	" 10	.....	" 21	...	11	....	37	....	....	...	...	...	...	...	...	...	....	37	61.0	71	16.0	.000
" 11	" 11	.....	" 22	...	12	53	....	....	....	...	...	...	...	...	...	...	....	53	60.4	71	17.5	.000
" 19	" 17	Sept. 24	" 25	5	8	....	....	....	19	...	...	...	...	...	...	...	....	19	61.5	70	20.1	.000
			Totals	...	...	85	228	98	170	42	29	26	80	10	17	10	10	805				

SUMMARY OF TABLE 18

Items.	Max.	Min.	Av.
Length of life of male moth	12	3	6.13
Length of life of female moth	24	3	11.00
Number of days from emergence to laying first egg	8	1	4.1
Number of days from emergence to laying last egg	12	1	5.2
Egg-laying period, in days	10	1	2.2
Number of eggs laid by one female	120	2	42.3
Average mean daily temperature	72.7	60.4	68.7
Average daily humidity	83	70	79.0
Average daily evaporation, in c.c.	20.1	10.7	12.9
Average daily rainfall, in inches	.283	.0	17.4

TABLE 19—LIFE-HISTORY DATA ON HIBERNATING GENERATION, OLNEY, 1915–16

Sex.	Egg laid. 1915.	Larva hatched. 1915.	Larva left apple. 1915.	Larva pupated. 1916.	Adult emerged. 1916.	Adult died. 1916.	Length of life periods. Egg.	Larva in apple.	Larva in cocoon.	Total larval period.	Pupa.	Egg, larva, and pupa.	Adult.	Total life period.	Total day-deg. above 50° from Jan. 1 to date of pupation.
F.	June 3	June 12	July 18	Apr. 19	May 15		9	36	276	312	26	347			165
M.	July 2	July 11	Aug. 9	" 13	" 11	May 20	9	29	248	277	28	314	9	323	115
F.	" 2	" 11	" 11	" 13	" 11	" 24	9	31	246	277	28	314	13	327	115
M.	" 2	" 11	" 2	" 13	" 12		9	22	255	277	29	315			115
M.	" 2	" 11	" 7	" 15	" 13		9	27	252	279	28	316			129
F.	" 2	" 11	" 5	" 16	" 14		9	25	255	280	28	317			140
M.	" 2	" 11	" 9	" 16	" 14		9	29	251	280	28	317			140
M.	" 2	" 11	" 10	" 17	" 14		9	30	251	281	27	317			147
F.	" 2	" 11	" 11	" 17	" 15		9	31	250	281	28	318			147
M.	" 2	" 11	" 2	" 17	" 15		9	22	259	281	28	318			147
M.	" 2	" 11	" 11	" 19	" 15		9	31	252	283	26	318			165
F.	" 2	" 11	" 7	" 19	" 18	" 25	9	27	256	283	29	321	7	328	165
F.	" 2	" 11	" 11	" 24	" 20		9	31	257	288	26	323			196
F.	" 2	" 11	" 9	" 28	" 21	" 27	9	29	263	292	23	324	6	330	205
	" 3	" 13	" 12	" 28	" 21		10	30	260	290	23	323			205
	" 4	" 13	" 3	" 19			9	21	260	281					165
		" 13		May 10			9			302					356
	" 7	" 14	" 17	Apr. 20	May 17		7	34	247	281	27	315			183
F.	" 8	" 15	" 16	" 19	" 15		7	32	247	279	26	312			165
F.	" 8	" 14	" 9		" 19	" 26	6	26				316	7	323	
F.	" 8	" 14	" 14	" 28	" 20	June 1	6	31	258	289	22	317	12	329	205
F.	" 9	" 15		" 18	" 15	May 25	6			278	27	311	10	322	151
F.	" 9	" 16	" 18	May 7	" 26	June 6	7	33	263	296	19	322	11	332	297
F.	" 11	" 17	" 12	" 7	" 26	" 2	6	26	269	295	19	320	7	327	297
M.	" 13	" 19	" 18	Apr. 17	" 14		6	30	243	273	27	306			147
F.	" 13	" 20	" 20	" 18	" 14	May 20	7	31	242	273	26	306	6	312	151
M.	" 13	" 19	Sept 3	" 17	" 14	" 25	6	46	227	273	27	306	11	317	147
M.	" 13	" 19	Aug. 23	" 19	" 15		6	35	240	275	26	307			165
F.	" 13	" 19	" 21	" 28	" 21		6	33	251	284	23	313			205
F.	" 14	" 20	" 25	" 23	" 21	" 28	6	36	242	278	28	312	7	319	192
M.	" 17	" 24	" 27	" 17	" 13		7	34	234	268	26	301			147
M.	" 17	" 24	Sept. 3	" 14	" 14		7	41	224	265	30	302			125
M.	" 17	" 24	Aug. 16		" 14		7	23				302			
M.	" 17	" 24	" 29	" 18	" 14		7	36	233	269	26	302			151
M.	" 17	" 25	" 13	" 19	" 15		8	19	250	269	26	303			165
M.	" 17	" 24	" 29	" 18	" 15		7	36	233	269	27	303			151
F.	" 17	" 24	" 29	" 19	" 15	" 26	7	36	234	270	26	303	11	314	165
F.	" 17	" 25		" 20	" 16	" 25	8				26	304	9	313	182
M.	" 17	" 25	" 18	" 18	" 17		8	24	244	268	29	305			151
M.	" 17	" 25	" 14	" 20	" 17		8	20	250	270	27	305			183
F.	" 17	" 25	" 16	" 24	" 18	" 26	8	22	252	274	24	306	8	314	196
F.	" 17	" 24	" 25	" 20	" 19	" 26	7	32	239	271	29	307	7	314	183
F.	" 17	" 26	" 14	" 22	" 20	" 26	9	19	252	271	28	308	6	314	192
F.	" 17	" 25	" 18	" 25	" 21		8	24	251	275	26	309			198
	" 20	" 28	Sept. 9	" 22	" 20		8	43	226	269	28	305			189
F.	" 20	" 28	" 9	" 22	" 20	" 26	8	43	226	269	28	305	6	311	189
M.	" 22	" 29	" 9	" 17	" 14		7	42	221	263	27	297			147
M.	" 23	" 29	" 8	" 19	" 15		6	41	224	265	26	297			165
F.	" 23	" 29	" 6	" 20	" 19	" 28	6	39	227	266	29	301	9	310	183
M.	" 23	" 29	Aug. 18	" 21	" 20		6	20	247	267	29	302			185
M.	" 23	" 29	Sept. 8	" 24	" 20		6	41	229	270	26	302			196
F.	" 23	" 29	Aug. 27	" 25	" 22		6	29	242	271	27	304			198
F.	" 23	" 29	Sept. 13	" 29	" 22	" 24	6	46	229	275	23	304	2	306	213
	" 23	" 29	" 12	" 20			6	45	221	266					183
M.	" 24	" 30	" 1	" 13	" 11		6	33	225	258	28	292			115
M.	" 24	" 30	Aug. 28	" 13	" 13		6	29	229	258	30	294			115
M.	" 24	" 30	Sept. 1	" 16	" 14		6	33	228	261	28	295			140
F.	" 24	" 30	" 7	" 19	" 15	" 29	6	39	225	264	26	296	14	310	165
F.	" 24	" 29	Aug. 29	" 20	" 19	June 2	6	30	235	265	29	300	14	314	183
M.	" 24	" 30	Sept. 16	" 21	" 19		6	48	218	266	28	300			185
F.	" 24	" 30	" 3	" 28	" 20	May 26	6	35	238	273	22	301	6	307	205
	" 24	" 30	" 1	" 24			6	33	236	269					196
M.	" 25	" 31	" 9	" 18	" 15		6	40	222	262	27	295			151
F.	" 25	" 31	" 23	" 18	" 15	" 25	6	54	208	262	27	295	10	305	151
F.	" 25	" 31	" 11		" 20		6	42				300			
F.	" 25	" 31	" 19	May 10	" 27	June 2	6	50	234	284	17	307	6	313	356
M.	" 28	Aug. 3	" 13	Apr. 16	" 14		6	41	216	257	28	291			140
F.	" 28	" 2	" 7	" 18	" 15	May 25	5	36	224	260	27	292	10	302	151
F.	" 28	" 3	" 11	" 19	" 17	" 25	6	39	221	260	28	294	8	302	165
F.	" 28	" 3	" 8	" 20	" 19	" 26	6	36	225	261	29	296	7	303	183
	" 28	" 2	" 11	" 21			5	40	223	263					185
M.	" 28	" 2	" 18	" 24	" 20	" 26	5	47	219	266	26	297	6	303	196
	" 28	" 3	" 9	" 25			6	37	229	266					198
M.	" 28	" 3		May 4	" 23		6				19	300			246
M.	" 28	" 3	" 12	" 5	" 23		6	40	236	276	18	300			258
F.	" 28	" 2	" 12	Apr. 28	" 24		5	41	229	270	26	301			205
F.	" 28	" 3	" 14	May 7	" 26	June 11	6	42	236	278	19	303	16	319	297
M.	" 28	" 3	" 14	" 7	" 26		6	42	236	278	19	303			297
M.	" 28	" 2	" 16	" 10	" 27	May 30	5	45	237	282	17	304	3	307	356
M.	" 30	" 6	" 8	Apr. 14	" 13		7	33	219	252	29	288			125
F.	" 30	" 6	" 15	" 14	" 14	" 25	7	40	212	252	30	289	11	300	125
M.	" 30	" 6	" 8	" 16	" 14		7	33	221	254	28	289			140
M.	" 30	" 6	" 8	" 19	" 15	" 25	7	33	224	257	26	290	10	300	165
F.	" 30	" 6		" 19	" 15	" 26	7				26	290	11	301	165
	" 30	" 6	" 11	" 17	" 16		7	36	219	255	29	291			147
F.	" 30	" 6	" 15	" 18	" 16	" 25	7	40	216	256	28	291	9	300	151
M.	" 30	" 6	" 7	" 19	" 17		7	32	225	257	28	292			165
F.	" 31	" 7	" 13	" 19	" 16	" 25	7	37	219	256	27	290	9	299	165
F.	Aug. 8	" 16	" 12	" 19	" 15	" 25	8	27	220	247	26	281	10	291	165
M.	" 8	" 16	" 15	" 19	" 16		8	30	217	247	27	282			165
M.	" 8	" 16	" 18	" 20	" 19		8	33	215	248	29	285			185
M.	" 8	" 16	" 13	" 23	" 19		8	28	223	251	26	285			192
F.	" 8	" 15	" 17	" 18	" 20	" 28	7	33	214	247	32	286	8	294	151
M.	" 8	" 15	" 11	" 30	" 21		7	27	232	259	21	287			225
F.	" 8	" 16	" 19	May 8	" 26		8	34	232	266	18	292			319
	" 13	" 21	" 17	Apr. 15			8	27	211	238					129
	" 13	" 21	" 17	" 17			8	27	213	240					147
F.	" 13	" 21	" 19	" 20	" 18	" 26	8	29	214	243	28	279	8	287	183
M.	" 13	" 22	" 15	" 19	" 19	" 25	9	24	217	241	30	280	6	286	165
F.	" 22	Sept. 2	" 28	" 21	" 19	June 5	11	26	206	232	28	271	17	288	185
	" 22	" 2	" 20	May 1			11	18	224	242					237
	" 22	" 2	" 27	" 6			11	25	226	251					273
	" 22	" 1	" 28	" 9			10	27	224	251					333
M.	" 22	Aug. 29	" 24	Apr. 17	" 14		7	26	206	232	27	266			147
	" 22	" 30	" 25	" 13	" 14		8	26	201	227	31	266			115
	" 22	Sept. 2	" 29	" 21			11	27	205	232					185
	" 24	" 5		" 19	" 16		12			227	27	266			165
	" 24	" 5		" 20	" 19		12			228	29	269			183
	" 24	" 5		May 4	" 23		12			242	19	273			246
	" 24	" 5		" 10			12			248					356
	Sept. 4	" 10		" 9			6			242					333

SUMMARY OF TABLE 19

Sex.	Egg. No.	Egg. Period in days.	Larva in fruit. No.	Larva in fruit. Period in days.	Larva in cocoon. No.	Larva in cocoon. Period in days.	Larva. No.	Larva. Period in days.	Pupa. No.	Pupa. Period in days.	Egg, larva, and pupa. No.	Egg, larva, and pupa. Period in days.	Adult. No.	Adult. Period in days.	Total life period. No.	Total life period. Period in days.
M.	43	7.1	43	33.7	41	232.5	41	265.5	42	26.5	43	299.3	6	7.5	6	306.0
F.	46	7.1	43	33.9	41	237.4	42	271.5	44	25.8	46	304.3	35	9.1	35	310.9
Und.	22	8.8	16	31.1	16	226.6	22	266.0	8	26.6	8	288.5				
M & F.	111	7.4	101	33.0	98	233.6	106	265.7	94	26.2	97	300.8	41	8.9	41	301.1

TABLE 20—LIFE-HISTORY DATA ON HIBERNATING GENERATION, QUEEN, 1916–17

Sex	Egg laid, 1916.	Larva hatched, 1916.	Larva left egg-case, 1916.	Larva pupated, 1917.	Adult emerged, 1917.	Adult died, 1917.	Length of life periods: Egg	Larva in egg.	Larva in cocoon.	Total larval period.	Pupa.	Egg, larva, and pupa.	Adult.	Total life period.	Total day-deg. above 50° from Jan. 1 to date of pupation.
	July 12	July 19	Aug. 19	Apr. 24			7	31	248	279					246
M.	" 14	" 21	" 21	" 19	May 15	May 20	7	31	241	272	34	313	7	320	179
M.	" 18	" 21	" 22	" 22	" 28	June 8	7	32	243	275	36	318	11	329	213
F.	" 15	" 20	" 13	" 15	" 19		5	24	245	269	34	308			126
F.	" 15	" 20	" 12		" 19		5	22				308			
M.	" 15	" 20	" 15		" 19		5	24				308			
F.	" 15	" 21	" 13		" 19		6	22				308			
F.	" 16	" 20	" 12	" 11	" 20	" 3	5	24	241	265	39	309	16	325	116
F.	" 15	" 20	" 18	" 23	" 27		5	24	252	277	34	316			221
F.	" 15	" 21	" 14	" 22	" 27		6	24	251	275	35	316			213
M.	" 15	" 20	" 14	" 15			5	25	244	269					126
F.	" 15	" 20	" 14	" 3			5	25	232	257					104
F.	" 16	" 21	" 24	" 21	" 27		5	24	240	274	36	315			203
M.	" 16	" 21	" 24	" 23	" 29	" 7	5	24	242	276	36	317	7	324	231
F.	" 16	" 21	" 22	" 24	" 30		5	22	245	277	36	318			246
M.	" 17	" 22	" 10	" 17	" 20		6	18	250	268	33	307			141
F.	" 18	" 22	" 14	" 2	" 18	May 30	5	22	232	254	45	304	12	316	104
M.	" 18	" 24	" 17	" 15	" 20		6	24	241	265	35	306			126
M.	" 18	" 24	" 16	" 16	" 20		6	23	243	266	34	306			129
F.	" 18	" 24	" 17	" 18	" 24	June 8	6	24	244	268	36	310	15	325	161
M.	" 15	" 24	" 17	" 18	" 24	" 2	6	24	245	269	35	310	12	322	179
F.	" 18	" 24	" 14	" 19	" 24	" 1	6	21	248	269	35	310	8	318	179
M.	" 18	" 24	" 19	" 20	" 25		6	26	244	270	35	311			197
M.	" 18	" 23	" 17	" 19	" 26	" 5	7	23	245	268	37	312	10	322	179
M.	" 18	" 24	" 16	" 27	" 27	May 21	6	22	249	271	37	313	4	317	212
F.	" 18	" 24	" 12	" 23	" 29	June 13	6	24	249	273	36	315	15	330	231
F.	" 18	" 24	" 13	" 23	" 29		6	28	253	273	36	315			231
F.	" 18	" 23		" 11			5			262					136
M.	" 18	" 22	" 13	" 12			5	21	242	263					121
	" 18	" 24	" 10	" 22			6	17	255	272					212
	" 18	" 24		" 17			6			268					161
	" 18	" 24			" 17		6					318			
M.	" 19	" 25	" 14	" 12	" 28	" 8	6	29	241	261	38	305	19	324	121
M.	" 19	" 25	" 15	" 17	" 29		6	23	245	266	33	305			141
F.	" 19	" 25	" 20	" 17	" 29	" 9	6	26	240	266	33	305	19	324	141
F.	" 19	" 25	" 20		" 21		6	26				306			
M.	" 19	" 25	" 21	" 11	" 21		6	27	232	260	40	306			116
M.	" 19	" 25	" 21	" 20	" 27		6	27	242	269	39	308			197
F.	" 19	" 25	" 17	" 18	" 24	" 9	6	23	247	269	35	308	15	324	179
M.	" 19	" 25	" 20	" 19	" 24		6	26	242	268	35	309			179
F.	" 19	" 25	" 19	" 26	" 28		6	25	244	269	35	310			197
F.	" 19	" 25	" 19		June 6		6	25				322			
F.	" 19	" 25	" 12	" 20			6	18	251	269					197
	" 19	" 25	" 21	" 22			6	27	244	271					213
F.	" 19	" 25	" 20	" 23			6	26	246	272					221
M.	" 20	" 27	" 15	" 11	May 17		7	19	239	258	36	301			116
M.	" 20	" 27	" 21	" 12	" 19		7	25	234	259	37	303			121
M.	" 20	" 27	" 19	" 15	" 20		7	23	239	262	35	304			126
M.	" 20	" 26	" 21	" 16	" 20		6	25	238	263	34	304			129
M.	" 20	" 27	" 17	" 17	" 20		7	23	242	264	33	304			141
F.	" 20	" 27	" 22	" 19	" 27	" 7	7	26	240	266	36	309	11	322	179
F.	" 20	" 27	" 22	" 20	" 25	" 1	7	26	242	267	35	309	13	322	197
F.	" 20	" 27	" 22	" 23	" 29	" 7	7	26	244	270	36	312	9	322	231
M.	" 21	" 27	" 19	" 16	" 20	" 5	6	23	240	263	34	303	16	319	129
F.	" 21	" 27	" 19	" 18	" 21		6	23	242	265	33	304			161
M.	" 21	" 27	" 23	" 18	" 21		6	27	238	265	33	304			161
F.	" 21	" 28	" 21	" 20	" 24	" 5	7	24	242	266	34	307	11	318	197
F.	" 21	" 27	" 17	" 20	" 25	" 5	6	23	246	267	35	308	11	319	197
F.	" 21	" 28	" 21	" 22	" 27		7	24	245	269	34	310			221
F.	" 21	" 27	" 22	" 23	" 29		6	23	239	270	36	312			231
F.	" 21	" 27	" 22	" 23	" 29		6	26	244	270	36	312			231
F.	" 21	" 27	" 21	" 19			6	25	241	266					179
M.	" 21	" 27	" 20	" 11			6	24	234	258					116
F.	" 22	" 29	" 21		" 21		7	23			33	303			
F.	" 22	" 28	" 22	" 18	" 21		6	25	239	264	33	303			161
M.	" 22	" 28	" 24	" 24	" 23		6	27	243	270	29	305			246
F.	" 22	" 28	" 24	" 22	" 27		6	27	243	268	35	309			212
M.	" 24	" 30	" 19	" 16	" 20		6	30	239	259	35	300			126
F.	" 24	" 30	" 20	" 15	" 20		6	23	238	259	35	300			126
M.	" 24	" 30	" 16	" 18	" 20		6	17	245	262	32	300			161
M.	" 24	" 30	" 17	" 17	" 21		5	18	242	261	34	301			141
F.	" 24	" 29	" 22	" 18	" 21		5	24	239	263	32	301			161
F.	" 24	" 29	" 24	" 19	" 21		5	26	238	264	32	301			179
	" 24	" 31	" 18	" 19	" 22		7	19	242	262	33	302			179
M.	" 24	" 30	" 15	" 20	" 25		6	16	243	264	35	305			197
F.	" 24	" 30	" 17	" 20	" 25		6	18	246	264	35	305			197
F.	" 24	" 30	" 17	" 20	" 25		6	18	246	264	35	305			197
M.	" 24	" 30	" 20	" 20	" 25		6	21	243	264	35	305			197
M.	" 24	" 29	" 20	" 21	" 26	" 5	5	22	244	266	35	306	10	316	203
M.	" 24	" 29	" 26	" 22	" 27		5	28	239	267	35	307			213
M.	" 24	" 30	" 20	" 23	" 27		6	21	246	267	34	307			231
F.	" 24	" 29	" 20	" 22	" 28	" 11	5	22	245	267	36	308	14	322	213
F.	" 24	" 29	" 12	" 23	" 29	" 12	5	19	249	268	36	309	15	324	231
F.	" 24	" 30	" 15	May 17	June 9		6	16	275	291	23	314			355
M.	" 25	" 30	" 19	Apr. 11	May 18		5	20	235	255	37	297			116
F.	" 25	" 30	" 19	" 11	" 19		5	20	235	255	38	298			116
F.	" 25	" 30	" 22	" 18	" 26	" 8	5	28	236	262	32	299	19	318	161
F.	" 25	" 30	" 19	" 19	" 24	" 8	5	20	243	263	35	303	15	318	179
F.	" 25	" 30	" 20	" 20	" 25	" 4	5	21	243	264	35	304	10	314	197
M.	" 26	Aug. 1	" 27	" 19	" 24		6	26	235	261	35	302			179
F.	" 26	" 1	Sept. 5	" 19	" 24	" 5	6	35	226	261	35	302	12	314	179
F.	" 26	" 1	" 3	" 20	" 25	" 5	6	31	229	262	35	302	11	314	197
M.	" 26	" 1	Aug. 30	" 22	" 28	" 8	6	29	236	265	35	306	11	317	231
F.	" 26	" 1	Sept. 1	" 24	" 29	" 12	6	31	235	266	35	310	14	324	246
F.	" 27	" 1	" 19	" 22	" 27		5	49	215	264	35	304			213
M.	" 28	" 3	Aug. 31	" 20	" 25	" 2	6	28	232	260	35	301	8	309	197
F.	" 28	" 3	" 27	" 21	" 26	" 5	6	24	237	261	35	302	10	312	203
M	" 28	" 3	Sept. 2	" 24	" 27	May 31	6	30	234	264	33	303	4	307	246
	" 28	" 2	" 4	" 24	" 30		5	33	232	265	36	306			246
F.	" 28	" 3	" 10	" 25	" 30		6	38	227	265	35	306			256
M.	" 29	" 4	" 1	" 25	" 30		6	28	236	264	35	305			126
M.	" 29	" 4	" 20	" 19	" 24	" 10	6	47	211	258	35	299	6	305	179
M.	" 29	" 3	" 9	" 20	" 25	June 2	5	37	222	260	35	300	9	309	197
F.	" 29	" 4			" 25		6					300			
M.	" 29	" 4	" 4	" 19	" 27		6	31	227	258	38	302			179
F.	" 29	" 4	" 1	" 24	" 29	" 5	6	28	235	263	35	304	7	311	246
M.	" 29	" 4	" 4	" 24	" 29		6	31	232	263	35	304			246
M.	" 29	" 4	" 6	" 16	" 30		6	33	222	255	44	305			129
F.	" 29	" 4	" 8		" 31	" 13	6	35				306	13	319	
M.	" 29	" 4	" 7		June 3	" 9	6	34				309	6	315	
F.	" 29	" 4	" 1	May 17	" 7		6	28	258	286	31	313			355
F.	" 30	" 4	" 7	Apr. 23	May 27		5	34	228	262	34	301			231
M.	Aug. 10	" 17	" 19	" 20	" 25	" 8	7	32	212	246	35	288	14	302	197
M.	" 10	" 17		" 20	" 25		7			246	35	288			203
M.	" 10	" 17	" 22	" 23	" 25		7	30	211	247	34	288			213
F.	" 10	" 16	" 13	" 22	" 27		6	28	221	249	35	290			231
M.	" 10	" 16	" 12	" 22	" 27		6	27	223	250	34	290			250
M.	" 10	" 16	" 9	" 25	" 29	" 1	6	24	228	252	34	292	3	296	246
M.	" 10	" 16	" 24	" 24	" 29		6	39	212	251	35	292			246
F.	" 10	" 16	" 19	" 24	" 30		6	34	217	251	36	293			256
M.	" 10	" 17	" 17	" 25	" 30		7	31	220	251	35	293			261
M.	" 10	" 17	" 18	" 27	" 31	" 10	7	32	221	253	34	294	10	304	
F.	" 10	" 16	" 18		June 2	" 14	6	32				296	12	308	
M.	" 10	" 16	" 15	May 18	" 7		6	30	245	275	30	301			274
F.	" 10	" 17	" 18		" 8		7	32				302			
F.	" 11	" 18	" 24	Apr. 19	May 24	" 5	7	37	207	244	35	296	12	308	179
F.	" 11	" 18		" 22	" 26		7			243	34	288			213
F.	" 11	" 18	" 24	" 21	" 28		7	37	209	246	37	290			203
M.	" 11	" 18	" 12	May 1	June 6		7	26	230	256	38	290			269
F.	" 12	" 19		" 5			7					297			
	" 12	" 18		Apr. 24			6			249					246

SUMMARY OF TABLE 20

Sex	Egg.		Larva in cocoon.		Larva in cocoon.		Larva.		Pupa.		Egg, larva, and pupa.		Adult.		Total life period.	
	No.	Period in days.	No.	Period in days.	No.	Period in days.	No.	Period in days.	No.	Period in days.	No.	Period in days.	No.	Period in days.	No.	Per in days.
M.	57	6.1	56	36.4	54	258	53	262	53	35.9	54	303	18	8.7	18	314
F.	60	6.3	62	34.2	61	249	56	266	62	35.0	61	306	35	12.8	35	318
Ind.	3	6.1	3	35.4	6	244	3	267	3	34.3	3	307				
M. & F.	113	6.6	123	34.9	112	253	112	264	108	34.3	118	305	43	11.3	43	317

TABLE 21—OVIPOSITION AND LIFE PERIOD OF ADULTS OF THE HIBERNATING GENERATION, 1915, WITH CLIMATIC DATA FOR FIRST TEN DAYS AFTER EMERGENCE OF FEMALE

Date emerged.		Date of death.		Life period.		Number of eggs laid daily 1 to 15 days after emergence.															Total.	Av. mean daily temp.	Av. daily humidity.	Av. daily evaporation.	Av. daily rainfall.
Male.	Female.	Male.	Female.	M.	F.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15					
May 3	May 3	May 13	.....	10	....	...	9	20	...	15	7	8	4	1	...	...	...	...	...	...	64	59.5	52.5	25.3	.116
" 3	" 3	" 13	May 14	10	11	...	26	...	2	9	15	2	1	...	...	...	...	...	...	...	55	59.5	52.5	25.3	.116
" 5	" 5	.....	" 14	..	9	12	8	1	2	...	...	...	...	...	...	...	...	...	...	...	23	62.0	51.5	24.2	.1305
" 5	" 5	.....	.....	..	....	...	...	...	...	...	...	...	...	30	...	...	...	...	...	...	30	62.0	51.5	24.2	.1305
" 17	" 17	" 26	" 31	9	14																	60.8	81.1	24.2	.50
" 17	" 17	June 1	.....	15	..	...	...	...	14	1	...	...	...	...	...	...	...	...	...	...	15	60.8	81.1	10.9	.50
" 17	" 17	" 10	" 24	24	..																	60.8	81.1	10.9	.50
" 17	" 17	May 29	June 5	12	19																	60.8	81.1	10.9	.50
" 17	" 17	" 4	" 10	18	24	...	...	...	...	34	...	3	...	...	...	...	...	...	...	...	37	60.8	81.1	10.9	.50
" 17	" 17	.....	.....	..	..																	60.8	81.1	10.9	.50
" 17	" 17	June 7	May 27	21	10																	60.8	81.1	10.9	.50
" 17	" 17	.....	" 28	..	11	...	...	...	22	4	3	...	6	...	...	...	...	...	...	...	35	60.8	81.1	10.9	.50
" 17	" 17	.....	June 9	..	23																	60.8	81.1	10.9	.50
" 17	" 17	May 26	May 26	9	9																	60.8	81.1	10.9	.50
" 17	" 17	" 29	June 2	12	16	..	...	...	39	25	8	5	23	...	...	...	...	...	...	...	100	60.8	81.1	10.9	.50
" 17	" 17	June 4	.....	18	..																	60.8	81.1	10.9	.50
" 18	" 18	May 24	May 28	6	10																	61.7	81.3	10.9	.513
" 18	" 18	" 29	June 7	11	20	...	...	...	5	28	6	...	17	11	...	...	...	...	...	...	67	61.7	81.3	6.5	.513
" 18	" 18	June 7	.....	20	..																	61.7	81.3	6.5	.513
" 18	" 18	" 1	May 28	14	10																	61.7	81.3	6.5	.513
" 18	" 18	" 5	.....	18	..	...	...	53	5	26	16	...	...	...	...	...	...	..	...	...	100	61.7	81.3	6.5	.513
" 18	" 18	" 7	.....	20	..																	61.7	81.3	6.5	.513
" 18	" 18	May 31	June 17	13	30																	61.7	81.3	6.5	.513
" 18	" 18	.....	.....	..	..	...	...	...	...	22	...	...	...	...	...	...	...	...	...	...	22	61.7	81.3	6.5	.513
" 18	" 18	.....	.....	..	..																	61.7	81.3	6.5	.513
" 21	" 21	June 4	June 7	14	17	...	...	...	...	...	...	73	...	...	...	...	...	...	...	...	73	63.0	83.6	6.7	.33
" 21	" 21	.....	" 4	..	14	...	...	...	...	...	...	...	...	...	1	...	...	...	...	...	1	63.0	83.6	6.7	.33
" 26	" 26	" 10	.....	15	....	...	...	...	...	58	...	...	...	...	...	...	...	...	...	...	58	64.1	85.2	6.4	.312
" 28	" 28	.....	" 10	..	13	...	...	1	46	...	7	...	...	26	...	...	...	...	...	...	80	67.1	84.3	8.6	.227
" 28	" 28	" 10	" 15	13	18	...	...	...	...	...	13	...	...	...	...	...	...	...	...	...	13	67.1	84.3	8.6	.227
" 30	" 30	" 7	" 7	8	8	...	...	...	88	...	...	...	...	...	...	...	...	...	...	...	88	66.9	82.2	10.6	.2045
" 30	" 30	" 7	" 26	8	27	...	1	5	31	25	...	...	...	...	...	...	...	...	...	...	62	66.9	82.2	10.6	.2045
" 30	" 30	" 7	" 9	8	10	32	3	55	9	...	...	13	...	...	...	...	...	...	...	...	112	66.9	82.2	10.6	.2045
" 30	" 30	" 9	" 10	10	12	...	...	3	47	...	...	48	3	2	...	...	...	...	...	...	153	66.9	82.2	10.6	.2045
" 31	" 31	" 10	" 9	11	9	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	1	67.0	81.1	11.6	.204
" 31	" 31	" 9	" 8	9	8	...	32	21	12	...	48	...	...	...	...	...	...	...	...	...	113	67.0	81.1	11.6	.204
" 31	" 31	" 11	" 11	11	11	...	1	12	...	...	...	...	...	...	...	...	...	...	...	...	13	67.0	81.1	....	.204
" 9	" 9	" 22	" 22	13	13	...	...	...	9	...	...	...	43	3	...	30	...	...	...	...	85	71.3	77.0	14.9	.085
" 10	" 10	" 21	" 26	11	16	...	...	...	...	...	...	...	...	...	...	...	2	6	1	5	14	72.4	77.1	15.2	.155
" 11	" 11	" 21	" 22	10	11	...	...	...	...	2	2	3	...	4	7	...	...	...	..	...	18	72.6	79.0	14.2	.282
	" 11	.....	" 28	..	17																	72.6	79.0	14.2	.282
" 12	" 12	" 19	" 24	7	12																	72.6	79.0	14.2	.282
	" 12	.....	" 24	..	12	47	46	14	25	...	3	...	3	...	...	...	...	...	...	...	138	72.6	79.0	13.1	.282
	" 12	.....	" 24	..	12																	72.6	79.0	14.2	.282
					Totals	91	126	186	356	249	128	205	100	79	8	30	2	6	1	5	1570				

SUMMARY OF TABLE 21

Items.	Max.	Min.	Av.
Length of life of male in days	24	6	12.8
Length of life of female in days	24	8	14.3
Number of days from emergence till laying of first eggs	12	1	4.3
Number of days from emergence till laying of last eggs	15	3	7.5
Egg-laying period in days	8	1	4.2
Number of eggs laid by one female	153	1	35.7

TABLE 22—Oviposition and Life Period of Hibernating Generation, Olney, 1916, with Climatic Data for first ten Days after Emergence of Female

Emerged.		Died.		Adult period.		Number of eggs laid daily 1 to 17 days after emergence.																			Av. mean daily temp.	Av. daily humid.	Av. daily evap.	Av. daily rainfall.
Male.	Female.	Male.	Female.	Male.	Female.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Total.					
May 11	May 11	May 20	May 24	9	13	..	...	...	...	...	...	...	2	...	...	...	...	...	...	...	...	...	2	61.2	68	19.0	.082
" 13	" 13	" 19	June 9	6	27	..	...	...	...	...	...	...	...	...	1	...	...	...	...	3	...	3*	7	63.6	69	19.3	.107
" 13	" 13	" 23	May 27	10	14	33	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	34	63.6	69	19.3	.107
" 14	" 14	" 20	" 20	6	6	..	...	...	...	2	...	...	...	...	...	...	...	...	...	...	...	...	2	63.2	69	17.6	.107
" 14	" 14	" 25	" 25	11	11	..	...	...	...	3	8	10	...	...	...	...	...	...	...	...	...	...	21	63.2	69	17.6	.107
" 15	" 15	" 26	" 27	11	12	..	...	...	...	...	...	...	2	...	...	...	...	...	...	...	...	...	2	63.9	68	20.2	.067
" 15	" 15	" 25	" 25	10	10	..	...	...	63	9	17	40	7	...	...	...	...	...	...	...	...	...	136	63.9	68	20.2	.067
" 15	" 15	" 25	" 25	10	10	..	...	...	...	11	43	6	...	...	...	...	...	...	...	...	...	...	60	63.9	68	20.2	.067
" 15	" 15	" 25	" 26	10	11	..	...	...	1	4	...	11	...	...	...	...	...	...	...	...	...	...	16	63.9	68	20.2	.067
" 15	" 15	" 25	" 29	10	10	..	...	...	8	...	5	2	...	...	...	...	...	...	...	...	...	...	15	63.9	68	20.2	.067
" 15	" 15	" 25	" 25	10	10	..	...	...	...	4	29	2	4	...	...	...	...	...	...	...	...	...	39	63.9	68	20.2	.067
" 15	" 15	" 25	" 25	10	10	..	...	...	10	34	9	...	...	...	...	...	...	...	...	...	...	...	53	63.9	68	20.2	.067
" 14	" 15	" 25	" 25	11	10	..	...	...	51	16	16	...	3	...	...	...	...	...	...	...	...	...	3	63.9	68	20.2	.067
" 15	" 15	" 26	" 26	11	11	..	...	...	51	16	16	...	22	17	...	...	...	...	...	...	...	...	122	63.9	68	20.2	.067
" 17	" 17	" 25	" 25	8	8			19	6		5	3	...	...	...	...	...	...	...	...	...	...	33	68.1	69	21.5	.108
" 19	" 18	" 26	" 26	7	8	..	...	...	...	3	...	...	...	...	...	...	...	...	...	...	...	...	3	69.6	72	20.5	.120
" 19	" 19	" 25	" 26	6	7	..	...	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2	71.1	74	18.4	.328
" 22	" 19	" 28	.....	6	...	..	...	8	...	...	...	...	...	...	...	...	...	...	...	...	...	...	8	71.1	74	18.4	.328
" 19	" 19	June 1	June 2	12	13	..	...	...	...	...	...	...	...	...	...	7	...	...	...	...	...	...	7	71.1	74	18.4	.328
" 19	" 19	May 25	May 25	6	6	..	1	21	17	...	...	...	...	...	...	...	...	...	...	...	...	...	39	71.1	74	18.4	.328
" 19	" 19	" 25	" 26	6	7	..	...	42	46	19	...	...	...	...	...	...	...	...	...	...	...	...	107	71.1	74	18.4	.328
" 19	" 19	" 25	" 25	6	6	..	...	32	30	5	...	...	...	...	...	...	...	...	...	...	...	...	67	71.1	74	18.4	.328
" 20	" 20	" 31	" 28	11	8	..	...	...	...	42	...	...	...	...	...	...	...	...	...	...	...	...	42	71.5	76	17.3	.332
" 20	" 20	" 26	" 25	6	5	..	37	23	...	...	...	...	...	...	...	...	...	...	...	...	...	...	60	71.5	76	17.3	.332
" 20	" 20	" 25	June 2	5	13	..	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	71.5	76	17.3	.332
" 21	" 21	" 29	May 28	8	7	..	...	54	...	...	...	...	...	...	...	...	...	...	...	...	...	...	54	71.4	76	18.3	.307
" 21	" 21	" 26	June 2	5	12	..	...	...	...	...	5	...	...	7	...	...	...	...	...	...	...	...	12	71.4	76	18.3	.307
" 23	" 23	June 2	" 7	10	15	..	...	4	...	...	...	...	...	...	...	...	...	...	...	...	...	...	4	71.4	75	17.9	.326
" 26	" 26	" 5	" 2	10	7	..	37	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	37	68.3	77	14.1	.329
" 26	" 26	" 3	" 6	8	11	..	10	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	10	68.3	77	14.1	.329
" 27	" 26	" 8	" 9	12	14	..	...	4	33	...	5	...	...	...	...	...	...	...	...	...	...	...	42	68.3	77	14.1	.329
" 28	" 28	" 14	" 14	17	17	..	...	15	23	...	...	...	...	...	...	...	...	...	...	...	...	...	38	66.4	77	15.1	.558
" 28	" 28	" 2	" 9	5	12	..	...	...	...	7	...	...	...	...	...	...	...	...	...	...	...	...	7	66.4	77	15.1	.558
" 29	" 29	" 11	" 22	13	24	..	...	3	...	...	...	...	...	...	...	...	...	...	44	...	...	...	47	65.6	74	17.3	.350
" 31	" 31	" 9	" 14	9	14	..	...	...	...	...	...	...	5	1	65	...	...	...	...	...	...	...	71	65.2	75	18.0	.347
June 3	June 3	.....	.....	...	..	..	...	...	12	...	...	...	...	...	...	...	...	...	...	...	...	...	12	64.9	75	17.5	.293
" 4	" 4	" 13	" 27	9	23	..	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2	...	2	65.6	76	17.0	.293
" 6	" 5	" 19	" 19	13	14	..	...	...	...	...	...	...	10	2	...	...	...	...	...	...	...	...	12	66.0	76	17.4	.305
" 7	" 7	" 23	" 22	16	15	..	...	...	...	5	...	...	...	...	...	...	...	...	...	...	...	...	5	66.3	74	16.8	.085
" 8	" 8	" 22	" 22	14	14	..	...	...	...	37	12	15	11	...	...	...	...	...	...	...	...	...	75	66.9	76	15.7	.097
" 10	" 10	" 16	" 28	6	18	..	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	1	67.7	77	13.9	.158
" 15	" 15	.....	" 24	...	9	..	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	1	67.1	78	13.5	.358
" 15	" 14	" 29	" 23	14	9	..	...	27	...	...	3	...	...	...	...	...	...	...	...	...	...	...	30	67.3	79	13.4	.373
" 16	" 11	" 20	" 24	4	13	1	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2	67.8	78	14.2	.294
				Totals		34	86	255	300	201	159	89	66	27	66	7	...	...	44	3	2	4	1343					

* 3 eggs laid June 5.

SUMMARY OF TABLE 22

Items.	Max.	Min.	Av.
Length of life of male moth in days	17	4	9.2
Length of life of female moth in days	27	5	11.9
Number of days from emergence to laying of first eggs	17	1	5.
Number of days from emergence to laying of last eggs	23	2	6.9
Egg-laying period, in days	14	1	2.9
Number of eggs laid by one female	136	1	30.5
Average mean daily temperature	71.5	61.2	67.1
Average daily humidity	79	68	73.2
Average daily evaporation in c. c.	13.4	21.5	17.74
Average daily rainfall, in inches	.558	.067	.234

TABLE 23—OVIPOSITION AND LIFE PERIOD OF HIBERNATING GENERATION, OLNEY, 1917, AND CLIMATIC DATA FOR FIRST TEN DAYS AFTER EMERGENCE OF FEMALE

Moths emerged.		Moths died.		Adult period.		Number of eggs laid daily 1 to 16 days from date of emergence.																	Av. mean daily temp.	Av. daily humid.	Av. daily evap.	Av. daily rainfall.
Male.	Female.	Male.	Female.	Male.	Female.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Total.				
May 19	May 19	.....	June 3	.....	15	24	32	...	...	31	...	...	...	9	...	...	...	...	...	...	...	96	62.1	72.3	11.3	.209
" 20	" 20	June 5	" 5	16	16	...	25	...	...	...	...	...	5	...	5	...	...	...	...	...	...	35	61.4	73.3	9.9	.210
" 21	" 21	May 30	" 9	9	14	...	...	...	...	...	11	...	...	...	3	...	...	...	...	...	...	14	61.4	73.9	11.4	.278
" 21	" 21	" 29	" 4	8	14	...	...	...	...	10	...	...	2	...	...	...	...	...	...	...	...	12	61.4	73.9	11.4	.278
" 21	" 21	.....	" 9	.....	19	...	...	...	...	41	7	...	1	...	...	...	...	...	...	...	...	49	61.4	73.9	11.4	.278
" 20	" 21	May 30	May 30	10	9	...	...	...	...	26	11	...	...	...	...	...	...	...	...	...	...	37	61.4	73.9	11.4	.278
" 20	" 21	June 3	June 12	14	22	...	...	...	...	33	...	...	14	...	...	...	...	...	...	...	7	54	61.4	73.9	11.4	.278
" 24	" 24	" 1	" 8	8	15	...	...	...	...	...	2	...	...	...	...	...	...	...	...	...	...	2	63.8	77.3	11.8	.457
" 24	" 24	" 5	" 5	12	12	...	...	...	...	32	...	...	...	...	...	...	...	...	...	...	...	32	63.8	77.3	11.8	.457
" 24	" 24	" 4	" 8	11	15	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	1	63.8	77.3	11.8	.457
" 24	" 24	" 5	" 8	12	15	...	...	...	...	11	...	...	...	...	...	...	...	...	...	...	...	11	63.8	77.3	11.8	.457
" 25	" 25	" 3	" 5	9	11	...	...	38	21	...	...	...	16	...	...	...	...	...	...	...	...	75	64.2	78.5	11.8	.457
" 25	" 25	" 8	" 5	14	11	...	...	...	48	...	...	...	...	...	...	...	...	...	...	...	...	48	64.2	78.5	11.8	.457
" 25	" 25	.....	.....	.....	.....	...	...	...	18	...	...	...	...	...	...	...	...	...	...	...	...	18	64.2	78.5	11.8	.457
" 25	" 25	June 2	June 7	8	13	...	...	...	7	41	9	21	...	...	...	...	...	...	...	...	...	78	64.2	78.5	11.8	.457
" 25	" 25	.....	.....	.....	.....	...	...	...	...	6	...	...	...	...	...	...	...	...	...	...	...	6	64.2	78.5	11.8	.457
" 29	" 29	June 1	June 9	3	11	...	...	...	...	...	6	...	...	...	9	...	...	...	...	...	...	15	67.8	76.2	12.2	.528
" 28	" 29	" 8	" 11	11	13	...	...	...	...	...	43	...	...	27	...	...	...	...	...	...	...	70	67.8	76.2	12.2	.528
" 28	" 29	.....	" 13	.....	15	...	...	...	...	...	...	...	...	...	4	...	...	...	...	...	...	4	67.8	76.2	12.2	.528
June 8	June 5	June 13	" 13	5	8	...	...	...	...	9	...	...	...	...	...	...	...	...	...	...	...	9	68.5	75.4	14.8	.188
" 5	" 5	" 13	" 15	8	10	...	69	28	...	...	55	4	...	...	...	...	...	...	...	...	...	156	68.5	75.4	14.8	.188
" 6	" 6	" 12	" 14	.....	.....	39	...	...	56	...	...	...	...	...	...	...	...	...	...	...	...	95	66.2	75.4	14.7	.17
" 9	" 9	" 17	" 23	.....	.....	...	...	...	...	...	...	...	16	...	6	...	...	...	...	...	...	22	64.8	75.1	16.0	.17
" 7	" 7	" 14	.....	7	.....	...	...	...	...	1	...	...	...	1	...	50	13	...	1	4	...	79	65.2	76.0	14.3	.17
					Totals	63	126	66	150	250	144	26	54	37	27	50	13	...	1	4	7	1018				

SUMMARY OF TABLE 23

Items.	Max.	Min.	Av.
Length of life of male moth in days	16	3	9.2
Length of life of female moth in days	22	8	13.5
Number of days from emergence to laying of first eggs	10	1	4.8
Number of days from emergence to laying of last eggs	16	4	7.8
Egg-laying period in days	12	1	4.0
Number of eggs laid by one female	156	1	42.4
Average mean daily temperature	68.5	61.4	64.3
Average daily humidity	78.5	72.3	76.0
Average daily evaporation, in c.c	16.0	9.9	12.3
Average daily rainfall, in inches	.528	.17	.33

TABLE 24—SUMMARY OF LIFE-HISTORY DATA. LARVAE REARED IN APPLES ON TREE

	Year.	Sex.	Egg.		Larva in fruit.		Larva in cocoon.		Larva.		Pupa.		Egg, larva, and pupa.				Adult.		Total life period.	
															Total effective day-degrees.					
			No.	Period in days.	No.	Period in days.	No.	Period in days.	No.	Period in days.	No.	Period in days.	No.	Period in days.	Sum for stages.	(50+)—2(86+).	No.	Period in days.	No.	Period in days.
First generation.	1915	Male	28	9.6	16	28.3	16	4.3	28	31.9	28	10.7	28	51.9	1096	1095				
		Female	46	9.7	36	28.9	31	4.4	44	34.6	44	10.5	46	54.3	1154	1154				
		Male and female	74	9.7	52	28.7	47	4.4	72	33.5	72	10.6	74	53.4	1132	1131				
	1916	Male	31	7.8	28	31.2	27	3.3	28	34.6	28	10.1	31	52.1	1127	1125	24	5.1	24	57.4
		Female	34	7.8	30	31.0	30	3.6	32	35.1	32	9.8	34	52.7	1132	1131	29	6.9	29	59.8
		Male and female	65	7.8	58	31.1	57	3.5	60	34.9	60	10.0	65	52.4	1129	1128	53	6.1	53	58.7
	1917	Male	44	9.2	43	25.1	41	4.7	41	29.6	41	10.9	44	49.8	1095	1107				
		Female	51	9.3	48	26.1	46	4.4	46	30.5	47	10.9	51	50.5	1104	1116				
		Undetermined	9	9.8	8	26.4	8	4.3	8	30.6	9	11.0	9	51.6	1095	1105				
		Male and female	104	9.3	99	25.7	95	4.5	95	30.1	97	10.9	104	50.3	1100	1111				
	1915, 1916, 1917	Male	103	8.9	87	27.6	84	4.2	97	31.7	97	10.6	103	51.1	1104	1109	24	5.1	24	57.4
		Female	131	9.0	114	28.3	107	4.2	122	33.2	123	10.5	131	52.4	1128	1133	29	6.9	29	59.8
		Undetermined	9	9.8	8	26.4	8	4.5	8	30.6	9	11.0	9	51.6	1095	1105				
		Male and female	243	9.0	209	27.9	199	4.2	227	32.5	229	10.6	243	51.8	1118	1122	53	6.1	53	58.7
Transforming part of second generation.	1915	Male	5	6.8	3	25.3	3	4.0	3	29.3	3	15.3	5	49.0	1106	1106				
		Female	8	6.5	8	24.8	8	4.1	8	29.0	8	13.6	8	49.0	1100	1099				
		Undetermined	1	9.0	1	20.0	1	5.0	1	25.0	0		0							
		Male and female	14	6.8	12	24.5	12	4.2	12	28.7	11	14.1	13	49.0	1102	1102				
	1916	Male	36	5.8	33	21.6	32	4.2	33	26.0	33	11.8	36	43.0	1084	1099	25	9.7	25	51.3
		Female	54	6.0	51	22.9	51	4.3	51	27.2	51	12.0	54	44.9	1119	1133	38	10.2	38	55.1
		Undetermined	2	6.5	2	20.5	2	3.0	2	23.5	2	10.5	2	40.5	1071	1088				
		Male and female	92	6.0	86	22.3	85	4.2	86	26.4	86	11.9	92	44.1	1106	1118	63	10.0	63	53.6
	1915, 1916	Male	41	5.9	36	21.9	35	4.2	36	26.3	36	12.1	41	43.7	1087	1100	25	9.7	25	51.3
		Female	62	6.1	59	23.1	59	4.3	59	27.4	59	12.2	62	45.4	1117	1129	38	10.2	38	55.1
		Undetermined	3	7.3	3	20.3	3	3.7	3	24.0	2	10.5	2	40.5	1071	1088				
		Male and female	106	6.0	98	22.6	97	4.2	98	26.8	97	12.1	105	44.7	1104	1119	63	10.0	63	53.6
Hibernating part of second generation and the third generation.	1915-16	Male	43	7.1	42	32.7	41	233	41	266	42	26.5	43	299			6	7.5	6	306
		Female	46	7.1	43	33.9	41	237	42	272	44	25.8	46	304			35	9.1	35	311
		Undetermined	22	8.8	16	31.1	16	227	22	255	8	26.6	8	289						
		Male and female	111	7.4	101	33.0	98	234	105	266	94	26.2	97	301			41	8.9	41	310
	1916-17	Male	57	6.1	56	26.4	54	236	55	262	52	35.0	54	303			18	8.7	18	314
		Female	66	5.9	62	26.3	54	240	56	266	52	35.0	61	306			25	12.8	25	318
		Undetermined	8	6.1	5	25.4	5	244	7	267	2	34.5	3	307						
		Male and female	131	6.0	123	26.3	113	238	118	264	106	34.3	118	305			43	11.1	43	317
	1915-16 and 1916-17	Male	100	6.5	98	29.1	95	235	96	264	94	31.2	97	301			24	8.4	24	312
		Female	112	6.4	105	29.4	95	239	98	269	96	30.8	107	305			60	10.6	60	314
		Undetermined	30	8.1	21	29.7	21	231	29	258	10	28.2	11	294						
		Male and female	242	6.7	224	29.3	211	236	223	265	200	30.9	215	303			84	10.0	84	313

TABLE 25—SUMMARY OF LIFE-HISTORY DATA. FIRST GENERATION LARVAE REARED IN PICKED APPLES

Year.	Sex.	Egg.		Larva in fruit		Larva in cocoon		Larva.		Pupa.		Egg, larva, and pupa.				Adult.		Total life period	
														Total effective day-degrees.					
		No.	Period in days.	No.	Period in days.	No.	Period in days.	No.	Period in days.	No.	Period in days.	No.	Period in days.	Sum for stages	$\frac{(50+98)}{2}$	No.	Period in days.	No.	Period in days.
1915	Male	14	8.0	7	24.9	7	3.7	14	27.2	14	10.6	14	45.9	1002	999				
	Female	17	7.8	9	22.4	9	3.6	17	27.1	17	10.8	17	45.7	1013	1012				
	Male and female	31	7.9	16	23.5	6	3.6	31	27.1	31	10.7	31	45.8	1008	1006				
1916	Male	37	9.7	32	21.2	32	4.6	33	26.0	33	10.1	37	46.0	1018	1018	30	5.3	30	51.6
	Female	50	9.4	50	20.4	49	4.6	49	24.8	49	10.0	50	44.4	1005	1006	44	6.4	44	50.5
	Male and female	87	9.5	82	20.7	81	4.6	82	25.3	82	10.1	87	45.1	1011	1011	74	5.9	74	50.9
1915 and 1916	Male	51	9.2	39	21.9	39	4.4	47	26.4	47	10.2	51	45.9	1014	1013	30	5.3	30	51.6
	Female	67	9.0	59	20.7	58	4.4	66	25.4	66	10.2	67	44.7	1007	1008	44	6.4	44	50.5
	Male and female	118	9.1	98	21.2	97	4.4	113	25.8	113	10.2	118	45.2	1010	1010	74	5.9	74	50.9

11. Taking 50 as the zero of development for all three stages and disregarding the slight differences in the units due to the use of 88, 85, and 87 as the degree of the maximum rate of development of the egg, larva, and pupa, respectively, we have for the equation of development of the three stages PE = 1101.

Since the larval period is about equal to the egg and pupal periods combined, the use of 86 degrees as the degree of maximum rate of development for all three stages will give about the same results and will give units of the same value for all three stages.

Observations on the Life History of the Codling-moth in 1915, 1916, and 1917

Continuous observations were made on the life history of individuals throughout the seasons of 1915, 1916, and 1917. The methods employed in making these observations are described on page 228 of this article.

The following tables give the principal facts as to length of the periods, oviposition, and number of effective day-degrees which accumulated during the entire period of development. In computing the effective day-degrees for the stages, 50 degrees F. was taken as the zero of development and 88, 85, and 87 as the degree of maximum rate of development of the egg, larva, and pupa, respectively. By reason of the slightly different degrees of the maximum rate of development used for the different stages, the effective day-degrees of the different stages are units of not quite the same size and strictly speaking can not be added, but they differ so slightly that their sums, which are recorded in next to the last column in the tables, will serve as a basis for comparison.

In order that we might have a common unit in terms of which to express the accumulated effective day-degrees of the whole period from the deposition of the eggs to the emergence of the adult, it was necessary to use as the degree of the maximum rate of development a single point instead of 85, 87, and 88, and 86 was selected as the nearest integral degree to the weighted average of the three. Using 50 as the zero of development and 86 as the degree of maximum rate of development, the effective day-degrees which accumulated during the combined egg, larval, and pupal periods were computed and recorded in the last column in the tables. All of the tables bearing on the life history of the insect (Tables 9—25) follow.

Erratum: P. 253, last line, for "*follow*" read "*precede this page.*"

INCUBATION PERIOD

Eggs of the first generation hatch during May and June. The period varied from 13 days during the cooler period early in May to 6 days during the warmer parts of June, the average being 9 days for the 243 eggs used in the life history series. In a larger series of observations consisting of 2664 eggs the period varied from 15 days to 6 days and the average was 9.3 days.

Eggs of the second generation hatched during July, August, and the early part of September and the incubation period varied from 5 to 9 days, depending upon the temperature, the average for 106 eggs from which transforming larvæ hatched being 6 days. The eggs of the transforming larvæ hatch prior to the middle of August, during the warmest part of the season. Their incubation period is shorter than the period of those from which the hibernating larvæ hatch later in the season. The average period for 1748 second-generation eggs was 6.6 days.

Eggs of the third generation hatched during the latter half of August and during September. The period varied from 6 to 15 days, the average for 302 eggs observed being 8.2 days.

Eggs of the hibernating generation, which consists of a very small per cent. of the first generation, a larger per cent. of the second, and all of the third generation, hatched during July, August, and September. The incubation period varied from 5 to 15 days, the average for the 242 eggs used in the life-history series being 6.7 days.

There was practically no difference between the incubation period of male and of female eggs; the average period of 340 of the former belonging to all generations was 7.9 days and of 395 of the latter 7.8 days.

Early in May and late in September the incubation period is comparatively long, varying from 12 to 15 days. It decreases in length till midsummer, when it is only 5 days, and then increases in length till the end of the season. The relation of temperature to the length of the incubation period is shown in Table 1, page 235.

LARVAL PERIOD

Transforming larvae.—The larval period of the first generation of larvæ reared in apples on the tree varied from a maximum of 42 days in the fruit and 9 days in the cocoon to a minimum of 18 days in the fruit and 1 day in the cocoon, the average period in the fruit being for males 27.6 days, for females 28.3 days, and for both males and females 27.9 days, and in the cocoon 4.2 days for both males and females.

The larval period of larvæ reared in picked apples averaged 21.2 days in the fruit and 4.4 days in the cocoon. The average total larval period of 227 first-generation larvæ reared in apples on the tree was 32.5 days and of 113 larvæ reared in picked fruit 25.8 days, the difference being 6.7 days. It was shown in Tables 3 and 4 that the accumula-

tion of effective day-degrees was 86 greater during the period of larvæ reared in apples on the tree than during the period of larvæ reared in picked fruit. Since the average daily accumlation of day-degrees shown in these tables is approximately 22.75, the difference in day-dgrees represents a difference of about 4 days in the period. That is, larvæ of the first generation may be expected to mature, on an average, about 4 days earlier in picked fruit than in fruit on the tree. The difference of 6.7 days shown above is, therefore, partly due to differences in temperature as well as to difference in the condition of the fruit in which the larvæ fed.

The period of transforming larvæ of the second generation varied from a maximum of 33 days in the fruit and 7 days in the cocoon to a minimum of 17 days in the fruit and 1 day in the cocoon, the average period in the fruit being 22.6 days and in the cocoon 4.2 days. The average total period for 36 males was 26.3 and for 59 females 27.4, the average for both being 26.8 days. The larval period of the female was about one day longer than that of the male.

Hibernating larvae.—In treating the larvæ of the hibernating generation no distinction has been made between larvæ of the different generations of the season which compose it. The period of the larvæ varied from a maximum of 46 days in the fruit and 269 days in the cocoon to a minimum of 16 days in the fruit and 209 days in the cocoon, the average period in the fruit being 29.0 days and in the cocoon 236. The average total period of hibernating larvæ was 264 for the males, 269 for the females and 265 for both males and females.

The length of the larval period is affected by temperature and the character of food. It also varies in length in different individuals, even when they are under the same conditions as to temperature and food. The individual variations are well illustrated by the following examples. The periods of 16 larvæ which hatched on May 31, 1917, varied from 25 to 33 days and the periods of 16 others which hatched June 11, 1917, varied from 24 to 38 days, though the environment of the individuals of each lot was as nearly the same as it was possible to have it. It is not infrequent that in lots of individuals kept under the same conditions as to light, food, heat, and moisture the variation in the period from the average for the group equals 30 per cent. of the average period.

The relation of temperatures to the length of the larval period is shown in Tables 3 and 4, pp. 240, 243. A comparison of these two tables also shows that development is more rapid in picked apples than in apples on the tree. According to Table 3, at an average mean daily temperature of 74.31° F., the average period is 29.07 days in apples on the tree; and according to Table 4, at an average mean daily temperature of 74.08° F., the period is 25.69 days in picked fruit, or 3.4 days less than the period in apples on the tree.

PUPAL PERIOD

Pupæ of the first generation were present from about the middle of June to the middle of August and the period varied from 8 to 14 days, the average being 10.6 days. Pupæ of the second generation were present during August and the first part of September. The period varied from 9 to 18 days, the average being 12.1 days. None of the third-generation larvæ pupated. The pupal period of this generation is therefore discussed in connection with the hibernating generation.

Pupæ of the hibernating generation were present during April, May, and the first part of June. The period varied from 39 days to 18 days, the average being 30.9 days. The average pupal period of the males and the females is practically the same. The period of the hibernating generation is much longer than that of the other generations because pupæ are present during early spring when the weather is cool.

COMBINED EGG, LARVAL, AND PUPAL PERIODS

The whole period of development is of the greatest importance since it is an index to the time which elapses from the deposition of the egg to the emergence of the adult. Since the deposition of eggs frequently begins within one day after the emergence of the female, the addition of one day to the period of development will give the time which elapses from the deposition of the egg of one generation to the deposition of the first egg of the following generation. For 103 males of the first generation the period varied from 40 to 59 days, the average being 51.1 days; for 131 females, the period varied from 43 to 62 days, the average being 52.4 days. For both males and females the average was 51.8 days.

The period of development for the individuals which hatch first in the spring is much longer than for those which hatch later, the minimum period for those hatching earliest being 50 days. We may expect, therefore, the deposition of the first eggs of the second generation to follow the deposition of the first eggs of the first generation in an average of about 51 days, though the average for this same period for the entire generation is only about 53 days. The above applies to individuals whose larval period was passed in apples on the tree. The period would be about 4 or 5 days shorter for those whose larvæ fed on picked apples.

The development period of 41 transforming males of the second generation varied from 38 to 50 days, the average being 43.7 days, and of 62 females from 33 to 56 days, the average being 45.4 days, the average for males and females being 44.7 days. The minimum period for the first individuals of the second generation was 37 days. We may, therefore, expect the deposition of eggs of the third generation to begin about 38 days after the deposition of the first eggs of the second generation.

The period from the first eggs of one generation to the first eggs of the next will vary with the season. The time which elapsed between

the deposition of the first eggs of the first and second generations was 59 days in 1915, in 1916 it was 53 days, and in 1917, 43 days. The time which elapsed between the deposition of the first eggs of the second and the first of the third generation in 1915 was 46 days, and in 1916, 39 days.

The total development period for 97 males of the hibernating generation varied from 266 to 318 days, the average being 301 days, and for 103 females from 271 to 324 days, the average being 305 days, and the average for both males and females being 303 days.

ADULT PERIOD

As shown in Tables 13 and 14,* 60 male adults of the first generation lived a maximum of 14 days, a minimum of 3 days, and an average of 6.4 days and 63 female adults a maximum of 15 days and an average of 7.4 days—an average of 6.9 days for both male and female adults. The averages given in Table 24 are for a smaller group and the averages are somewhat smaller.

Twenty-five male adults of the second generation lived a maximum of 12 days, a minimum of 3 days, and an average of 6.1 days; and 28 female adults lived a maximum of 24 days, a minimum of 5 days, and an average of 10.3 days (Tables 17, 18). The averages for a different and somewhat larger group shown in Table 24 are 9.7 days for the males, 10.2 days for the females, and 10 days for both males and females.

Ninety-one males of the hibernating generation, according to Tables 21, 22, and 23, lived a maximum of 24 days, a minimum of 3 days, and an average of 10.5 days, and 95 females lived a maximum of 27 days, a minimum of 5 days, and an average of 13.05 days. The averages of a smaller group, shown in Table 24, are smaller, being 10 days for both males and females.

TOTAL LIFE PERIOD

The total life period of 24 males of the first generation, the larvæ of which were reared in apples on the tree, varied from 40 days to 68 days, the average being 57.4 days; and that of 29 females varied from 43 days to 68 days, the average being 59.8, and the average for both males and females being 58.7.

The total life period of 30 males of the first generation, the larvæ of which were reared in picked apples, varied from 42 to 60 days, the average being 51.6 days, and that of 44 females varied from 42 to 58 days, the average being 50.5 days, and the average for both males and females being 50.9 days.

Of the second generation the total life period of 25 males whose larvæ transformed, varied from 42 to 61 days, the average being 51.3 days, and that of 38 females varied from 45 to 65 days, the average being 53.6 days.

---

* See group of tables following p. 253.

The remaining portions of the second generation and all of the third generation belong to the hibernating generation.

Of the hibernating generation, the total life period of 24 males varied from 286 days to 329 days, the average being 312 days, and that of 60 females varied from 288 to 330 days, the average being 314 days, and the average of both males and females being 313 days.

The maximum periods are for individuals whose larvæ left the fruit early in August, and the minimum periods for those whose larvæ left the fruit late in the fall. Larvæ which left the fruit late in the fall pupated and developed into moths at the same time as those which left the fruit earlier in the season as will be shown later on.

OVIPOSITION

Most of the first-generation females began to deposit eggs on the first or second day after emerging. The maximum number of eggs were laid on the second day. Oviposition ceased after the ninth day. The average number of eggs laid by each female was 39 in 1915 and 47.3 in 1916.

Oviposition by females of the second generation began later, but a majority of the moths had begun to oviposit by the third day. The maximum number of eggs in 1915 was laid on the sixth day and in 1916 on the second day after the emergence of the adults. This difference was no doubt due to the lower temperatures which prevailed in 1915. The average number of eggs laid by each female in 1915 was 66.3 and in 1916 it was 68.7.

Oviposition by females of the hibernating generation takes place in the spring when the weather is cool. Very few females begin to oviposit on the first day after emerging, and a majority do not begin to oviposit till the fourth day. The maximum number of eggs was laid on the fourth day after the emergence of the female in 1915 and 1916 and on the fifth day in 1917. Oviposition practically ceased after the tenth day but a few eggs were laid as late as the sixteenth day. The average number of eggs laid by each female varied from 30.5 in 1916 to 42.4 in 1917. Low temperatures and heavy precipitation delay oviposition.

Adults when confined in small cages do not act normally. They attempt to escape from the cage and soon become disabled. Doubtless in the open the females live longer and deposit a larger number of eggs than the averages above given. The maximum number of eggs laid by a single female was 172, the next highest numbers were 167, 156, 143, 136 and 120.

RELATION OF TEMPERATURE TO LENGTH OF DEVELOPMENT PERIOD

The total effective day-degrees which accumulated during the three development periods were determined in two ways: first, by adding together the total effective day-degrees of the egg, larval, and pupal periods

as determined by the use of 50 degrees F. as the zero of development and 88, 85, and 87 degrees F. as the degrees of the maximum rate of development of the egg, larva, and pupa respectively; and, second, by using 50 as the zero of development and 86 as the degree of the maximum rate of development for the entire period. The results are recorded in the next to the last and the last column, respectively, in the tables. The average total for the first generation, as shown in Table 24, computed by the latter method, was 1122, or 4 more than the total computed by the former method, and for the second generation it was 1119, or 15 more computed by the latter method than by the former method. The maximum difference amounts to less than half a day in the development period and hence the latter method may be used for practical purposes, and the following discussion will have reference to results obtained by it.

The average total day-degrees for the female is about 20 greater than for the male and 10 greater than the average for the male and the female, which indicates that the female has a slightly longer period than the male.

There is a large variation in individuals as to the length of the development period and hence in the total effective day-degrees which accumulate during the period. In individual cases these totals varied from 814 to 1475, but less than 4 per cent. of them were below 950, and less than 2 per cent above 1350. Since some of the extremely high and extremely low totals recorded were probably due to errors in observations, 950 and 1350 may be regarded as the approximate extremes, 1120 being the average.

The total day-degrees which accumulated during the development period of individuals whose larvæ were reared in picked fruit, as shown in Table 25, were 1010, or 109 less than the average for individuals whose larvæ were reared in apples on the tree, showing that larvæ develop more rapidly in picked fruit than in fruit on the tree.

Seasonal History of the Codling-moth, 1915*

The seasonal history of the codling-moth was determined at Olney by large-cage experiments, supplemented by data secured from band collections and the life history studies.

LARGE-CAGE SERIES

The cages (Fig. 5, 6, 7) used in these experiments were large enough to cover entire trees and were used for the purpose of keeping the generations under observation separate, so that the number of generations, the time of beginning, and the time of ending could be definitely determined. The events especially noted were dates when the first and the last moths

* A preliminary report on the observations and experiments of the year 1915 was published in the 29th report of the State Entomologist of Illinois, issued in January, 1916, and also in the annual report of the State Horticultural Society for 1915. That paper ("On the Life History of the Codling-moth," by Stephen A. Forbes and Pressley A. Glenn) contains some data and discussions not repeated in the present article.

were liberated in their respective cages, dates when the first and the last larvæ left the fruit, when they pupated, and when the moths emerged.

First generation, 1915.—The first moths which emerged from hibernating larvæ were liberated in cage No. 1, as follows:

Date	Males	Females
May 1	4	1
" 2	2	0
" 3	8	4
" 4	0	1
" 5	4	2
" 6	12	6

The first eggs were found in the cage on the morning of May 6. They had probably been laid during the evening of the preceding day. These eggs hatched May 17. There was a heavy June drop of apples all over the orchard and the drop was especially heavy from some of the trees caged. In cage No. 1, 275 apples were picked up May 20 and placed in battery jars. They averaged only about one-half inch in diameter. June 4, 800 were picked up, June 9, 700, June 12, 300, and June 19, 150. At this time only a few apples remained on the tree. Larvæ began to leave the fruit in this cage June 22.

In another cage; in which moths had been liberated on May 12, or 12 days later than in cage No. 1, larvæ began to leave the fruit June 22. Judging from this, had normal conditions prevailed in cage No. 1, larvæ should have begun to leave the fruit 11 days earlier than they did—that is, on June 11. This date corresponds very well with the date when the first larvæ were taken under bands, which was June 12.

The last moths of the hibernating generation were liberated in cage No. 2, as follows:

Date	Males	Females
May 31	11	9
June 1	4	5
" 2	3	4
" 3	5	8
" 8	6	12
" 9	2	3
" 10	1	1
" 11	1	3
" 12	2	3
" 13	1	4
" 15	1	1

Larvæ began to leave the fruit in cage No. 2 on July 6 and continued to leave the fruit till August 1. Pupation continued till August 4, and moths continued to emerge till August 17. Two larvæ which left the fruit July 17 and 19 respectively, hibernated. All other larvæ kept under observation transformed or died.

Second generation, 1915.—The first moths from cage No. 1 were liberated in cage No. 3, to rear the first of the second generation, as follows:

Date	Males	Females
July 1	2	3
" 3	1	1
" 5	11	11
" 6	5	10

The first eggs were laid July 3, the first larvæ hatched July 11, the first larvæ left the fruit August 2 (these larvæ were lost), the first pupæ were found August 7, and the first moths emerged August 17.

The first larvæ to hibernate, left the fruit August 9. All larvæ which left the fruit after August 15, hibernated. The last pupa was obtained August 19 and the last moth September 2.

The last adults of the first generation to emerge from materials reared in cage No. 2 were liberated in cage No. 4, to rear the last of the second generation, as follows:

Date	Males	Females
Aug. 2	4	2
" 3	6	3
" 4		3
" 5	5	8
" 6	4	4
" 7	2	
" 8	5	6
" 12	1	1
" 13	1	1
" 14	1	1
" 17		1
Sept. 6		1

The last eggs were laid September 12. The last of these eggs hatched September 17. Larvæ began to leave the fruit in this cage September 12 and continued to leave the fruit till November 1, the date of the last observation. All of the larvæ reared in this cage hibernated.

Third generation, 1915.—To rear the third generation, moths which were reared in cage No. 3 were liberated in cage No. 5, as follows:

Date	Males	Females
Aug. 22	2	2
" 23	4	4
" 24	7	4
" 25	2	1
" 27	2	1
" 29	1	1
Sept. 3		2
" 5		1

The first eggs were observed August 26 and the first larvæ left the fruit September 28. The last egg observed was laid September 1 and hatched September 9. Since adults of the second generation continued

to emerge till September 5, oviposition no doubt continued till about September 15 and hatching till about September 25. Larvæ continued to leave the fruit till November 1, the date of the last observation. All the larvæ reared in cage No. 5 hibernated.

BAND COLLECTIONS

Hibernating generation, 1914–1915.—Hibernating larvæ were collected at Centralia and Olney April 12, 13, and 14. About 1400 were kept at Olney and the remaining 600 were kept under observation at Ozark. From 5 to 10 per cent. of the larvæ collected on the above dates had pupated. Judging from the time the first moths emerged, pupation began about April 9. Pupation was very irregular owing to variable weather conditions. It was at its maximum at Olney from April 22 to April 29, and continued till June 2. Larvæ kept under observation at Urbana, Illinois, 100 miles north of Olney, began to pupate April 20 and continued to pupate till May 24.

The first moths emerged at Olney April 27, the maximum emergence occurred May 14 and 15, and moths continued to emerge till June 26. A record of pupation and emergence of adults at Olney will be found in Table 26.

Collections made in 1915.—The bands used at Olney were two-ply burlap bands about 4 inches wide. They were placed on the trees about June 1 and examined daily until the first larvæ were found. After that they were examined every third day. When collected the number of males and females were recorded, and, at Olney, they were preserved for the purpose of observing pupation and emergence (Table 26).

Larvæ of the first generation began to leave the fruit June 12. The maximum number were leaving the fruit about June 25. The larvæ of the first and second generations overlapped during the last week in July and the first week in August. Development was greatly retarded during August on account of unusually cool weather, and was greatly accelerated during the second and third weeks of September on account of unusually warm weather. These weather influences are indicated in the band records by the relatively small number of larvæ collected during August and the large number during September. The falling off in band collections after September 21 was due largely to the fact that apple-picking began at about that date.

A daily record of the band collections, life-history observations, and climatic conditions at Olney in 1915 have been brought together in Table 26 for ready reference.

TABLE 28—Seasonal History of the Codling-moth at Olney in 1915

TABLE 26—Data obtained from Band Collections and Life-history Observations, with accompanying Climatic Data, Olney, 1915

Date.	From hibernating larvæ.		From larvæ collected 1915.			Life history data.										Climatic data.				
						First generation.				Second generation.				Third generation.						
	Pupæ.	Adults.	Larvæ under bands.	Pupæ.	Adults.	Eggs.	Larvæ hatching.	Larvæ pupating.	Moths emerging.	Eggs laid.	Larvæ hatching.	Larvæ pupating.	Moths emerging.	Eggs.	Larvæ hatching.	Mean temp.	Effective day-deg. (50+)—2(86+).	Humidity.	Evaporation.	Rainfall
Apr. 1	....	....	.....	.....	.....	.....	....	....	....	.....	....	....	....	....	....	34.5				
" 2	....	....	.....	.....	.....	.....	....	....	....	.....	....	....	....	....	....	38.0				
" 3	....	....	.....	.....	.....	.....	....	....	....	.....	....	....	....	....	....	38.0				
" 4	....	....	.....	.....	.....	.....	....	....	....	.....	....	....	....	....	....	44.8	1.6			
" 5	....	....	.....	.....	.....	.....	....	....	....	.....	....	....	....	....	....	56.8	8.5			
" 6	....	....	.....	.....	.....	.....	....	....	....	.....	....	....	....	....	....	64.0	14.1			
" 7	....	....	.....	.....	.....	.....	....	....	....	.....	....	....	....	....	....	62.0	12.1			
" 8	....	....	.....	.....	.....	.....	....	....	....	.....	....	....	....	....	....	64.3	14.3			
" 9	....	....	.....	.....	.....	.....	....	....	....	.....	....	....	....	....	....	66.7	16.7			
" 10	....	....	.....	.....	.....	.....	....	....	....	.....	....	....	....	....	....	60.0	10.1			
" 11	....	....	.....	.....	.....	.....	....	....	....	.....	....	....	....	....	....	54.5	5.1			
" 12	....	....	.....	.....	.....	.....	....	....	....	.....	....	....	....	....	....	45.3	.6			
" 13	1	....	.....	.....	.....	.....	....	....	....	.....	....	....	....	....	....	46.0	1.6	53		
" 14	....	....	.....	.....	.....	.....	....	....	....	.....	....	....	....	....	....	50.3	4.7	45		
" 15	1	....	.....	.....	.....	.....	....	....	....	.....	....	....	....	....	....	52.4	5.8			
" 16	3	....	.....	.....	.....	.....	....	....	....	.....	....	....	....	....	....	60.8	11.3	72		
" 17	4	....	.....	.....	.....	.....	....	....	....	.....	....	....	....	....	....	59.6	10.0	51		
" 18	1	....	.....	.....	.....	.....	....	....	....	.....	....	....	....	....	....	58.2	9.5	52		
" 19	6	....	.....	.....	.....	.....	....	....	....	.....	....	....	....	....	....	63.5	14.2	59		
" 20	8	....	.....	.....	.....	.....	....	....	....	.....	....	....	....	....	....	65.7	15.8	61		
" 21	9	....	.....	.....	.....	.....	....	....	....	.....	....	....	....	....	....	63.2	14.9	80		
" 22	10	....	.....	.....	.....	.....	....	....	....	.....	....	....	....	....	....	64.1	14.1	80		
" 23	13	....	.....	.....	.....	.....	....	....	....	.....	....	....	....	....	....	68.8	19.0	62		
" 24	13	....	.....	.....	.....	.....	....	....	....	.....	....	....	....	....	....	72.7	22.7	65		
" 25	8	....	.....	.....	.....	.....	....	....	....	.....	....	....	....	....	....	71.4	21.4	59		
" 26	22	....	.....	.....	.....	.....	....	....	....	.....	....	....	....	....	....	72.3	22.4	59		
" 27	9	1	.....	.....	.....	.....	....	....	....	.....	....	....	....	....	....	73.8	23.7	67		
" 28	6	2	.....	.....	.....	.....	....	....	....	.....	....	....	....	....	....	72.8	22.8	54		
" 29	14	2														69.5	19.5	46		
" 29	....	....	.....	16	6	.....	....	8	8	11	69	....	....	....	....	79.1	29.1	78	17	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	56.7	7.5	52		

TABLE 26—Data obtained from Band Collections and Life-history Observations, with accompanying Climatic Data, Olney, 1915

Date	From hibernating larvæ: Pupæ	From hibernating larvæ: Adults	From larvæ collected 1915: Larvæ under bands	From larvæ collected 1915: Pupæ	From larvæ collected 1915: Adults	Life history data, First generation: Eggs	First generation: Larvæ hatching	First generation: Larvæ pupating	First generation: Moths emerging	Second generation: Eggs laid	Second generation: Larvæ hatching	Second generation: Larvæ pupating	Second generation: Moths emerging	Third generation: Eggs	Third generation: Larvæ hatching	Climatic data: Mean temp.	Effective day-deg. (50+)—2(86+).	Humidity	Evaporation	Rainfall
Apr. 1																34.5				
" 2																38.0				
" 3																38.0				
" 4																44.8	1.6			
" 5																66.8	8.5			
" 6																64.0	14.1			
" 7																62.0	12.1			
" 8																64.3	14.2			
" 9																66.7	16.7			
" 10																60.0	10.1			
" 11																54.5	5.1			
" 12																45.3	.6			
" 13	1															46.0	1.6	53		
" 14																50.3	4.7	45		
" 15	1															52.4	5.8			
" 16	3															60.8	11.3	73		
" 17	4															59.6	10.0	51		
" 18	1															58.2	9.5	53		
" 19	6															63.5	14.2	59		
" 20	8															65.7	15.8	61		
" 21	9															63.2	14.9	80		
" 22	10															64.1	14.1	80		
" 23	13															68.8	19.0	62		
" 24	13															72.7	22.7	65		
" 25	8															71.4	21.4	59		
" 26	22															72.3	22.4	59		
" 27	9	1														73.8	23.7	67		
" 28	6	2														72.8	22.8	54		
" 29	14	2														69.5	19.5	46		
" 30	7	2														60.0	11.0	48		
May 1	5	1														58.8	8.8	70	26	
" 2	5	2														60.8	10.8	77	15	.67
" 3	13	12														69.1	19.1	55	37	.21
" 4	4	0														58.4	8.4	70	25	
" 5	5	5				46										56.1	6.8	64	31	
" 6	2	15				2										59.0	9.0	78	24	.02
" 7	4	20				12										62.1	12.1	67	8	1.14
" 8	2	18				19										57.1	7.5	60	33	
" 9	2	0				16										54.1	5.2	61	24	
" 10	3	29				7										54.5	7.0	59	24	
" 11	1	46				5										60.0	10.8	63	22	
" 12	1	65														65.0	15.0	64	25	
" 13	4	84														70.0	20.0	59	28	
" 14	4	146														73.0	23.0	72	17	.15
" 15	2	147														75.3	24.7	52	45	
" 16	12	82														74.6	24.6	50	47	
" 17							12									54.2	5.0	64	50	
" 18																50.9	2.1	87		.39
" 19	2	2														50.5	1.4	83	8	.12
" 20		59					33									60.4	10.4	76	7	1.61
" 21		62				93	48									71.0	21.0	70	19	.33
" 22	2	43				126	11									65.3	15.3	72	13	.01
" 23	1	9				74	2									61.0	11.0	84		.47
" 24	2	24				75										66.0	16.0	79	15	
" 25		21				30										65.5	15.5	88	3	.60
" 26		4				23										64.1	41.1	85		.85
" 27		6				17										57.3	7.3	86	6	.62
" 28	3	22				12										63.3	13.3	89	3	.52
" 29																62.8	12.8	85	6	.23
" 30		15														58.8	8.8	85	5	.01
" 31		5														62.3	12.3	84	12	
June 1		9				92										64.8	14.8	90	5	.22
" 2	1	7				50	5									65.6	15.6	85	3	.14
" 3		13				96	113									67.3	17.3	79	13	
" 4		12				243	63									71.1	21.1	85	7	1.15
" 5		13				36	42									73.7	23.7	83	12	.13
" 6		7				120	37									73.6	23.6	79	15	.30
" 7		11				61	11									73.3	23.3	79	14	
" 8		1				3	15									58.2	8.4	74	15	
" 9		5				2	28									61.2	11.2	73	15	
" 10		2					30									64.9	14.9	71	18	
" 11		4					96									72.6	22.6	82	14	
" 12		5	1				127									75.6	25.6	75	17	
" 13		5					107									77.0	26.5	79	14	
" 14		4				40	29									72.1	22.1	84	14	.24
" 15		1				49	5									68.9	18.9	78	13	.06
" 16			17			15	2									68.8	18.8	74	18	
" 17				1		29										70.8	20.8	71	15	
" 18						53										72.6	22.6	83	12	.45
" 19			48	6		9		3								71.6	21.6	79	18	
" 20		2		6			5	7								73.6	23.6	85	9	.70
" 21		1		1		7	36	1								74.4	24.4	83	4	1.27
" 22			96	2		7	30	2								72.1	22.1	71	18	
" 23				7		2	37	2								67.8	17.8	69	18	
" 24		1				5										67.4	17.4	77	14	
" 25			211	6		1	37	5								67.8	17.8	74	18	
" 26				58		4	2	15								71.1	21.1	70	20	
" 27				33			4	24								72.5	22.5	80	12	
" 28			189	37	1			22								73.1	23.1	89	10	.25
" 29				98				17								72.6	22.6	89		.62
" 30				29				6								71.5	21.5	80	11	
July 1			113	18	3			19	4							71.1	21.1	79	11	
" 2				23	2			10	2							71.5	21.5	74	17	
" 3			101	36	3			12	2	55						69.5	19.5	75	11	.15
" 4				22	4			7	4	7						65.2	15.2	85	4	.54
" 5				63	19			36	1	18						61.1	11.1	71	18	
" 6				38	16			12	2	7						65.6	15.6	71	19	
" 7			133	67	5			8		27						69.4	19.4	88	6	.96
" 8				37	5			5	3	83						68.4	18.4	87	6	.61
" 9				41	18			9	11	4						68.3	18.3	78	14	
" 10			66	14	35			18	31	25						72.2	22.2	87	4	.62
" 11				23	29			8	15	5	52					71.7	21.7	84	3	.42
" 12				10	105			15	9		6					73.7	23.7	86	8	.85
" 13			37	14	37			14	18	76	20					77.4	27.1	78	12	
" 14				24	33			27	17	47	50					80.3	28.8	80	16	
" 15				13	40			15	27		4					82.6	30.5	74	20	
" 16			46	5	61			6	34		8					82.3	30.6	79	24	
" 17				8	40			1	24	87	6					80.2	29.7	78	12	.64
" 18				3	65			15	17	4						80.5	29.7	80	16	
" 19			39	6	44			7	13		58					77.2	27.2	78	9	.32
" 20				14	40			4	17	25	16					76.6	26.6	71	15	
" 21				15	14			4	7	1						68.9	18.9	71	22	
" 22			40	13	28			6	11	7						68.8	18.8	83	17	.10
" 23				7	16			5	6	74						70.2	20.2	70	16	
" 24			31	12	18			6	25	80	32					71.3	21.3	75	15	
" 25				6	15			4	15	32	14					72.4	22.4	77	12	
" 26				5	11			16	9		2					75.5	25.5	78	26	.01
" 27				16	8			16	6							77.4	27.4	82	15	
" 28			40	13	5			10	4	76	20					77.2	26.0	74	16	.20
" 29				16	6			8	8	31	69					79.1	29.1	78	17	
" 30				4	14			9	10	93	50					79.3	29.3	80	10	.28
" 31			19	8	15			1	1	75	24					82.0	29.5	80	16	.67
Aug. 1				6	9			2	12							77.3	27.3	83	12	
" 2				9	11				8		37					76.8	26.8	83	11	.04
" 3			21	6	8			1	5		40	1				75.8	25.8	83	9	.05
" 4				5	3			1	5							65.1	15.1	81	7	.04
" 5				2	4				4		7					63.8	13.8	72	7	.02
" 6			65	0	16				11		66					70.1	20.1	72	23	
" 7				7	13				8		18	1				70.4	20.4	69	17	
" 8				13	13				10	39	20	3				76.1	26.1	74	18	
" 9			100	4	5				6	1		4				75.3	25.3	74	13	
" 10				30	7				6			10				72.7	22.7	91		.55
" 11				13	5				4	7		4				68.8	18.8	87	4	.45
" 12			82	12	10				1	41		6				68.2	18.2	78	12	
" 13				22	6				1	1		6				70.3	20.3	76	5	
" 14			54	13	1				4	2		1				71.4	21.4	87	2	.64
" 15					2					7	13	2				70.7	20.7	78	9	
" 16				4	4			1	1		19	1	1			77.3	27.0	81	6	1.07
" 17				3	2			1		1	1	5				74.1	24.1	82	4	.58
" 18			145	13								1				67.3	17.3	86		.32
" 19				14	1								2			64.7	14.7	78	12	.01
" 20				10												65.8	15.8	91		3.02
" 21			136	15	7						22					61.1	16.1	81	7	.35
" 22				5	5					121	4		3	78		66.8	16.8	75	12	
" 23				8	8					20			8	18		68.7	18.7	80	15	
" 24			174	2	16					7			7	3		72.7	22.7	78	10	.03
" 25				2	9								2	39		63.8	13.8	76	9	
" 26				6	12									41		62.0	12.0	81	5	
" 27			161	2	19								7	12		65.8	15.8	80	14	
" 28					20											63.8	13.8	79	11	
" 29				1	13								2		4	63.9	13.9	87	1	.08
" 30			139		4									49	2	60.9	10.9	75	10	
" 31					3								1			56.4	7.1	76	9	
Sept. 1					13						32				14	61.4	11.4	77	14	
" 2			143		12						56		1	65	3	67.5	17.5	77	21	
" 3					11						6		2			68.8	18.8	79	14	
" 4			176		15						4		2		12	69.4	19.4	82	14	
" 5					4						2		1	23	16	69.2	19.2	87	5	
" 6				2	5										6	68.8	18.8	82	11	.32
" 7					1										1	73.2	23.2	85	15	
" 8			434		7										1	77.9	27.9	78	22	
" 9					6											76.1	26.1	83	16	
" 10					5										3	76.9	26.9	79	17	.06
" 11			369		1									29		77.3	26.8	79	16	
" 12					1											78.5	27.7	92	20	
" 13				1	1									56		79.6	27.8	74	26	
" 14			393													81.2	29.7	75	25	
" 15				1	1											79.2	28.4	81	21	
" 16					1											76.0	26.0	83	18	.01
" 17			395													75.2	25.2	87	7	
" 18																74.1	24.1	84	8	.30
" 19															20	70.5	20.5	80	11	
" 20			232													66.9	16.9	84		.41
" 21																57.1	7.4	71	18	.01
" 22																53.4	5.8	72	14	
" 23			118													56.6	7.6	75	19	
" 24																62.0	12.0	77	17	
" 25			111		2											66.6	16.6		19	
" 26																75.3	25.3			
" 27																69.4	19.4		33	
" 28																59.1	9.1	82	10	.08
" 29			205													59.8	9.8	72	17	
" 30																56.8	6.8	77		
Oct. 1																62.1	12.1	67		
" 2																60.4	10.4	84		
" 3																64.0	14.0	71		
" 4																66.6	16.6	82		.05
" 5			169		1											51.8	3.8	76		
" 6					1											47.7	2.2	74		
" 7																49.4	2.2	71		
" 8																42.4		67		
" 9																43.4	.6	71		
" 10																47.0	3.6	57		
" 11			69													56.2	6.8	60		
" 12																60.9	10.9	70		
" 13																64.7	14.7	85		
" 14																62.0	12.0	82		
" 15																53.7	3.7	91		
" 16																60.5	10.5	87		
" 17																64.1	14.1	83		
" 18			128													65.5	15.5	84		.82
" 19																62.9	12.9	78		
" 20																63.4	13.4	79		
" 21																[illegible]	7.1	67		
" 22																[illegible]	6.2	66		
" 23																[illegible]	6.8	67		
" 24																[illegible]	7.5	63		
" 25			78													[illegible]	[illegible]	[illegible]		
" 26																[illegible]	[illegible]	[illegible]		
" 27																[illegible]	[illegible]	[illegible]		
" 28																[illegible]	[illegible]	[illegible]		
" 29																[illegible]	[illegible]	[illegible]		
" 30																[illegible]	[illegible]	[illegible]		
" 31																[illegible]	[illegible]	[illegible]		
Nov. 1			[illegible]													[illegible]	[illegible]	[illegible]		

TABLE 27—NUMBER OF LARVAE COLLECTED ON VARIOUS DATES IN 1915, NUMBER TRANSFORMING AND NUMBER HIBERNATING.

Date of leaving apples.	Number of larvae collected.				Number discarded.	Number transforming.		Per cent. transforming.		Number of adults emerging.	
	Total number.	Average number per day.	Sex.	Number of each sex.		1915.	1916.	1915.	1916.	1915.	1916.
June 11-16	18	5	M.	10	2	8	.....	100.	.....	7	
			F.	8	2	6	.....	100.	.....	4	
" 17-19	48	16	M.	26	1	25	.....	100.	.....	21	
			F.	22	7	15	.....	100.	.....	14	
" 20-22	96	32	M.	50	6	44	.....	100.	.....	41	
			F.	46	16	30	.....	100.	.....	24	
" 23-25	211	70	M.	77	14	63	.....	100.	.....	63	
			F.	134	34	100	.....	100.	.....	99	
" 26-28	189	63	M.	86	26	60	.....	100.	.....	50	
			F.	103	35	68	.....	100.	.....	66	
" 29-July 1	113	38	M.	46	6	40	.....	100.	.....	40	
			F.	67	15	52	.....	100.	.....	52	
July 2- 3	101	51	M.	48	8	40	.....	100.	.....	40	
			F.	53	6	47	.....	100.	.....	47	
" 4- 7	133	33	M.	57	5	49	3	94.2	5.8	49	3
			F.	76	15	59	2	95.1	3.3	59	2
" 8-10	66	22	M.	29	15	14	.....	100.	.....	14	
			F.	37	8	29	.....	100.	.....	26	
" 11-13	37	12	M.	19	7	12	.....	100.	.....	11	
			F.	18	6	12	.....	100.	.....	12	
" 14-16	46	15	M.	23	3	20	.....	100.	.....	20	
			F.	23	6	17	.....	100.	.....	17	
" 17-19	39	13	M.	18	3	15	.....	100.	.....	12	
			F.	21	11	10	.....	100.	.....	10	
" 20-22	40	13	M.	20	4	16	.....	100.	.....	16	
			F.	20	1	19	.....	100.	.....	19	
" 23-24	31	16	M.	14	0	14	.....	100.	.....	14	
			F.	17	4	13	.....	100.	.....	13	
" 25-28	40	10	M.	19	6	13	.....	100.	.....	13	
			F.	21	6	14	1	93.3	6.7	14	1
" 29-31	19	6	M.	9	4	5	.....	100.	.....	3	
			F.	10	1	9	.....	100.	.....	8	
Aug. 1- 3	21	7	M.	6	0	6	.....	100.	.....	6	
			F.	15	6	9	.....	100.	.....	4	
" 4- 6	65	22	M.	32	4	26	2	92.9	7.1	22	2
			F.	33	17	15	1	93.8	6.2	11	1
" 7- 9	100	33	M.	46	8	34	4	89.5	10.5	31	4
			F.	54	9	45	.....	100.	.....	45	
" 10-12	82	27	M.	40	12	17	11	60.7	39.3	17	11
			F.	42	16	20	6	77.1	22.9	20	6
" 13-14	54	27	M.	26	7	13	6	68.4	31.6	13	6
			F.	28	12	13	3	81.3	18.7	13	3
" 15-18	145	36	M.	75	34	7	34	17.1	81.9	6	31
			F.	70	36	10	24	29.4	70.6	4	20
" 19-21	136	45	M.	74	18	3	53	5.4	94.6	3	53
			F.	62	19	6	37	14.0	86.0	6	37
" 22-24	174	58	M.	89	40	1	48	2.0	98.0	1	48
			F.	85	39	2	44	4.4	95.6	2	44
" 25-27	161	54	M.	75	8	2	65	3.	97.	2	51
			F.	86	18	0	68	.....	100.	0	45
" 28-30	139	46	M.	71	25	0	46	.....	100.	0	22
			F.	68	23	0	45	.....	100.	0	30
" 31-Sept. 2	143	48	M.	69	18	0	51	.....	100.	0	20
			F.	74	10	0	64	.....	100.	0	28
Sept. 3- 4	176	88	M.	83	18	0	65	.....	100.	0	34
			F.	93	34	0	59	.....	100.	0	22
" 5- 8	434	109	M.	193	46	1	146	.7	99.3	1	124
			F.	241	89	2	150	1.3	98.7	2	127
" 9-11	369	123	M.	148	31	0	117	.....	100.	0	89
			F.	221	66	0	155	.....	100.	0	107
" 12-14	393	131	M.	166	44	0	122	.....	100.	0	94
			F.	227	59	0	168	.....	100.	0	139
" 15-17	395	132	M.	176	53	0	123	.....	100.	0	62
			F.	219	88	0	131	.....	100.	0	61
" 18-20	232	77	M.	103	34	0	69	.....	100.	0	57
			F.	129	47	0	82	.....	100.	0	57
" 21-23	118	39	M.	61	7	0	54	.....	100.	0	40
			F.	57	6	0	51	.....	100.	0	37
" 24-25	111	37	M.	52	3	0	49	.....	100.	0	43
			F.	59	9	0	50	.....	100.	0	40
" 26-29	205	51	M.	103	29	0	74	.....	100.	0	48
			F.	102	17	0	85	.....	100.	0	35
" 30-Oct. 5	169	28	M.	89	17	0	72	.....	100.	0	60
			F.	80	5	0	75	.....	100.	0	64
Oct. 6-11	67	11	M.	37	3	0	34	.....	100.	0	29
			F.	30	1	0	29	.....	100.	0	25
" 12-18	128	18	M.	54	16	0	38	.....	100.	0	32
			F.	74	12	0	62	.....	100.	0	53
" 19-25	79	11	M.	33	9	0	24	.....	100.	0	24
			F.	46	14	0	32	.....	100.	0	32
" 26-Nov. 1	48	7	M.	28	2	0	26	.....	100.	0	22
			F.	20	.....	0	20	.....	100.	0	15
Totals	5371		M.	2480	596	548	1336	29.09	70.91	515	1009
			F.	2891	825	622	1444	30.04	69.96	589	1031
			M.&F.	5371	1421	1170	2780	29.54	70.46	1104	2040

TABLE 28—SEASONAL HISTORY OF THE CODLING-MOTH AT OLNEY IN 1915

Generation	Period	Earliest	Relatively numerous	Maximum	Relatively numerous	Latest
Hibernating	Pupæ	Apr. 9	Apr. 19	Apr. 26	May 4	June 2
	Adults	" 27	May 10	May 15	" 22	" 24
First	Eggs	May 5	" 16		" 31	" 30*
	Young larvæ	" 17	" 26		June 12	July 9†
	Mature larvæ	June 12	June 19	June 25	July 7	Aug. 9
	Pupæ	" 17	" 25	" 29	" 10	" 17
	Adults	" 28	July 10	July 12	" 22	Sept. 6
Second	Eggs	July 3	" 13		" 28	" 12
	Young larvæ	" 11	" 13		Aug. 3	" 17
	Mature larvæ	Aug. 2	Aug. 18	Sept. 17	" 20	—‡
	Pupæ	" 3		Aug. 10		Aug. 18§
	Adults	" 16				Sept. 5§
Third	Eggs	" 22				" 13
	Young larvæ	" 29				" 19
	Mature larvæ	Sept. 22				—‡

* The last eggs observed were laid June 26.

† The latest hatching-date record is June 27, the egg having been laid June 18.

‡ Larvæ were collected Nov. 1, the date of the last observation.

§ These dates are from materials collected from cages, but larvæ from the much larger band-collections continued to pupate till Aug. 30, and moths to emerge till Sept. 16. No doubt egg-laying continued till about Sept. 26 and hatching of larvæ till about Oct. 7.

Data based on the band collections give in a general way the distribution as to relative numbers of individuals of each stage throughout the season; the life history data indicate only approximately the general periods during which the different stages of each generation occurred. Since only a small number of individuals were used in the life-history observations as compared with the number of individuals in the whole orchard, activities in the orchard, no doubt, began somewhat earlier and continued somewhat later than the life history data indicate. This is especially true in regard to the date of the deposition of the last eggs, the hatching of the last larvæ, etc., of each generation, because usually the last individuals were very few in number and were mostly females, many of which died without oviposition or laid infertile eggs.

Hibernation, 1915.—The first larvæ to hibernate left the fruit between July 3 and July 7. There was a period of three cool days, including July 4, 5, and 6, when the mean daily temperatures were 65.2, 61.1 and 65.5 degrees F. respectively. For the remainder of July the temperature was much higher. The cool days no doubt account for the early hibernation of some of the larvæ which left the fruit from July 3 to July 7. Hibernation proper began with larvæ which left the fruit between August 3 and August 6, after which the per cent. that hibernated increased rapidly until August 20. Practically all larvæ maturing after this date hibernated. The weather during the second week in September was unusually warm and it was expected that larvæ would again begin to transform, but only three out of about 1000 which were under observation responded to this increased temperature.

Of the total number of larvæ collected, 46.2 per cent. were males and 53.8 per cent. were females; 29.1 per cent. of the males and 30.1 per cent. of the females collected, transformed; and 70.9 per cent. of the males and 69.9 per cent. of the females hibernated.

SUMMARY OF THE SEASONAL HISTORY, 1915

From the foregoing data the seasonal history of the codling-moth at Olney in 1915 may be constructed quite accurately (Table 28, preceding this page).

In Chart 1, these same details of the seasonal history are shown. An attempt is made here to show in graphic form the relative numbers of pupæ, adults, eggs, young larvæ, and mature larvæ that appeared from day to day, all of which have been averaged for three-day periods. The chart is divided vertically into columns for the months from April to October and longitudinally by lines representing elevations above certain base lines, the degree of elevation being represented by the figures in the column to the left of the chart. The average numbers of pupæ, adults, eggs, young larvæ and mature larvæ which appeared daily during each of the three-day periods are represented by the black vertical columns. At the top of the chart the three broods of pupæ are represented, next comes the three broods of moths, then the eggs, then young larvæ, and lastly, the larvæ leaving the fruit. The three broods are indicated very distinctly in the parts of the chart representing different stages. In the lower part of the chart the mean daily temperatures above 50° are represented, also averaged for three-day periods.

RECORDS FOR OTHER POINTS THAN OLNEY

Thus far the discussion has been confined almost entirely to the Olney records. A few words additional will suffice for the less complete records at Ozark, Plainview, and Princeton. The codling-moth was so scarce at the last-mentioned place as to render the records of little value. A distinct third generation was detected at Ozark the same as at Olney. Since only band records were kept at Plainview no evidence of the third generation was noticed there, though it doubtless occurred and would have been detected if a daily, or even a weekly, record of the emergence of moths from the larvæ collected under bands had been kept.

The first moths observed at Ozark emerged April 28, or one day later than at Olney. The first larvæ of the first generation were taken under bands at Ozark June 2, at Olney June 12, and at Plainview June 25. The first of the second-brood moths emerged at Ozark June 20, or 8 days before the first moths of this brood emerged at Olney, and the first of the second-brood larvæ hatched at Ozark July 2, or 9 days before they hatched at Olney.

GENERAL REMARKS ON THE SEASON

March and April, 1915, were dry months and much warmer than normal, causing the pupation of the hibernating larvæ to begin early, but during May, June, July, and August the temperature averaged from 4 to 7.5 degrees cooler than normal, and the rainfall for these months was much above normal. These months were characterized by many cool, cloudy, rainy days, all of which tended to retard the development of the codling-moth, and to reduce the numbers of each generation that survived. This threw the beginning of the pupation of the first third-brood pupæ as late as August 7, which was only two weeks before pupation ended for the season. For this reason the third generation was very small.

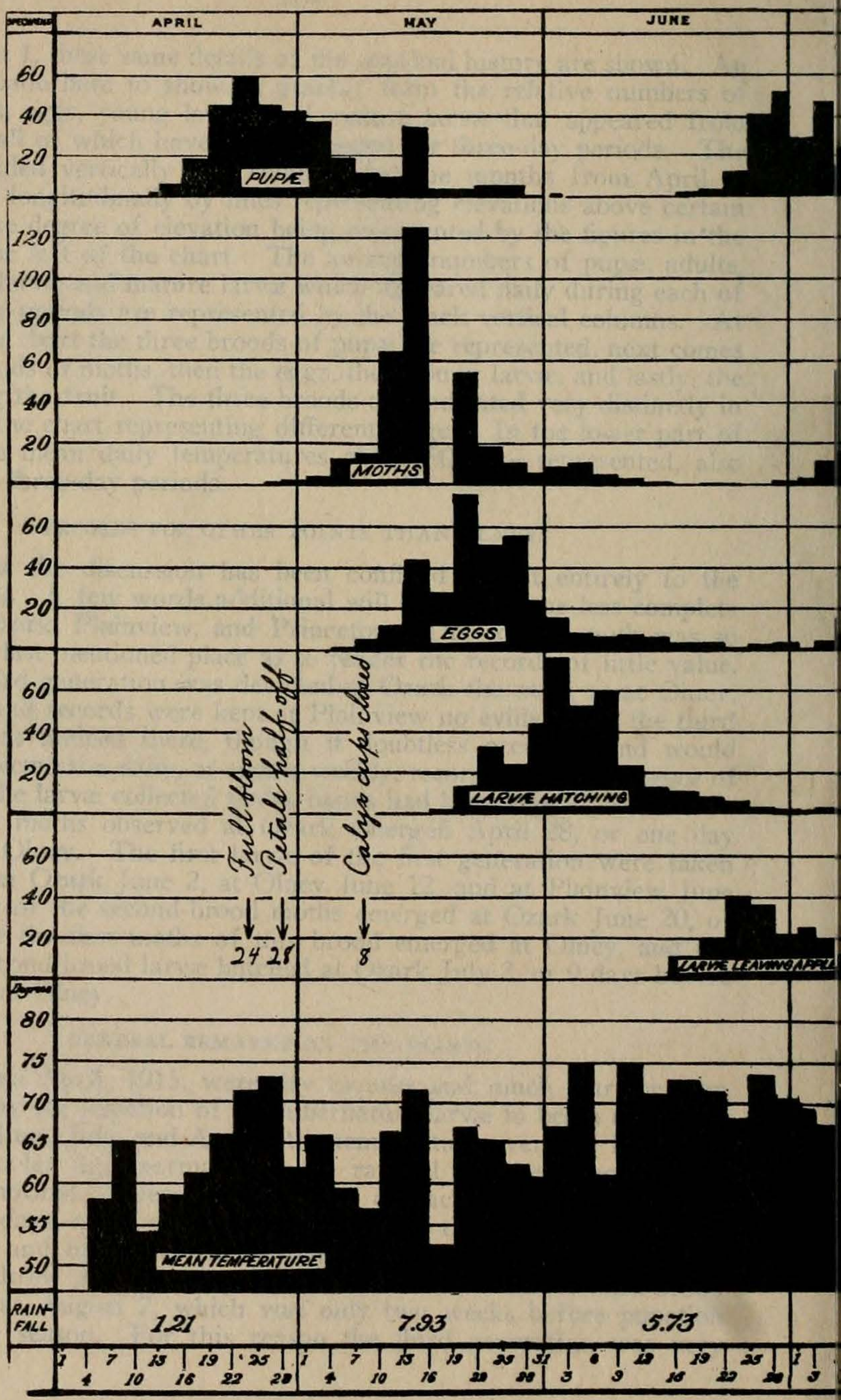
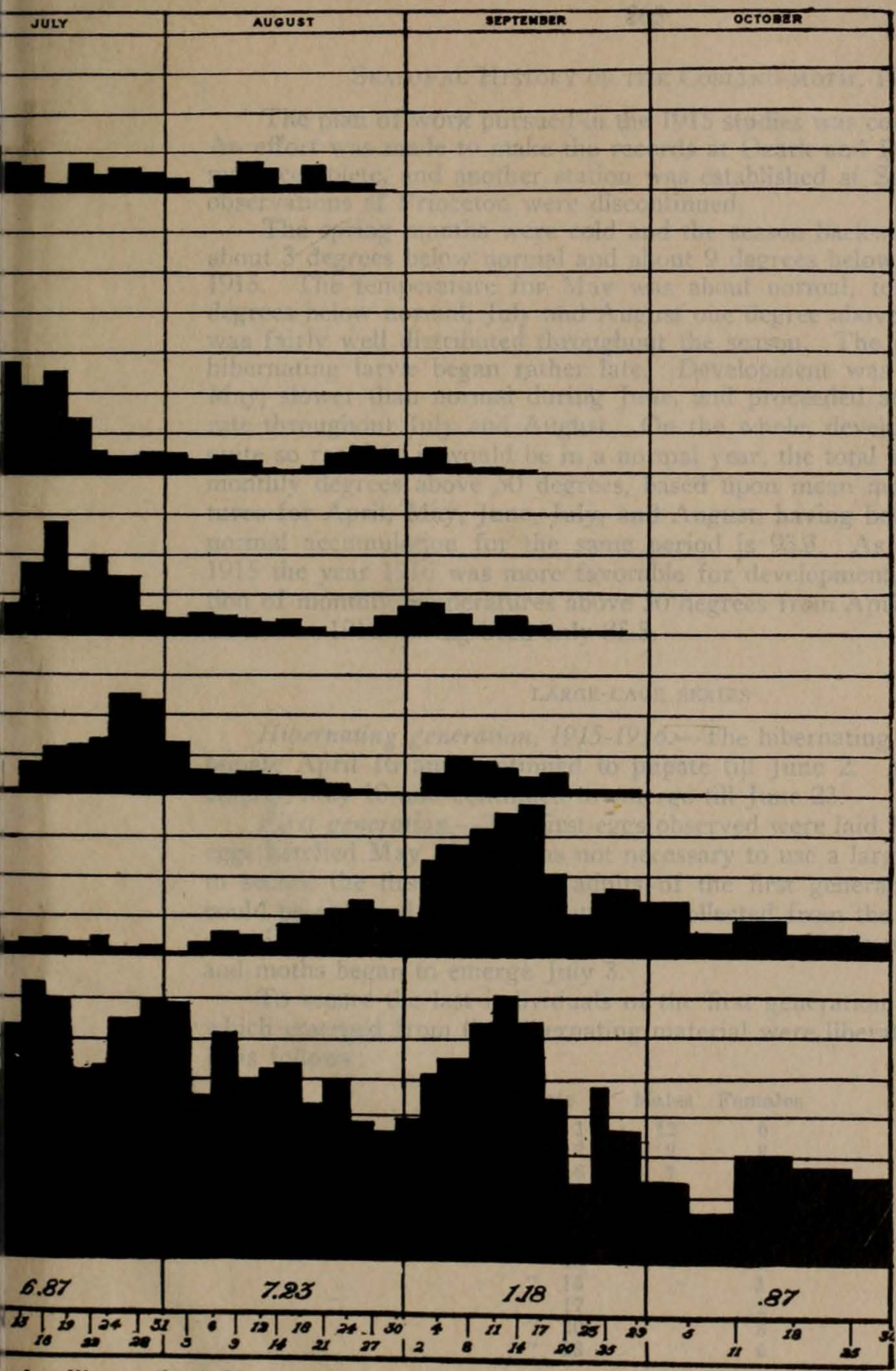


Chart 1. Seasonal histo



of codling-moth at Olney, 1915.

Seasonal History of the Codling-moth, 1916

The plan of work pursued in the 1915 studies was continued in 1916. An effort was made to make the records at Ozark and Plainview a little more complete, and another station was established at Springfield. The observations at Princeton were discontinued.

The spring months were cold and the season backward. April was about 3 degrees below normal and about 9 degrees below what it was in 1915. The temperature for May was about normal, for June about 5 degrees below normal, July and August one degree above normal. Rain was fairly well distributed throughout the season. The pupation of the hibernating larvæ began rather late. Development was normal during May, slower than normal during June, and proceeded at the maximum rate throughout July and August. On the whole, development was not quite so rapid as it would be in a normal year, the total accumulation of monthly degrees above 50 degrees, based upon mean monthly temperatures for April, May, June, July, and August, having been 89 while the normal accumulation for the same period is 93.3. As compared with 1915 the year 1916 was more favorable for development, the accumulation of monthly temperatures above 50 degrees from April to August inclusive in 1915 having been only 85.5.

LARGE-CAGE SERIES

Hibernating generation, 1915-1916.—The hibernating larvæ began to pupate April 16 and continued to pupate till June 2. Moths began to emerge May 10 and continued to emerge till June 23.

First generation.—The first eggs observed were laid May 14. These eggs hatched May 25. It was not necessary to use a large cage in order to secure the first pupæ and adults of the first generation, since they could be obtained from the first larvæ collected from the bands. Larvæ of this generation began to leave the fruit June 20, to pupate June 24, and moths began to emerge July 3.

To secure the last individuals of the first generation, the last adults which emerged from the hibernating material were liberated in cage No. 1, as follows:

Date	Males	Females
June 1	12	0
" 3	9	8
" 6	1	3
" 8	6	3
" 10	5	4
" 12	11	11
" 13	1	3
" 15		1
" 17		2
" 20		3
" 23		6

Larvæ began to mature and leave the fruit July 11 and continued to leave the fruit till August 9. The last pupation occurred August 14, and the last emergence on August 20. All the larvæ of this generation transformed.

Second generation.—For the purpose of getting the earliest individuals of the second generation, the first moths of the first generation were liberated in large-cage No. 2, as follows:

Date	Males	Females
July 6	3	3
" 7	1	1
" 8	1	3
" 9	2	1
" 10	3	2
" 12	5	7
" 14	13	8
" 16	2	12

July 20, many apples in the cage were showing signs of worminess. Larvæ began to leave the fruit August 3, to pupate August 7, and moths began to emerge August 16.

To rear the last individuals of the second generation, moths which emerged from cage No. 1 on or after August 10 were liberated in cage No. 3 as follows:

Date	Males	Females
Aug. 10	4	4
" 11	8	3
" 12	4	3
" 13	1	1
" 15	1	1
" 17	1	
" 18	2	
" 20		1

Larvæ began to leave the fruit September 20 and continued to leave it until observations closed, October 12. All the larvæ reared in this cage hibernated.

Third generation.—To rear the third generation, moths which emerged from cage No. 2 were liberated in cage No. 4 as follows:

Date	Males	Females
Aug. 16	1	1
" 18	2	
" 20	1	1
" 23	5	1
" 24	1	3
" 25		4
" 26		1
" 27		2
" 30	1	1
Sept. 2	1	2
" 8	2	1

The adults liberated September 8 were from the second generation of the life-history series.

TABLE 29—Relation of Time of Leaving the Fruit to Time of Emergence of Moths of the Hibernating Generation of 1915-16, Olney, 1916

Date of leaving fruit	Sex.	Dates of emergence and number emerging. May. 3	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	June. 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	Totals. M.	F.	Average dates of emergence
1915																																																			
July 3- 7	M.	3	..	..	..	....	....	....	....	....	....	....	....	....	....	....	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	3		
" 3- 7	F.	2	..	..	..	....	....	....	....	....	....	....	....	....	....	....	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	....	2	
" 8-10																																																			
" 11-13																																																			
" 14-16																																																			
" 17-19																																																			
" 20-22																																																			
" 23-24																																																			
" 25-28	F.	..	..	..	..	....	....	....	....	....	....	1	....	....	....	....	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	....	1	May 26
" 29-31	M.																																																		
" 29-31	F.																																																		
Aug. 1- 3	M.																																																		
" 1- 3	F.																																																		
" 4- 6	M.	..	..	..	..	....	....	....	....	....	1	....	....	....	....	....	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2		May 26
" 4- 6	F.	..	..	..	..	....	....	....	....	....	....	....	....	....	....	....	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	....	1	June 9
" 7- 9	M.	..	..	..	..	1	1	....	....	....	....	....	....	....	1	....	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	4	....	May 21
" 7- 9	F.	..	..	..	..	....	....	....	....	....	....	....	....	....	....																																				
" 10-12	M.	..	..	..	..	2	1	....	....	....	1	1	....	3	....	....	..	..	3	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	11	....	" 21
" 10-12	F.	..	..	..	..	....	....	1	....	1	....	....	2	....	1	....	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	....	6	" 23
" 13-14	M.	..	..	..	..	1	....	1	....	....	1	....	....	....	....	....	1	..	1	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	6	....	" 22
" 13-14	F.	..	..	..	..	....	....	....	....	....	1	1	....	....	....	....	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	....	3	" 23
" 15-18	M.	..	..	..	..	4	6	1	....	1	5	2	2	2	1	....	..	..	..	..	..	1	..	..	2	2	1	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	31	....	" 19
" 15-18	F.	..	..	..	..	1	4	....	....	1	1	....	1	1	2	....	2	2	..	..	2	1	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	....	20	" 23
" 19-21	M.	..	..	..	..	6	11	1	3	1	9	9	....	4	3	1	1	2	..	..	..	..	1	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	53	....	" 19
" 19-21	F.	..	..	..	..	1	2	1	1	....	5	8	7	5	1	2	1	1	..	..	1	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	....	37	" 21
" 22-24	M.	..	1	..	..	8	6	....	4	....	8	5	3	3	2	....	2	1	3	..	..	..	..	..	1	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	48	....	" 19
" 22-24	F.	..	..	..	..	1	3	1	1	....	1	6	7	5	7	2	3	1	..	..	..	1	..	..	..	..	..	..	..	2	..	..	1	..	1	..	..	..	..	..	..	..	1	..	..	..	..	..	..	....	44	" 24
" 25-27	M.	..	2	1	1	20	9	....	....	....	7	4	1	....	2	1	1	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	51	....	" 16
" 25-27	F.	..	..	..	..	5	8	1	....	1	9	5	5	4	1	2	..	1	..	..	..	..	1	1	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	....	45	" 20
" 28-30	M.	..	..	..	..	....	3	....	....	....	4	2	2	4	2	1	1	..	..	..	..	..	..	1	..	..	..	1	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	22	....	" 23
" 28-30	F.	..	..	..	..	7	2	....	2	1	2	2	....	1	1	1	..	..	1	..	2	2	1	..	1	..	1	..	1	..	..	..	..	..	1	..	..	..	..	..	1	..	..	..	..	..	..	..	..	....	30	" 25
Sept. 1- 2	M.	..	..	..	..	1	1	....	....	....	....	2	1	2	1	....	1	1	..	..	1	1	1	1	..	..	..	..	..	1	1	1	..	..	1	..	..	..	..	..	1	..	..	..	..	..	..	1	20	....	" 31
" 1- 2	F.	..	..	..	..	....	4	1	2	....	....	2	3	1	2	4	1	..	2	..	2	..	..	..	..	..	..	..	..	..	1	..	1	..	..	..	1	..	1	..	..	..	..	..	..	..	..	..	....	28	" 26
" 3- 4	M.	..	..	..	..	3	3	2	1	1	4	1	2	2	....	....	1	1	1	..	1	2	..	1	..	1	..	..	..	..	..	..	1	2	3	1	..	..	..	..	..	..	..	..	..	..	..	..	34	....	" 26
" 3- 4	F.	..	..	..	..	....	2	....	....	....	....	....	1	1	1	1	2	4	2	3	..	..	..	2	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	1	..	..	1	..	..	....	22	" 28
" 5- 8	M.	..	..	..	..	11	23	3	4	2	19	13	17	6	7	4	5	5	..	..	1	1	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	2	..	..	..	..	..	..	..	..	124	....	" 20
" 5- 8	F.	..	..	..	1	13	22	2	5	1	19	25	11	6	7	3	4	3	1	1	3	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	....	127	" 19
" 9-11	M.	..	2	2	..	30	10	1	1	3	11	8	5	5	3	....	1	..	2	..	..	1	2	..	..	..	..	..	..	2	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	89	....	" 18
" 9-11	F.	..	..	..	..	6	14	1	2	2	7	19	15	13	4	10	3	4	3	1	1	..	..	..	..	1	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	....	107	" 20
" 12-14	M.	..	..	..	4	22	14	....	2	3	17	7	9	6	2	2	1	1	2	..	..	1	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	94	....	" 18
" 12-14	F.	..	..	..	1	7	2	3	5	2	19	21	22	21	10	11	4	1	3	..	..	..	2	..	1	2	1	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	....	139	" 21
" 15-17	M.	..	..	..	..	5	8	5	1	1	6	4	4	4	....	1	3	2	7	..	2	1	..	..	..	3	..	1	..	1	..	1	..	..	1	..	1	..	..	..	..	..	..	..	..	..	..	..	62	....	" 23
" 15-17	F.	..	..	..	2	....	....	....	....	2	5	2	6	....	4	6	2	2	8	1	1	3	1	1	2	1	..	1	..	1	..	1	2	..	3	..	..	1	1	1	1	1	..	..	..	..	..	..	....	61	" 22
" 18-20	M.	..	1	..	..	1	3	....	....	....	3	7	6	7	5	3	..	1	5	2	1	..	2	1	3	..	1	1	..	1	1	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	57	....	" 23
" 18-20	F.	..	..	..	..	1	1	....	....	....	2	9	6	6	4	6	2	2	6	..	3	..	1	1	..	2	..	1	..	..	..	1	..	..	..	1	..	..	..	..	..	..	2	..	..	..	..	..	....	57	" 25
" 21-23	M.	..	..	..	..	4	2	....	2	1	5	3	4	3	1	3	..	..	..	..	..	2	3	1	1	..	..	1	..	1	..	..	..	..	..	2	..	..	1	..	..	..	..	..	..	..	..	..	40	....	" 24
" 21-23	F.	..	..	..	..	1	1	....	....	....	....	3	3	3	4	3	2	3	4	..	..	..	..	1	1	2	1	1	..	..	..	1	2	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	....	37	" 27
" 24-25	M.	..	..	..	..	3	2	....	2	1	1	3	4	2	4	1	2	2	3	3	2	..	2	..	1	.	..	..	..	..	..	..	2	..	1	1	..	1	..	..	..	..	..	..	..	..	..	..	43	....	" 25
" 24-25	F.	..	..	..	..	1	2	....	....	1	2	4	2	4	3	5	3	3	4	..	.	2	..	..	..	1	..	1	..	..	1	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	....	40	" 27
" 26-29	M.	..	..	..	..	2	2	1	....	....	6	3	2	3	1	1	2	2	2	1	1	3	3	..	1	2	1	..	..	1	1	1	3	..	1	..	..	1	1	..	..	..	..	..	..	..	..	..	48	....	" 27
" 26-29	F.	..	..	..	..	....	....	....	....	....	2	....	3	....	1	1	3	5	2	..	1	..	2	..	2	1	1	1	..	1	1	..	..	..	1	1	..	..	..	..	..	..	..	2	..	*4	..	..	....	35	June 3
" 30-Oct. 5	M.	..	..	..	..	4	3	1	....	2	6	2	5	9	4	3	2	5	3	..	3	1	1	..	1	1	1	..	..	1	1	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	60	....	May 23
" 30- " 5	F.	..	..	..	..	1	..	....	1	....	3	4	5	7	8	6	11	4	4	..	1	..	2	1	..	..	1	..	..	..	..	..	3	..	1	..	..	..	..	..	1	..	..	..	..	..	..	..	....	64	" 25
Oct. 6-11	M.	..	..	..	..	1	6	1	....	1	2	2	3	2	1	1	1	3	..	1	2	1	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	29	....	" 22
" 6-11	F.	..	..	..	..	....	1	....	....	1	2	2	4	2	3	2	..	2	2	1	..	..	..	..	1	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	....	25	" 25
" 12-18	M.	..	..	..	..	2	5	....	....	1	1	7	4	6	2	1	..	..	1	..	..	..	2	..	..	..	..	..	..	1	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	32	....	" 20
" 12-18	F.	..	..	..	..	....	....	1	....	....	4	4	2	5	6	8	5	5	8	..	..	2	1	..	..	..	..	1	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	....	53	" 24
" 19-25	M.	..	..	1	..	3	3	1	....	2	3	2	3	1	3	....	1	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	24	....	" 19
" 19-25	F.	..	..	..	..	1	....	1	....	1	3	5	6	3	4	4	1	1	1	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	....	32	" 22
" 26-Nov. 1	M.	..	..	..	..	2	....	....	....	....	....	4	2	5	5	2	..	..	..	1	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	22	....	" 21
" 26- " 1	F.	..	..	..	..	....	....	....	....	....	1	3	2	4	3	....	..	..	..	1	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	....	15	" 22
Totals	M.	3	6	4	6	136	122	18	20	20	120	91	79	79	50	25	26	26	33	8	16	15	18	5	12	11	4	5	1	9	7	4	6	2	8	4	1	2	2	1	3					1	1009		" 21
Totals	F.	2			4	46	68	13	19	14	88	126	113	92	77	77	49	44	51	8	18	12	11	7	9	12	6	8	2	5	5	4	9		7	5	1	1	2	1	2	2	4			4		4		1031	" 23
Grand totals		5	6	4	10	182	190	31	39	34	208	217	192	171	127	102	75	70	84	16	34	27	29	12	21	23	10	13	3	14	12	8	15	2	15	9	2	3	4	2	5	2	4			4		5	2040		" 22

The first eggs were observed August 19. These hatched August 23. The first mature larvæ left the fruit between September 26 and October 3, and larvæ continued to leave the fruit till October 23—the date of the last observation.

Thus the presence of a partial third brood was again demonstrated this year at Olney. Larvæ of the first generation were entering the fruit from May 25 to about July 4, and larvæ of the second generation from about July 13 to September 1, and larvæ of the third generation from August 23 to about September 15.

BAND COLLECTIONS

Hibernating generation, 1915–1916.—Pupation of the hibernating larvæ collected from bands in 1915 began at Ozark April 10, at Olney, Plainview, and Springfield April 13, and closed at Ozark May 31, at Olney June 17, and at Springfield May 26.

Moths began to emerge at Ozark and at Olney May 11 and at Springfield May 10. They continued to emerge at Ozark till June 19, at Olney till June 30 (Table 29, foot-note), and at Springfield till June 28. Pupation was very irregular on account of changes in the weather conditions.

The dates when the larvæ left the fruit had no appreciable influence on the time of pupation and emergence the following spring. The average date of the emergence of males was May 21, and of the females May 23. We should naturally expect that hibernating larvæ maturing in July would develop into moths earlier in the spring than those maturing later in the season, but this is not the case. The male moths in three collections emerged an average of from one to five days later than the females; in two collections the average dates of emergence of both sexes were the same; and in the other eighteen collections the males emerged an average of from one to seven days earlier than the females. For the whole series the average date of emergence of the males was 2.6 days earlier than that of the females.

Collections made in 1916.—Band collections were made at Ozark, Olney, and Springfield. The results are shown in Table 30.

The first eggs were observed August 19. These hatched August 23.

While the first moths of the hibernating generation observed at the three places emerged at about the same time, the first larvæ of the first generation matured 10 days later at Olney than at Ozark and 9 days later at Springfield than at Olney. The first pupæ were observed at Olney June 24, and at Springfield July 2; the first adult at Olney emerged July 3, and at Springfield July 11 (Table 31). The second and third broods of pupæ and moths are very clearly indicated in these pupation and emergence records. The pupation of the second brood at Olney began June 24 and continued till the first or second week in August, at which time the beginning of the pupation of the third brood is indicated by the increase in the number of pupæ. The second brood of moths began to emerge July 3 and continued to emerge until about the second

week in August. The beginning of the emergence of the third brood is indicated by the increase in the number of moths emerging daily after the 16th of August. Judging from the above data the third brood was about equal in number to the second brood.

TABLE 30—RECORD OF LARVAE COLLECTED UNDER BANDS AT OZARK, OLNEY, AND SPRINGFIELD IN 1916

Date	Ozark	Olney	Spring-field	Date	Ozark	Olney	Spring-field
June 10	11	.....	.....	Aug. 16	24	344	28
12	7	.....	.....	19	16	315	
14	6	.....	.....	22	31	350	42
17	8	.....	.....	25	22	490	44
20	15	7	.....	28	30	412	46
23	50	11	.....	31	37	516	
26	31	29	.....	Sept. 2	43	354	45
29	53	47	5	6	24	797	55
July 1	56	65	27	9	28	515	91
5	45	213	20	12	45	551	79
8	55	228	17	15	37	566	
11	48	225	32	18	22	399	
14	30	110	33	21	15	388	
17	56	121	33	23	31	276	
20	73	138	30	25	28	217	132
24	36	76	41	28	21		
26	22	197	22	Oct. 3	37	136	
29	28	72	15	6	8		
Aug. 1	61	43	.....	10	8	142	
4	52	70	36	13	5		
7	40	125	59	16	5		
10	53	221	67	19	1		
12	53	230	86	24		92	
				Totals	1407	9086	1085

Hibernation, 1916.—Table 32 shows the dates between which the transition was made from transforming to hibernating larvæ.

Hibernation began with larvæ which left the fruit between August 4 and August 7, but hibernation in considerable numbers began with larvæ collected between August 16 and August 19. Practically all larvæ collected after August 28 hibernated. This was fully a week later than the date on which active hibernation began in 1915. It will be seen, then, that a large per cent. of the larvæ which left the fruit during the first three weeks in August transformed; it will also be seen by referring to Table 30 that larvæ of the second generation were leaving the fruit in large numbers during this period. This accounts for the relatively large size of the third generation in 1916.

Of the 9088 larvæ collected at Olney, 4100, or about 45 per cent., were males, and 4988, or about 55 per cent., were females.

TABLE 31—RECORD SHOWING THE NUMBER OF LARVAE PUPATING AND MOTHS EMERGING DAILY AT OLNEY AND SPRINGFIELD FROM BAND COLLECTIONS IN 1916

Date.	No. of larvae pupating.		No. of moths emerging.	
	Olney.	Springfield.	Olney.	Springfield.
June 20				
" 21				
" 22				
" 23				
" 24	2			
" 25	5			
" 26	2			
" 27	5			
" 28	3			
" 29	6			
" 30	2			
July 1				
" 2	9			
" 3	11	4	1	
" 4	42	5	1	
" 5	22	2	4	
" 6	7		5	
" 7	15	4	3	
" 8	19	1	4	
" 9	46	7	3	
" 10	40	2	5	
" 11	47	6	5	5
" 12	54	8	14	1
" 13	44	2	7	10
" 14	32	2	23	9
" 15	82	4	22	6
" 16	63	.....	6	7
" 17	47	.....	11	14
" 18	62	.....	34	14
" 19	26	.....	23	13
" 20	36	.....	34	17
" 21	36	.....	37	
" 22	15	.....	32	
" 23	26	.....	31	37
" 24	19	.....	39	
" 25	39	.....	37	
" 26	50	.....	47	14
" 27	35	.....	34	7
" 28	26	.....	33	7
" 29	38	.....	25	6
" 30	32	.....	37	7
" 31	30	.....	20	9
Aug. 1	33	.....	14	8
" 2	23	.....	18	14
" 3	11	.....	26	8
" 4	18	.....	24	
" 5	6	.....	29	23
" 6	17	.....	10	
" 7	23	.....	33	15
" 8	16	.....	29	5
" 9	8	.....	28	13
" 10	46	.....	28	2
" 11	28	.....	17	2
" 12	5	.....	11	3
" 13	46	.....	7	1
" 14	39	.....	8	3
" 15	27	.....	4	
" 16	79	.....	16	12
" 17	92	.....	20	7
" 18	38	.....	19	9
" 19	93	.....	16	1
" 20	39	.....	23	21
" 21	37	.....	17	10
" 22	23	.....	14	10
" 23	21	.....	15	22
" 24	9	.....	47	8
" 25	14	.....	31	9
" 26	31	.....	51	8
" 27	8	.....	10	3
" 28	4	.....	44	9
" 29	6	.....	15	6
" 30	13	.....	19	9
" 31	7	.....	34	24
Sept. 1	8	.....	25	1
" 2	11	.....	29	
" 3	3	.....	10	1
" 4	1	.....	29	1
" 5	.....	.....	17	
" 6	.....	.....	27	1
" 7	.....	.....	21	1
" 8	1	.....	11	
" 9	.....	.....	8	1
" 10	.....	.....	11	
" 11	.....	.....	13	1
" 12	.....	.....	13	
" 13	.....	.....	3	
" 14	.....	.....	7	1
" 15				
" 16				
" 17				
" 18				
" 19	.....	.....	3	
" 20				
" 21				
" 22	.....	.....	2	
" 25	.....	.....	1	

TABLE 32—NUMBER OF LARVAE COLLECTED ON VARIOUS DATES IN 1916, NUMBER TRANSFORMING AND NUMBER HIBERNATING

Dates of leaving apples.	Number of larvæ collected.				Number discarded.	Number transforming.		Per cent. transforming.		Number of adults emerging.	
	Total number.	Average number per day.	Sex.	Numbers of each sex.		1916.	1917.	1916.	1917.	1916.	1917.
June 15-20	7	1.4	M.	5	.....	5	.....	100.	.....	4	
			F.	2	.....	2	.....	100.	.....	2	
" 21-23	11	4	M.	3	.....	3	.....	100.	.....	3	
			F.	8	.....	8	.....	100.	.....	7	
" 24-26	29	10	M.	16	4	12	.....	100.	.....	8	
			F.	13	2	11	.....	100.	.....	6	
" 27-29	47	16	M.	19	2	17	.....	100.	.....	12	
			F.	28	6	22	.....	100.	.....	18	
" 30-July 1	65	38	M.	32	7	25	.....	100.	.....	19	
			F.	33	4	29	.....	100.	.....	21	
July 2- 5	213	53	M.	108	31	77	.....	100.	.....	63	
			F.	105	33	72	.....	100.	.....	48	
" 6- 8	228	76	M.	106	28	78	.....	100.	.....	59	
			F.	122	29	93	.....	100.	.....	65	
" 9-11	225	75	M.	98	18	80	.....	100.	.....	65	
			F.	127	25	102	.....	100.	.....	79	
" 12-14	110	37	M.	64	9	55	.....	100.	.....	49	
			F.	46	6	40	.....	100.	.....	34	
" 15-17	121	40	M.	55	7	48	.....	100.	.....	33	
			F.	66	17	49	.....	100.	.....	35	
" 18-20	138	49	M.	68	17	51	.....	100.	.....	43	
			F.	70	16	54	.....	100.	.....	37	
" 21-22	76	38	M.	35	.....	35	.....	100.	.....	35	
			F.	41	15	26	.....	100.	.....	20	
" 23-26	197	49	M.	93	35	58	.....	100.	.....	47	
			F.	104	34	70	.....	100.	.....	50	
" 27-29	72	24	M.	33	6	27	.....	100.	.....	24	
			F.	39	13	26	.....	100.	.....	26	
" 30-Aug. 1	43	14	M.	27	11	16	.....	100.	.....	13	
			F.	16	.....	16	.....	100.	.....	16	
Aug. 2- 4	70	23	M.	32	9	23	.....	100.	.....	22	
			F.	38	13	25	.....	100.	.....	24	
" 5- 7	125	42	M.	64	20	43	1	98.	2.	33	1
			F.	61	20	41	.....	100.	.....	34	
" 8-10	221	70	M	108	24	82	2	98.	2.	63	
			F.	113	38	75	.....	100.	.....	65	
" 11-12	230	115	M.	130	38	90	2	98.	2.	81	2
			F.	100	34	64	2	97.	3.	44	2
" 13-16	344	88	M.	162	115	47	.....	100.	.....	41	
			F.	182	132	45	5	90.	10.	28	5
" 17-19	315	105	M.	153	83	39	31	56.	44.	31	23
			F.	162	98	25	39	39.	61.	20	35
" 20-22	350	117	M.	148	49	24	75	24.	76.	16	69
			F.	202	79	29	94	24.	76.	22	80
" 23-25	490	163	M.	252	93	19	140	12.	88.	15	123
			F.	238	48	23	167	12.	88.	19	149
" 26-28	412	104	M.	171	63	5	103	5.	95.	4	91
			F.	241	86	8	147	4.	96.	6	132
" 29-31	516	172	M.	241	69	.....	172	.....	100.	.....	148
			F.	275	87	1	187	.5	99.5	1	147
Sept. 1- 6	354	177	M.	143	40	.....	103	.....	100.	.....	85
			F.	211	93	.....	118	.....	100.	.....	100
" 1- 6	797	199	M.	346	201	.....	145	.....	100.	.....	113
			F.	451	318	.....	133	.....	100.	.....	89
" 7- 9	515	172	M.	209	127	.....	82	.....	100.	.....	67
			F.	306	242	.....	64	.....	100.	.....	54
" 10-12	551	184	M.	243	137	.....	106	.....	100.	.....	90
			F.	308	199	.....	109	.....	100.	.....	85
" 13-15	566	189	M.	237	237						
			F.	329	219	.....	110	.....	100.	.....	88
" 16-18	399	133	M.	177	74	.....	103	.....	100.	.....	93
			F.	222	108	.....	114	.....	100.	.....	87
" 19-21	388	129	M.	168	69	.....	99	.....	100.	.....	78
			F.	220	113	.....	107	.....	100.	.....	95
" 22-23	276	138	M.	107	5	.....	102	.....	100.	.....	89
			F.	169	14	.....	155	.....	100.	.....	89
" 24-25	217	109	M.	86	.....	.....	86	.....	100.	.....	76
			F.	131	16	.....	115	.....	.....	.....	103
" 26-Oct. 2	136	19	M.	56	17	.....	39	.....	.....	.....	39
			F.	80	33	.....	47	.....	.....	.....	47
Oct. 3-10	142	12	M.	68	16	.....	52	.....	.....	.....	52
			F.	74	32	.....	42	.....	.....	.....	42
" 11-24	92	7	M.	37	20	.....	17	.....	.....	.....	17
			F.	55	55						
Totals	9088	....	M.	4100	1681	959	1460	39.6	60.4	783	1258
			F.	4988	2277	956	1755	35.3	64.7	727	1429
			M-F	9088	3958	1915	3215	37.3	62.7	1510	2687

TABLE 33.—DATA OBTAINED FROM BAND COLLECTIONS AND LIFE-HISTORY OBSERVATIONS, WITH ACCOMPANYING CLIMATIC DATA. OLNEY, 1916

Date	From larvæ collected 1915. Pupæ.	From larvæ collected 1915. Adults.	From larvæ collected 1916. Larvæ under bands.	From larvæ collected 1916. Pupæ.	From larvæ collected 1916. Adults.	Life-history data. First generation. Eggs laid.	First generation. Larvæ hatched.	First generation. Larvæ pupated.	First generation. Moths emerged.	Second generation. Eggs laid.	Second generation. Larvæ hatched.	Second generation. Larvæ pupated.	Second generation. Moths emerged.	Third generation. Eggs laid.	Third generation. Larvæ hatched.	Climatic data. Mean daily temp.	Effective day degrees (50+)—2(86+).	Humidity.	Evaporation.	Rainfall, inches.
Apr. 10																36.3				
" 11																53.3	7.5			
" 12																65.7	15.7			
" 13	8															69.3	19.3	67		
" 14	7															59.7	9.7	72	20	
" 15	2															51.1	4.3	66	18	
" 16	16															60.9	10.9	67	24	
" 17	37															56.0	7.2	56	36	
" 18	21															52.0	4.8	67	18	.08
" 19	53															64.0	13.8	55	49	
" 20	60															67.3	17.3	69	22	.37
" 21	10															51.2	2.3	76	4	
" 22	9															49.5	3.8	61	27	.01
" 23	8															50.0	3.8	63	15	
" 24	11															50.0	3.3	70	12	.10
" 25	22															47.0	2.6	71	14	.11
" 26																44.8	.3	81	4	.08
" 27	6															48.2	1.4	82	9	.01
" 28	14															50.0	5.0	72	18	
" 29	24															54.8	8.3	70	22	
" 30	22															61.5	11.6	63	33	
May 1	15															62.3	12.3	65	27	.08
" 2	5															50.6	1.8	88	6	.23
" 3	8															50.8	2.2	91	0	.25
" 4	7															53.9	4.6	80	6	
" 5	15															62.0	12.0	64	30	
" 6	22															65.5	15.5	69	31	
" 7	23															74.0	24.0	67	36	
" 8	38															72.0	22.0	64	36	
" 9	21															62.0	12.4	40	38	
" 10	27															73.0	23.0	49	48	
" 11	17	6														64.0	15.0	50	30	.02
" 12	7	4														58.5	8.5	66	18	.03
" 13	4	10														59.5	9.5	76	16	.12
" 14	10	182				34										75.5	25.5	67	37	
" 15	12	190														69.2	19.2	81	4	.40
" 16	7	31														61.2	11.2	64	16	
" 17	6	39														53.3	5.8	66	19	.02
" 18	4	34														53.5	5.5	60	22	
" 19	5	208				141										53.7	8.4	64	24	
" 20	2	217				94										64.1	14.1	62	26	
" 21	3	192				131										63.9	13.9	73	8	.25
" 22	8	171				192										70.4	20.4	80	17	.05
" 23	4	127				162										71.5	21.5	70	20	.35
" 24	12	102				98										71.3	21.3	71	20	
" 25	7	75				43	31									76.5	25.0	67	30	
" 26	18	70				4	20									78.9	27.6	68	32	
" 27	4	84					172									77.2	27.2	73	15	.43
" 28	6	16				55	65									68.8	18.8	87	12	.12
" 29	6	34				4	136									68.6	18.6	87	3	2.08
" 30	1	27				47	85									67.3	17.3	78	15	.04
" 31	4	29				15	54									63.5	13.5	68	18	
June 1	2	12				30	27									67.0	17.0	71	20	
" 2	2	21				7	25									74.1	24.1	78	13	.59
" 3		23					5									66.3	16.3	....	16	
" 4		10				3	2									64.0	14.0	73	18	
" 5		13														65.6	15.6	78	11	.08
" 6	1	3				12	4									64.5	14.5	89	16	2.78
" 7		14				5	38									62.4	12.4	73	21	.06
" 8		12														61.1	11.1	64	25	
" 9	3	8				2	11									61.7	11.7	70	20	
" 10	1	15					30									65.2	15.2	81	20	.01
" 11		2				65	8									66.2	16.2	....	11	
" 12		15				47	20									68.0	18.0	....	15	.05
" 13		9				43										70.2	20.2	72	18	
" 14		2				14										71.0	21.0	79	13	
" 15		3				15	3									70.0	20.0	78	15	.15
" 16		4				12										65.0	15.0	78	12	.64
" 17	1	2					10									65.0	15.0	71	19	
" 18		5				27	4									66.6	16.6	81	14	.12
" 19		2				1	8									67.0	17.0	81	11	.62
" 20		4	7			6	27	1								68.5	18.5	79	11	
" 21						1	1									67.4	17.4	83	10	.83
" 22							28									66.6	16.6	78	14	
" 23		4	11				12									72.4	22.4	75	14	
" 24				2			7	1								72.3	22.3	81	14	1.37
" 25		1		5			1	5								68.8	18.8	72	16	
" 26			29	2			18	1								71.6	21.6	76	20	
" 27		1		5		1	6	5								76.2	26.2	70	21	
" 28		1		3			2	7								73.6	23.6	73	17	
" 29			47	6				7								74.9	24.9	73	21	
" 30		1		2				2								77.8	25.5	74	22	
July 1			66					8								78.7	28.2	75	18	
" 2				9				9								79.8	26.5	73	18	
" 3				11	1			15	1							80.3	29.0	75	2	
" 4				42	1			34	1							75.1	25.1	69	18	
" 5			213	22	4			22	4							73.6	23.6	66	39	
" 6				7	5			12	4	6						73.9	23.9	64	33	
" 7				15	3			16	3	11						76.8	25.3	65	16	
" 8			228	19	4			23	7							78.2	26.2	69	12	
" 9				46	3			42	3	16						75.0	25.0	75	17	
" 10				40	5			29	5							76.2	26.2	73	25	
" 11			225	47	5			38	5							78.4	27.1	75	22	
" 12				54	14			43	19	67	6					76.5	26.5	86	1	.30
" 13				44	7			39	11		4					75.7	25.4	77	6	.01
" 14			110	32	22			26	28	18	3					77.2	27.2	77	10	.32
" 15				82	22			64	27	83						81.6	28.6	77	21	
" 16				63	6			46	12	21	14					82.2	28.9	78	16	
" 17			121	47	11			41	19	41						81.1	27.4	77	21	
" 18				62	34			47	45	138						81.3	28.4	79	22	
" 19				26	23			30	22	116	18					80.1	28.6	81	21	
" 20			138	36	34			26	43	22	48					77.7	26.9	81	16	
" 21				36	37			27	48	58	40					76.4	26.4	84	15	.15
" 22				15	32			9	2	63	4					75.6	24.4	71	24	
" 23				26	31			18	42		43					78.3	24.6	72	28	
" 24			76	19	39			20	42	141	49					79.2	25.0	68	29	
" 25				39	37			31	39	45	85					81.0	25.0	69	31	
" 26			197	50	47			30	50	70	6					82.3	27.1	72	32	
" 27				35	34			25	34	10	45					83.9	26.4	71	29	
" 28				26	32			17	38	24	48					83.6	27.0	73	29	
" 29			72	38	25			26	33	64	18					85.6	27.4	72	26	
" 30				32	37			23	35	52	58					84.3	28.8	76	21	
" 31				30	20			24	20		18					85.7	29.7	74	20	
Aug. 1			43	33	14			29	16		25					77.8	27.8	81	22	
" 2				23	18			20	19		5					79.0	27.4	70	25	.10
" 3				11	26			8	26		36					81.3	26.8	75	26	
" 4			70	18	24			16	27		51					84.8	28.4	71	33	
" 5				6	29			7	29		6					84.4	28.2	71	29	
" 6				17	10			17	12							84.0	28.2	71	36	
" 7			125	22	33			24	30							84.8	28.5	68	33	
" 8				16	29			11	29							82.1	30.3	71	26	
" 9				8	28				28			8				78.7	28.2	83	24	.02
" 10			221	46	28				28	174		35				81.1	27.9	76	31	
" 11				28	17				18	145		24				83.0	29.0	71	20	
" 12			230	5	11				13	149		7	1			77.9	27.4	85	9	.59
" 13				46	7				7			36	1			73.4	23.4	90	8	.49
" 14				39	8				8	58		47	1			63.6	13.6	85	6	.12
" 15				27	4				6			31	1			70.6	20.6	90	0	2.31
" 16			344	79	16				14		22	65				77.2	27.2	83	17	
" 17				92	20				20		69	65				77.6	26.4	81	8	
" 18				38	19				18		81	29	3			83.1	28.9	80	19	
" 19			315	93	16				1		39	57	16	73		83.0	29.2	81	19	
" 20				39	23							17	24			82.8	30.3	81	16	
" 21				37	17						13	19	16			80.0	27.3	82	15	.62
" 22			350	23	14							19	16			74.8	24.8	92	2	1.70
" 23				21	15							14	30		37	69.8	19.8	73	22	
" 24				9	47							5	51		16	69.3	19.3	75	18	
" 25			490	14	31							9	33			72.1	22.1	76	21	
" 26				31	51							24	62	96		71.1	21.1	82	8	.13
" 27				8	10							10	12	15		66.8	16.8	90	1	.53
" 28			412	4	44							2	45	74		63.8	13.8	78	14	.10
" 29			72	38	25			26	33			5	17	12		62.9	12.9	75	15	
" 30				32	37			23	35			11	17	7		65.4	15.4	70	15	
" 31				30	20			24	20			7	28	5		69.3	19.3	77	18	
Sept. 1				8	25							6	22	55		68.9	18.9	91	0	1.06
" 2			354	11	29							9	23	74		70.8	20.8	88	6	.13
" 3				3	10							3	8	74		72.2	22.2	81	13	
" 4				1	29								21	58	68	71.6	21.6	80	17	
" 5					17								16	10	23	78.9	28.2	81	19	.22
" 6			797		27								22	5	8	78.4	27.2	80	19	
" 7					21								19	10	2	77.7	27.7	84	9	1.00
" 8				1	11							1	10		19	71.6	21.6	88	7	.42
" 9			515		8								9		3	67.6	17.6	78	14	
" 10					11								10	62		67.7	17.7	77	14	
" 11					13								12	1		72.8	22.8	84	14	
" 12			551		13								8	106	11	75.3	25.3	75	19	
" 13					3								7	1	28	67.7	17.7	84	8	
" 14					7								3	7	7	64.9	14.9	79	12	
" 15			566												1	58.3	8.6	62	20	
" 16																50.0	5.4	68	18	
" 17														41		58.9	9.6	65	17	
" 18			399													54.5	6.3	76	15	
" 19					3								3			50.7	6.2	67	15	
" 20																55.6	8.2	69	22	
" 21			388											19		66.6	16.6	52	29	
" 22					2											62.2	12.2	62	26	
" 23			276													56.3	8.3	66	19	
" 24																53.9	9.1	74	17	
" 25			217		1								1			64.0	14.0	73	18	
" 26																72.6	22.6	65		
" 27																75.2	25.2	55		
" 28																65.8	15.8	76		
" 29																50.6	2.3	71		
" 30																45.8	2.7	83		
Oct. 1																		84		
" 2																		82		
" 3			136															76		
" 4																		67		
" 5																		70		
" 6																		75		
" 7																		73		
" 8																		74		
" 9																		84		
" 10			142															40		
Totals	588	2040	8604	1960	1454	1019	670	1031	901	1602	864	868	666	806	223					

Of the males, 39.6 per cent., and of the females, 35.3 per cent. transformed, 60.4 per cent. of the males and 64.7 per cent. of the females hibernated. Altogether, 37.3 per cent. of those collected transformed and 62.7 per cent. hibernated. Undoubtedly a much larger per cent. hibernated than the above figures indicate, since the collections do not include all the hibernating larvæ that left the fruit late in the season, after collections had ceased. It is probably true that three fourths or more of the larvæ which develop during a given season hibernate. This being the case it is very evident that if a very large per cent. of them did not perish during the winter, the first generation in the spring would be much larger than it usually is.

A daily record of the band collections, life-history observations, and climatic conditions at Olney in 1916 have been brought together in Table 33 for ready reference.

SUMMARY OF THE SEASONAL HISTORY, 1916

From the foregoing data and an occasional reference to original notes we can summarize quite accurately the seasonal history of the codling-moth for 1916 (Table 34).

Chart 2 gives a graphic representation of the seasonal history of the codling-moth in 1916, the daily temperatures above 50 degrees F., and the monthly rainfall.

The number of pupations observed daily are shown in the top section of the chart, the number of moths emerging daily in the second section from the top, the number of eggs deposited in the third, the number of larvæ hatched in the fourth, and the number of larvæ leaving the fruit in the fifth. The daily temperatures above 50 degrees F. are shown in the bottom section, beneath which is given the rainfall for each month.

The order of events in the seasonal history is indicated by the numbers from 1 to 12 in the chart.

Thus: 1 indicates the first brood of pupæ
2 " " " " " adults
3 " " " " " eggs
4 " " " " " larvæ hatching and leaving the fruit
5 " " second " " pupæ
6 " " " " " adults
7 " " " " " eggs
8 " " " " " larvæ hatching and leaving the fruit
9 " " third " " pupæ
10 " " " " " adults
11 " " " " " eggs
12 " " " " " larvæ hatching and leaving the fruit.

TABLE 34—SEASONAL HISTORY OF THE CODLING-MOTH AT OLNEY, IN 1916

Generation	Period	Earliest	Relatively numerous	Maximum	Relatively numerous	Latest
Hibernating	Pupæ	April 13	April 16	April 20	May 11	June 17
	Adults	May 11	May 14	May 15	May 27	June 30
First	Eggs	May 14	May 19	May 24	June 1	July 10*
	Young larvæ	May 25	May 26	June 2	June 9	July 18*
	Mature larvæ	June 20	June 29	July 8	July 26	Aug. 9
	Pupæ	June 20	July 4	July 15	Aug. 2	Aug. 14
	Adults	July 3	July 14	July 26	Aug. 10	Aug. 24*
Second	Eggs	July 6	July 15	July 26	Aug. 13	Sept. 4
	Young larvæ	July 12	July 21	Aug. 1	Aug. 21	Sept. 21
	Mature larvæ	July 31	Aug. 8	Sept. 10	Sept. 25	Oct. 23†
	Pupæ	Aug. 3	Aug. 11	Aug. 17	Sept. 22	Sept. 3
	Adults	Aug. 12	Aug. 15	Aug. 26	Sept. 7	Sept. 14*
Third	Eggs	Aug. 14*	Aug. 18	Aug. 29	Sept. 10	Sept. 21
	Young larvæ	Aug. 20*	Aug. 28	Sept. 12	Sept. 13	Sept. 15
	Mature larvæ	Oct. 1				Oct. 23†

* Dates computed.
† Last observation.

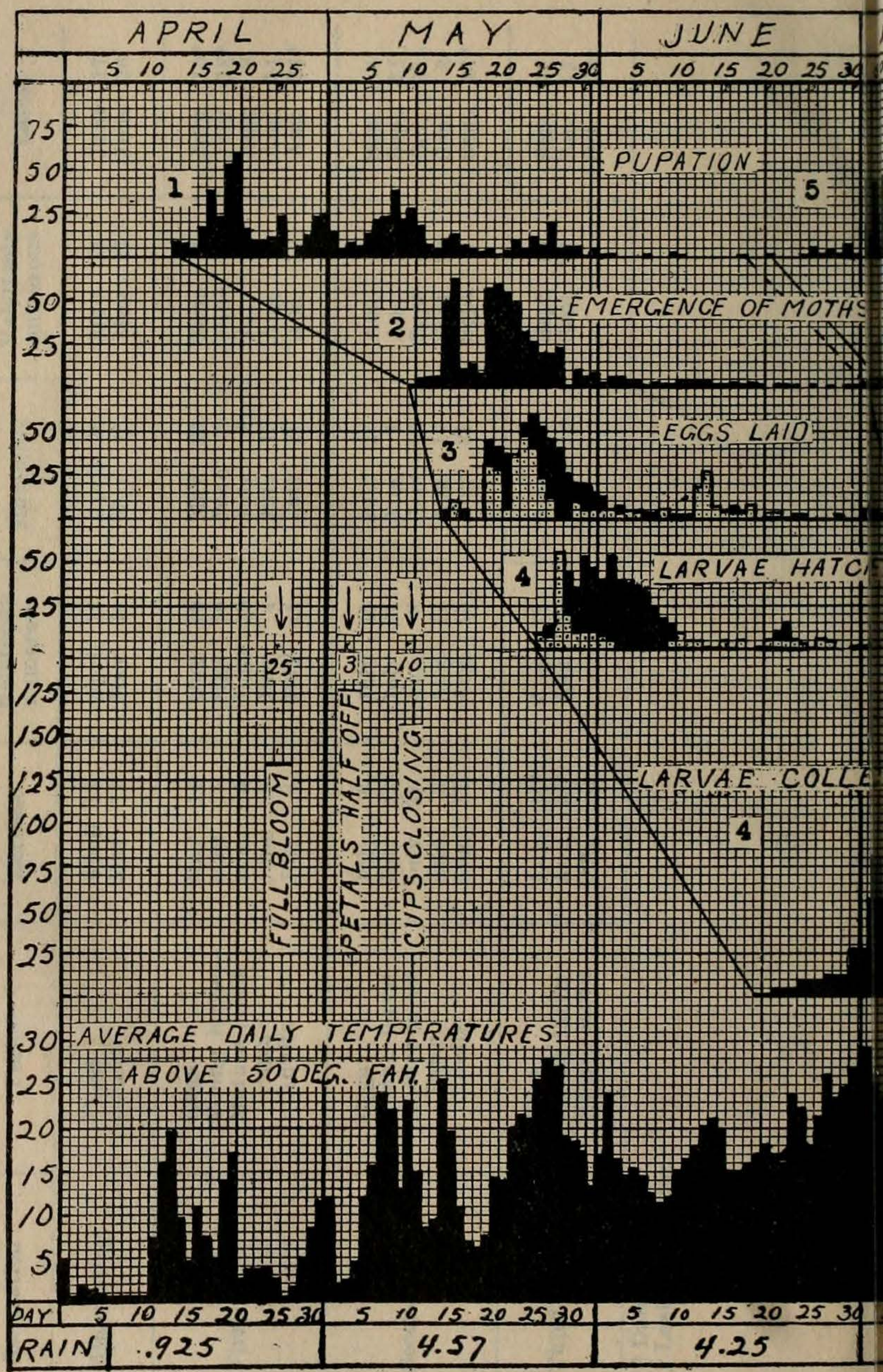
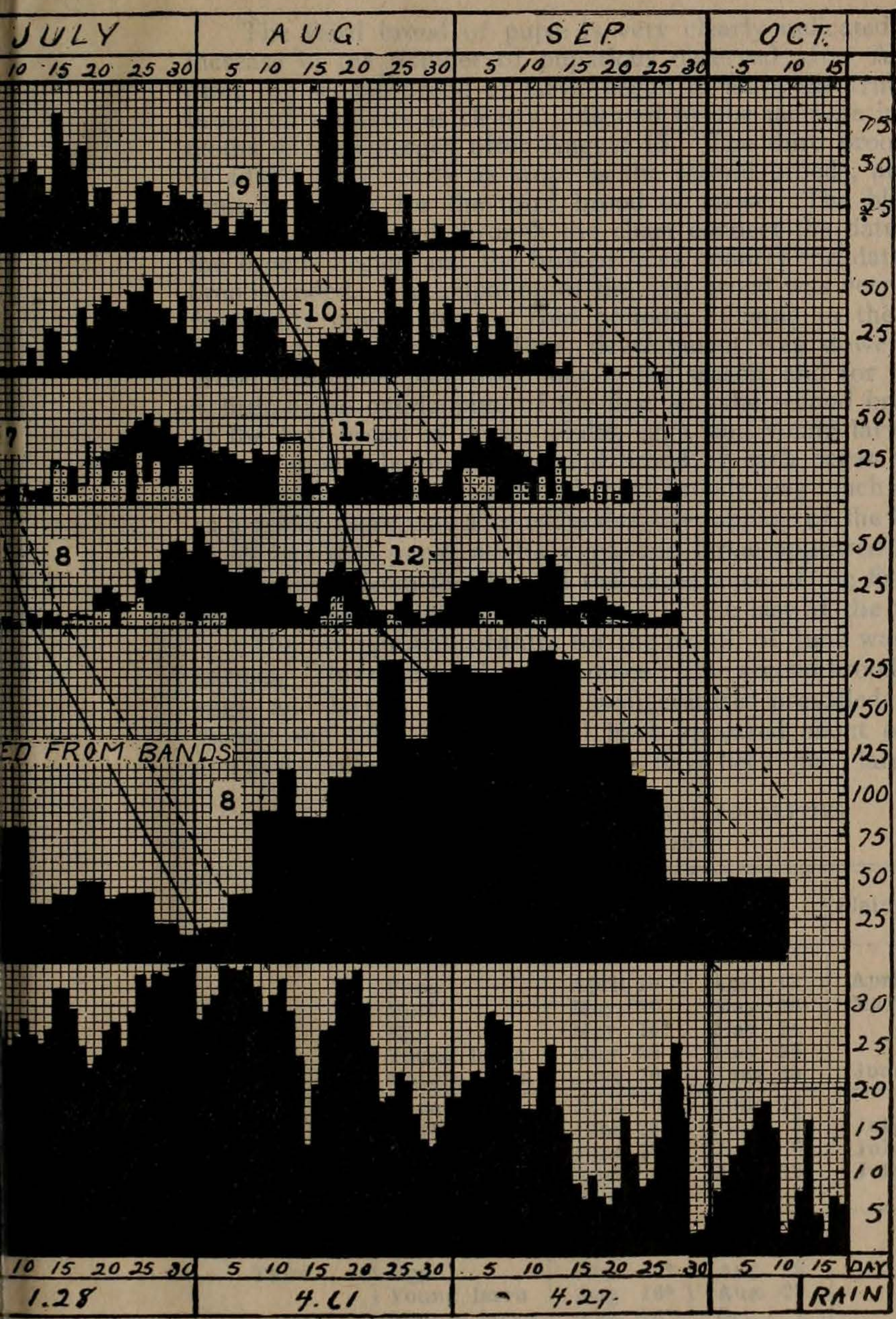


CHART 2. Seasonal histor



! codling-moth at Olney, 1916.

The third brood of pupæ is very clearly indicated by the marked increase in the number of pupations observed after August 8 or just after the second brood of larvæ began to leave the fruit, and the third brood of adults is as clearly indicated by the increase in the number of moths which emerged after August 15. The third broods of pupæ and of adults were nearly as large as the second broods, and no doubt the same held true for the third brood of larvæ. The black lines drawn obliquely downward through the chart connect the dates when each of the broods began, and the broken lines connect the dates on which the broods ended. The pupation of the first brood was very irregular, being frequently interrupted by cold periods. Owing to the cooler weather during April, May, and June, development was slower while the first brood was developing than later in the season, and for this reason there is little or no overlapping of the first and the second broods. The bulk of the first brood of pupæ, adults, eggs, and young larvæ had appeared fully a month before the second brood of each began to appear. The development of the second and third broods was much more rapid, and as a result there was a considerable overlapping of the broods, so much so in fact that pupæ, adults, eggs, and larvæ appeared daily, with little interruption, from the date of the appearance of the first of the second brood to the date of the appearance of the last of the third brood.

The average temperature for the month of June was about 5° below normal. This delayed the appearance of the second brood of pupæ, adults, eggs, and larvæ. Had normal temperatures prevailed during June the second and third broods would have appeared about one week earlier, and as a result the third brood would have been much larger.

RECORDS FOR SEVERAL LOCALITIES

TABLE 35

Generation	Stage	Ozark	Olney	Plainview	Springfield
First	Pupa	April 10	April 13	April 13	April 13
	Moth	May 10	May 10	May 11	May 10
	Egg	May 14*	May 14		May 20
	Young larva	May 25	May 25		May 28
	Mature larva	June 10	June 20	June 26	June 29
Second	Pupa	June 10	June 24		July 3
	Moth	June 25*	July 3	July 8	July 11
	Egg	June 29*	July 6	July 10	July 13
	Young larva	July 4*	July 12	July 16	July 18
	Mature larva	July 26*	Aug. 3		Aug. 5
Third	Pupa	July 31*	Aug. 7		Aug. 9
	Moth	Aug. 8*	Aug. 16		Aug. 17
	Egg	Aug. 10*	Aug. 18		Aug. 19
	Young larva	Aug. 16*	Aug. 23		Aug. 29
	Mature larva	Aug. 26*	Oct. 1		

* Dates followed by an asterisk were computed.

Dates of the appearance of the different stages at Olney and other points in 1916 are given in Table 35, immediately preceding.

Olney is 75 miles, Plainview 108 miles, and Springfield 150 miles north of Ozark. The overwintering larvæ began to pupate at Ozark April 10, at Olney, Plainview, and Springfield April 13. The first moths emerged and the first eggs hatched on nearly the same dates at the four places. Larvæ of the second generation began to hatch about 8 days later at Olney, 12 days later at Plainview, and 14 days later at Springfield than at Ozark, and larvæ of the third generation began to hatch 7 days later at Olney and 13 days later at Springfield than at Ozark. Three generations were recorded at all four points. The third generation at Springfield was small as compared with the third generation at Olney.

Seasonal History of the Codling-moth, 1917

The methods of work pursued during 1915 and 1916 were continued in 1917. The work at Olney was closed in July, so complete records were not kept of the second and third generations at that place.

The season was not favorable for rapid development. While the mean temperature for April was about normal the temperature during the first half of the month was much below normal. May and June were cold months. The total accumulation of monthly degrees above 50 for April, May, June, July, and August was 86.9, the normal being 93.3.

LARGE-CAGE SERIES

First generation.—The material collected from cages in 1916 was not preserved, hence no record of the pupation and emergence of hibernating material was secured from cages. Hibernating larvæ collected from bands in 1916 began to pupate April 3. Moths began to emerge May 17 and continued to emerge till June 24. The first moths to emerge were not liberated in a large cage because the dates when the first eggs, larvæ, pupæ, and adults of the first generation appeared could be easily observed without using a cage; but the last moths to emerge from the hibernating band material were liberated in a large screen-cage to get the dates when the last eggs, larvæ, pupæ, and adults of the first generation appeared.

The first eggs of the first generation were laid May 19 and hatched June 1. The first mature larvæ left the fruit June 23 and pupated June 26, and the first moths emerged July 7. The last eggs of the first generation were noted in the large cage June 27. They were probably laid two or three days earlier. They hatched July 1. Mature larvæ were found under the band on the tree in this cage from July 13 to August 13. No observations were made to ascertain the dates of the last pupæ and adults.

TABLE 36—Relation of Time of Leaving the Fruit to Time of Emergence of Moths of the Hibernating Generation of 1916-17. Olney, 1917

Dates of leaving fruit	Sex	Number emerging and dates of emergence, 1917. May 17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	June 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	Totals M.	Totals F.	Average dates
1916																																												
Aug. 4- 7	M.										1																															1		May 26
	F.																																											
" 8-10	M.														1										1																	2		June 4
	F.																																											
" 11-12	M.				1									1																												2		May 25
	F.											1																							1								2	June 8
" 13-16	M.																																											
	F.				1				2		1			1																												5	May 26
" 17-19	M.			3	5	2	1			3	1	1		2	2	1	1						1																			23		" 25
	F.			6	5	4			3	5	1	4		2	3		1				1																						35	" 24
" 20-22	M.		4	15	11	10	1		9	9	1	8			3		2						2																			69		" 22
	F.				9	7	3		7	9	9	14		4	7	2	4	1				1	1		1										1								89	" 26
" 23-25	M.		5	11	21	19	5		13	9	11	2	1	4	3	2	4			1	1	3	1	3			2	1							1								123	" 25
	F.			5	12	12	5		11	21	19	13		10	5	6	6	2	5	1	3	2	1	4			1	1	2				1			1							149	" 27
" 26-28	M.			4	4	18	1		6	10	15	6	1	4	3	3	4		2	1	2	1	2				1		2				1										91	" 27
	F.			5	10	15	6		11	11	16	14		8	5	6	7	1	2	1	1	6	1	2	2	1			1														132	" 27
" 29-31	M.			9	23	26			17	20	13	9		7	3	5	6	1	3			3	2	1																			148	" 25
	F.			2	11	9	4		18	17	19	23	1	8	9	3	1	6		1	3		2	2	4		2	1					1			1							147	" 27
Sept. 1- 2	M.		2	7	10	25	5		14	7	6	1		3	2		1							1									1									85		" 25
	F.				11	9	2		9	17	16	6	1	3	3	6	9	1	2		1		1				1	1									1						100	" 27
" 3- 6	M.	1	4	8	19	15	2		11	10	12	8	2	3	2	3	2	4		2	1			3			1															113		" 25
	F.				12	10	1		2	10	6	12	1	8	6	5	7		4		1		1	2		1																89	" 27
" 7- 9	M.		1	7	14	8	1		12	4	4	3		3		3	2		2		1		1	1											1							67		" 25
	F.				2	7	1		2	8	2	6	1	1	2	8	3	2	1			1		2	1			1					1	1	1								54	" 29
" 10-12	M.		1	13	18	14	1		3	5	2	2		2	2	1		1	1		1	1	6	7	3	2							1	1		2						90		" 27
	F.			2	3	3			5	8	8	13		4	10	6	2	1	2	2	3	1	2	1	1	1	2		1							2	1							86	" 30
" 11-15	M.																																											
	F.			5	11	12	5		13	11	8	10	2	2	2																												88	" 25
" 16-18	M.	1	6	16	25	11	2		6	8	2	5		4	3	1	3					1	1				1															93		" 22
	F.			3	10	8	5		7	12	7	5	1	5	3		2									1		1				1											87	" 27
" 19-21	M.		2	10	16	16	3		2	5	4	4		2	4	7	5	2	1	1				1		1		1	1														78		" 24
	F.			2	8	16	9		7	13	10	11		2			4	2	1			2		1												1							95	" 25
" 22-23	M.		2	6	19	12	4		5	4	6	8		4	4	5	2	1	1	1	1		2				1										1						89		" 25
	F.			1	5	13	6		7	14	7	10	2	3	3	3		1		1	2	2	1		3			1							1		2						89	" 27
" 24-26	M.	1	3	13	16	15	3		5	7	5	2	1			2	3	1	1			2		1	1		1	1	1	1													76		" 22
	F.			7	7	8	1		5	16	18	18	1	5	4	1	1	2					1																				103	" 26
" 26-Oct. 2	M.		1	8	2	4			3	2	3	1	1	2	3	4	2	2	1	1		1							2			1										39		" 26
	F.			3	3	4	2		2	1	9	5		4	6	3	1	2					2																				47	" 26
Oct. 3-10	M.				5	9	2		8	6	5	7	3	3		2	3	1	1					1																			52		" 25
	F.		1	1	4	9	1		5	5	3	4		1	1	2	1				1						1																42	" 25
" 11-24	M.				2	6	1		2	2	2				1	2	5																										17		" 25
	F.																							1																					
Totals	M.	3	31	130	211	210	32		116	105	93	66	8	44	36	27	31	13	9	5	9	12	19	18	7	4	4	3	2			1	3	1	2	2	1					1258		" 25
	F.		1	44	128	146	31		116	178	159	169	10	72	69	65	63	21	21	8	14	15	12	16	10	4	9	6	8	1		1	3	2	2	6	3						1429	" 27
	M. & F.	3	32	174	339	356	63		232	283	252	235	18	116	105	92	94	34	30	13	23	27	31	34	17	8	13	9	10	1		2	6	3	4	8	4					2687		" 26

Second generation.—The first moths of the first generation were liberated in cage No. 2 to rear the first individuals of the second generation.

Moths were liberated in cage No. 2, as follows:

Date	Males	Females
July 8	1	1
" 9	1	1
" 10	4	3
" 11	4	1
" 12	8	1
" 13	6	6
" 14	9	12

Eggs were found July 11 and young larvæ July 17. Daily observations ceased before larvæ began to leave the fruit in this cage.

Third generation.—The first eggs probably were laid about August 16 and hatched about August 22.

BAND COLLECTIONS

Hibernating generation, 1916-1917.—Of the 2687 adults of the hibernating generation emerging in 1917, 1258 were males and 1429 were females (Table 36). The average date of the emergence of the males was May 25, of the females May 27, and of the entire brood May 26. This was five days after the date of the maximum emergence. There was practically no difference between the dates of emergence of moths from larvæ which left the fruit in August and the emergence of those from larvæ which left the fruit later.

Collections made in 1917 (see Table 37).—The first mature larvæ were taken under bands at Springfield only two days later than at Olney. The second generation of larvæ began to leave the fruit at Olney between July 23 and July 30, but, unfortunately, there was a period of seven days here between the records, and the exact date can not be accurately determined. The bands at Springfield were torn from the trees some time between August 4 and August 12 by some one unknown, and hence the date when the second generation began to leave the fruit at Springfield is also uncertain.

The falling off in the number of larvæ taken at Springfield after October 6 was due largely to the fact that the apples were picked from half of the trees soon after that date.

Complete records of pupation, and the emergence of moths from band material were not preserved. At Ozark the first larvæ left the apples June 18 and the first moth emerged July 1. At Olney the first larvæ left the fruit June 23, and pupated June 26, the first moths emerging July 7. At Springfield the first larvæ left the fruit June 25, and pupated June 28, the first moths emerging July 9. (Table 40, p. 277.)

Observations ceased too early to get complete data on pupation and emergence of the second generation, or on the third generation. There is no doubt, however, that there was a third generation at Olney. Larvæ of the second generation began to leave the fruit about August 4, and since transforming of larvæ usually continues till the end of August, no doubt many of the first larvæ of the second generation transformed and produced a partial third generation. The first eggs of the third generation were laid about August 23 and hatched about August 31.

TABLE 37—RECORD OF LARVAE COLLECTED UNDER BANDS AT OZARK, OLNEY, AND SPRINGFIELD IN 1917

Date	Number of larvæ collected		
	Ozark	Olney	Springfield
June 21	2		
" 23	2	3	
" 24		1	
" 25			3
" 26	9	26	
" 29	8	43	
" 30			29
July 2			
" 5	15	117	
" 7	3	55	65
" 11	4	91	
" 13	5		96
" 14		46	
" 17	6	26	
" 19		23	
" 20			116
" 21	7	8	
" 23	2	4	
" 28	2		125
" 30		44	
Aug. 2	6		62
" 6	9	182	Bands off*
" 13	3	243	Bands off*
" 17	14		
" 20		362	
" 22	12		
" 24	11		114
" 29	13		365
Sept. 1	13		
" 4	15		544
" 9	42		
" 21	31		1860
" 28	14		1334
Oct. 6	16		1395
" 13			299
" 18			500
" 30	54		51

* See p. 273, line 13 from bottom.

TABLE 38—DATA OBTAINED FROM BAND COLLECTIONS AND LIFE-HISTORY OBSERVATIONS, WITH ACCOMPANYING CLIMATIC DATA. OLney, 1917.

Date.	From larvæ collected 1916.		From larvæ collected 1917.			Life-history data. First generation.				Climatic data.				
	Pupæ.	Adults.	Number collected from bands.	Pupæ.	Adults.	Eggs laid.	Larvæ hatching.	Larvæ pupating.	Moths emerging.	Mean temp.	Effective day-degrees (50+)—(86+).	Humidity.	Evaporation.	Rainfall.
Apr. 3	2									55.8	1.1			
" 4										48.0	1.6	72		
" 5										46.8	1.8	93		
" 6										40.6	.1	71		
" 7										43.7	.5	56		
" 8										38.7	.2	83		
" 9										31.2		84		
" 10										42.1	1.6	64		
" 11	53									52.3	5.5	61		
" 12	53									55.0	5.3	78		
" 13	3									40.2	.5	74		
" 14	24									39.2	1.1	69		
" 15	27									49.7	3.3	65	18	
" 16	52									48.5	2.8	79	11	.1
" 17	95									61.9	11.9	71	27	
" 18	184									70.3	20.3	76	35	
" 19	255									68.0	18.0	75	26	
" 20	308									67.9	17.9	64	42	
" 21	100									55.8	6.1	57	32	
" 22	86									60.3	10.4	58	32	
" 23	124									68.1	18.1	50	42	
" 24	87									65.1	15.1	69	26	
" 25	64									59.7	9.7	65	15	.28
" 26	53									51.2	3.7	62	22	
" 27	19									49.2	1.3	80	3	.28
" 28										47.0	.1	93	0	1.1
" 29	43									51.0	1.8	80	7	.5
" 30										49.1	3.3	83	7	.48
May 1	42									49.5	3.0	66	14	
" 2	22									52.0	4.6	72	20	
" 3	19									50.3	1.5	74	10	.27
" 4	11									44.2		91	7	.62
" 5	6									42.7		76	7	.03
" 6	12									47.0	.7	69	8	
" 7	4									46.5	.8	78	9	.01
" 8										48.1	3.3	72	9	.15
" 9	9									52.0	5.6	74	12	
" 10	10									55.2	6.6	75	14	.15
" 11	9									55.3	5.3	77	11	.21
" 12	3									49.9	4.3	61	17	
" 13	6									50.8	4.3	67	18	
" 14	8									51.3	5.5	65	15	
" 15	11									59.1	11.1	66	19	
" 16	13									64.0	14.3	66	25	
" 17	19	3								67.6	17.6	58	31	
" 18	32	32								68.3	19.3	60	25	
" 19	23	174								73.2	23.2	65	33	
" 20	16	339				24				72.4	22.4	65	25	
" 21	11	356				32				68.5	18.5	72	2	.5
" 22	6	63				5				62.4	12.6	70	2	.85
" 23	6					34				49.3	3.6	68		
" 24	4	337				74				58.3	9.0	62	19	
" 25	1	283				41				59.9	10.6	70		
" 26	2	252				76				64.4	14.4	75	15	.07
" 27	1	235				23				67.8	17.8	77	10	.10
" 28		18				52				57.3	7.3	88	4	.57
" 29	1	116				104				60.8	11.3	76	13	
" 30	2	105				108				65.0	15.0	75	14	.01
" 31	3	92				3				68.3	18.3	78	14	1.29
June 1	1	94				1	25			65.2	15.0	85	6	.71
" 2	1	34				37	14			67.1	17.1	80	14	1.82
" 3	1	30				49				61.9	11.9	69	16	
" 4	3	13				49	16			64.4	14.4	82	16	
" 5	2	23					28			68.8	18.8	84	0	1.27
" 6		27				11	42			74.8	24.8	72	18	.18
" 7		31				135	28			69.3	19.3	67	29	
" 8		34				41	63			73.3	23.3	70	21	
" 9		17					39			69.6	19.6	83	0	1.53
" 10		8				65	7			68.2	18.2	79	11	
" 11	1	13				58	16			70.1	20.1	79	17	
" 12		9				4	29			73.2	23.2	77		
" 13		10								74.7	24.7	83	13	.17
" 14		1								61.9	11.9	75	19	
" 15										52.7	3.6	69	14	
" 16		2				1	47			51.9	5.2	72	16	
" 17		6				16	40			59.2	10.2	73	17	
" 18		3				66				66.8	16.8	70		
" 19		4				37	13			71.9	21.9	74	21	
" 20		8				17	37			69.2	19.2	70	30	
" 21		4				1	28			72.8	22.8	71	27	
" 22						10	3			73.8	23.8	75	23	
" 23			3							78.2	28.2	74	21	
" 24			1							77.7	27.7	72	33	
" 25			26							75.2	23.4	73	32	
" 26			26	2						81.5	27.7	68	36	
" 27						Last		3		78.4	27.9	77	25	
" 28				2				1		78.4	28.4	78	26	
" 29			43	12			1	14		73.2	23.2	75	25	
" 30				*				5		72.6	22.6	71	20	
July 1							1	6		74.6	24.1	65		
" 2								14		76.8	25.2	67		
" 3								8		68.5	18.5	61		
" 4								4		66.4	16.4	64		
" 5			117					10		70.5	20.5	63		
" 6									1	72.6	22.6	75	16	
" 7			55		1			9	2	78.8	26.3	69	26	
" 8					1			8		79.5	27.3	65	26	
" 9					3			6	5	75.7	24.5	64	33	
" 10				7	9			8	10	73.7	23.7	64	30	
" 11			91	10	1			12	3	71.3	20.8	68	26	
" 12				18	2			10	9	74.7	24.7	60	35	
" 13				8	8			7	1	71.6	20.4	66	25	.05
" 14			46	12	12			4	11	74.2	24.2	72	15	.23
" 15				25	5			2	10	72.5	22.5	82	15	
" 16				9†	2			7	6	68.4	18.4	88	5	.52
" 17			26		1			5	5	69.0	19.0	85	12	
" 18					1			2	8	72.2	21.8	70	20	
" 19			23		24			8	4	75.7	25.4	85	12	.32
" 20								4	6	76.0	25.9	70	20	
" 21			8		3			7	8	80.2	25.8	70	20	
" 22					8†			2	14	78.0	27.6	82	15	
" 23			4					2	6	80.0	28.4	83		
" 24								1	14	78.3	26.3	84		
" 25								3	2	77.4	25.4	80		.15
" 26								1	8	78.4	28.4	80		
" 27									6	79.1	27.8	77		
" 28								1	7	81.2	27.7	74		
" 29									11	83.0	27.8	73		
" 30			44						7	84.0	25.8	67		
" 31									1	86.6	29.3	64		
Aug. 1									3	85.0	28.7	67		
" 2									3	79.7	27.7	65		
" 3										76.6	23.4	59		
" 4									2	79.3	24.5	61		
" 5										80.0	24.8	62		
" 6			182						1	76.5	26.2	70		.36
" 7										72.6	22.6	81		
" 8										72.8	22.8	84		
" 9										68.4	18.4	81		
" 10										66.2	16.2	72		
" 11								Lost		66.5	16.5	70		
" 12										69.2	19.2	71		
" 13			243							70.9	20.9	71		
" 14										71.0	21.0	71		
" 15										74.1	24.1	72		1.26
" 16										74.8	24.8	76		
" 17										72.8	22.1			
" 18										71.4	20.2			
" 19										70.8	20.8			
" 20			302						Lost	74.1	24.1			.04
Totals	1953	2687	1274			1174	487	174	174					

* Re-report of emergence from June 30 to July 8 inclusive.

A daily record of the band collections, life-history observations, and climatic conditions at Olney in 1917 have been brought together in Table 38 for ready reference.

SUMMARY OF THE SEASONAL HISTORY, 1917

From the foregoing data, the seasonal history of the codling-moth at Olney can be quite accurately determined (Table 39).

Chart 3 represents in graphic form, the data given in Table 39. These data are disconnected and meager for the second and third generations. The position and form of the curved lines in the chart, representing the relative number of eggs and young larvæ of the first generation and the number of the different stages of the second and third generations, are based upon estimates only, since complete daily records were not kept.

The bulk of the hibernating larvæ pupated during the unusually warm period in the third week of April; the bulk of the adults emerged during the last two weeks of May; the bulk of the eggs of the first generation were laid during the last ten days of May and the first week in June; and the bulk of the larvæ hatched during the first three weeks of June. There was no overlapping of the first and second generations except in the larval stage.

Relation of Temperature to the Seasonal History of the Codling-moth

It has already been shown that there is quite a constant relation between the temperatures above 50 degrees when corrected for retarding temperatures above 86 degrees and the length of time required to bring the insect through the egg, larval, and pupal periods. This applies to all the periods except the larval period of the hibernating larvæ. The length of time the hibernating larvæ remain in the cocoon is independent of the day-degrees which accumulate between the time when hibernation begins and the winter months. It is found, however, that there is a more or less definite relation between the average daily temperatures above 50 degrees in the spring months and the dates when the first pupæ and the first adults appear. There is a very great individual variation in this respect, as will be seen by referring to the last column of Tables 19 and 20.* In Table 19, it will be seen that the hibernating larvæ began to pupate when the sum of the day-degrees above 50 degrees F. after January 1 amounted to 115; the accumulations for the others ranged from 115 to 356, the average being 186. In Table 20 it will be seen that the hibernating larvæ of 1916-1917 began to pupate when the sum of the day-degrees above 50 degrees F. amounted to 104. The others varied from 104 to 355, the average being 190.

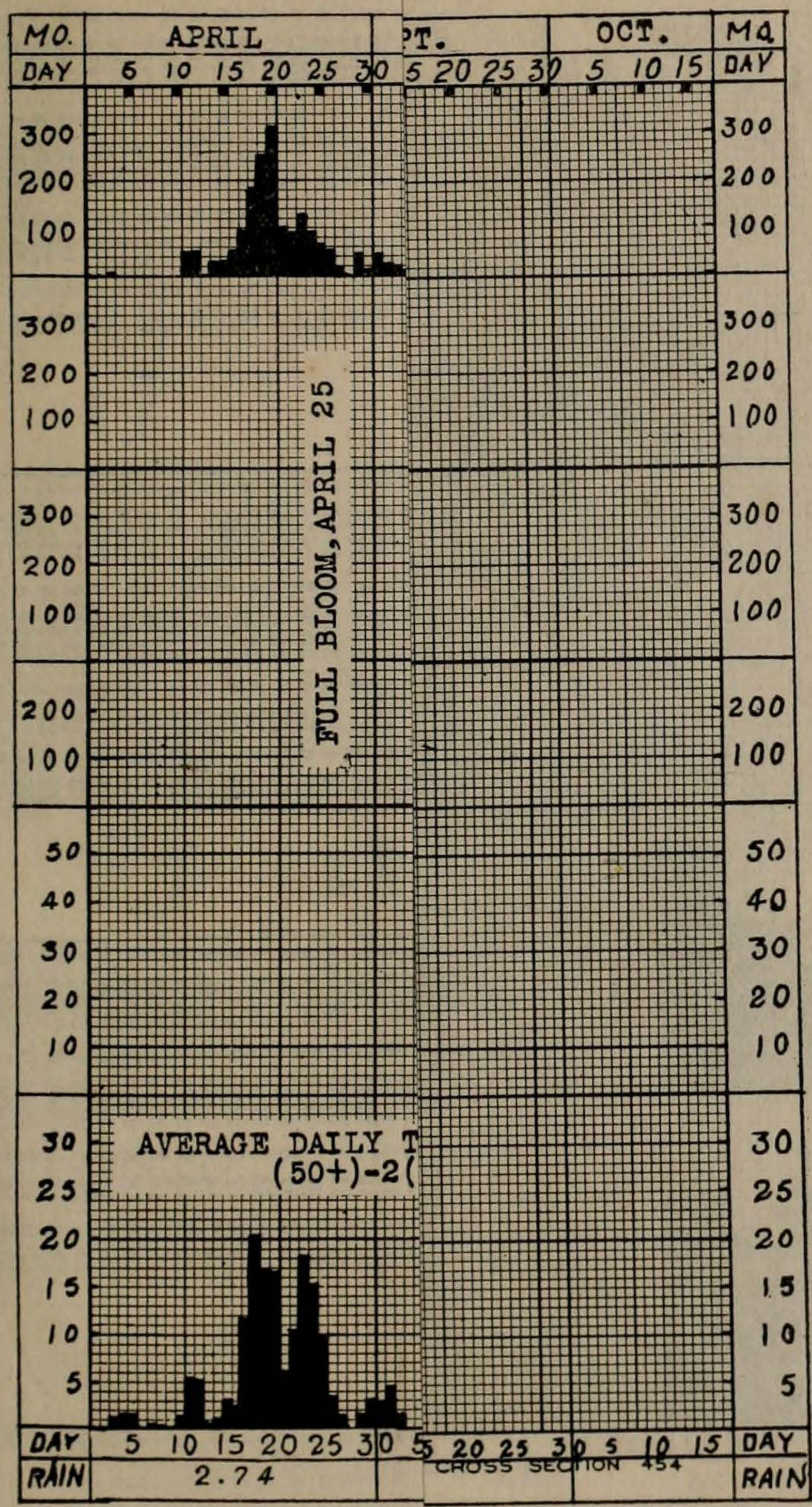
---

* Tables 9-25 follow p. 253.

TABLE 39—SEASONAL HISTORY OF THE CODLING-MOTH AT OLNEY, 1917

Generation	Period	Earliest	Relatively numerous	Maximum	Relatively numerous	Latest
Hibernating	Pupæ	April 3	April 11	April 20	April 26	June 11
	Adults	May 17	May 19	May 21	June 1	June 21
First	Eggs	May 20	May 21	May 25	June 3	June 27
	Young larvæ	June 1	June 2	June 8*	June 10	July 1
	Mature larvæ	June 23	June 26	July 6	July 19	Aug. 6*
	Pupæ	June 27	June 30	July 10*	July 22*	Aug. 11*
	Adults	July 7	July 10	July 20*	Aug. 2	Aug. 20*
Second	Eggs	July 11				
	Young larvæ	July 17				
	Mature larvæ	Aug. 4*				
	Pupæ	Aug. 8*				Aug. 23*
	Adults	Aug. 21*				
Third	Eggs	Aug. 23*				
	Young larvæ	Aug. 31*				

* Computed.


MO.
APRIL
PT.
OCT.
MO.
DAY
5 10 15 20 25 30
5 20 25 30
5 10 15
DAY
300
200
100
50
40
30
20
10
25
15
5
FULL BLOOM, APRIL 25
AVERAGE DAILY T
(50+)-2(
RAIN
2.74
CROSS SECTION 454

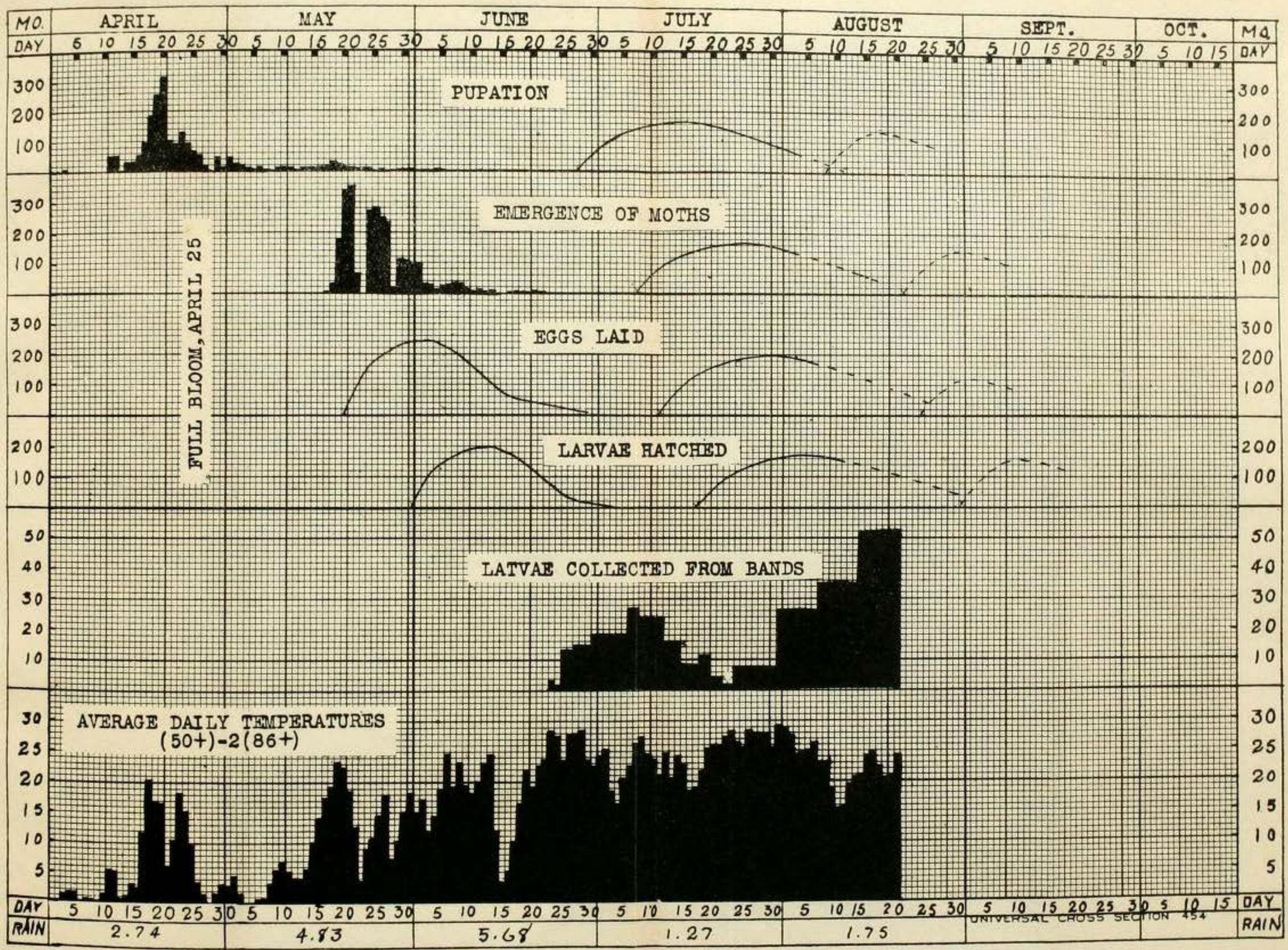


CHART 3. Seasonal history of the codling-moth at Olney, 1917.

TABLE 41—ACCUMULATED EFFECTIVE DAY-DEGREES AFTER JANUARY 1 TO AUGUST 31, ALSO DATES WHEN INDIVIDUALS OF EACH BROOD APPEARED AT OLNEY, 1915, 1916, 1917.

Date	1915.					1916.					1917.				
	Stage.	Daily day-degrees.		Total day-degrees.		Stage.	Daily day-degrees.		Total day-degrees.		Stage.	Daily day-degrees.		Total day-degrees.	
		50+	(50+)/2(86+)	50+	(50+)/2(86+)		50+	(50+)/2(86+)	50+	(50+)/2(86+)		50+	(50+)/2(86+)	50+	(50+)/2(86+)
Mar. 31			20.4	20.4	20.4				64.3	64.3				95.9	95.9
Apr. 1							3.8	3.8	68.1	68.1		7.2	7.2	103.1	103.1
" 2									68.1	68.1		.1	.1	103.2	103.2
" 3							1.9	1.9	70.0	70.0	Pupa	1.1	1.1	104.3	104.3
" 4		1.6	1.6	22.0	22.0		2.0	2.0	72.0	72.0		1.6	1.6	105.9	105.9
" 5		8.5	8.5	30.5	30.5		.5	.5	72.5	72.5		1.8	1.8	107.7	107.7
" 6		14.1	14.1	44.6	44.6		.2	.2	72.7	72.7		.1	.1	107.8	107.8
" 7		12.1	12.1	56.7	56.7				72.7	72.7		.5	.5	108.3	108.3
" 8		14.3	14.3	71.0	71.0				72.7	72.7		.2	.2	108.5	108.5
" 9	Pupa	16.7	16.7	87.7	87.7				72.7	72.7				108.5	108.5
" 10		10.1	10.1	97.8	97.8				72.7	72.7		1.6	1.6	110.1	110.1
" 11		5.1	5.1	102.9	102.9		7.5	7.5	80.2	80.2		5.5	5.5	115.6	115.6
" 12		.6	.6	103.5	103.5		15.7	15.7	95.9	95.9		5.3	5.3	120.9	120.9
" 13		1.6	1.6	105.1	105.1	Pupa	19.3	19.3	115.2	115.2		.5	.5	121.4	121.4
" 14		4.7	4.7	109.8	109.8		9.7	9.7	124.9	124.9		1.1	1.1	122.5	122.5
" 15		5.8	5.8	115.6	115.6		4.3	4.3	129.2	129.2		3.3	3.3	125.8	125.8
" 16		11.3	11.3	126.9	126.9		10.9	10.9	140.1	140.1		2.8	2.8	128.6	128.6
" 17		10.0	10.0	136.9	136.9		7.2	7.2	147.3	147.3		11.9	11.9	140.5	140.5
" 18		9.5	9.5	146.4	146.4		4.8	4.8	152.1	152.1		20.3	20.3	160.8	160.8
" 19		14.2	14.2	160.6	160.6		13.8	13.8	165.9	165.9		18.0	18.0	178.8	178.8
" 20		15.8	15.8	176.4	176.4		17.3	17.3	183.2	183.2		17.9	17.9	196.7	196.7
" 21		14.9	14.9	191.3	191.3		2.3	2.3	185.5	185.5		6.1	6.1	202.8	202.8
" 22		14.1	14.1	205.4	205.4		3.8	3.8	189.3	189.3		10.4	10.4	213.2	213.2
" 23		19.0	19.0	224.4	224.4		3.8	3.8	193.1	193.1		18.1	18.1	231.3	231.3
" 24		22.7	22.7	247.1	247.1		3.3	3.3	196.4	196.4		15.1	15.1	246.4	246.4
" 25		21.4	21.4	268.5	268.5		2.6	2.6	199.0	199.0		9.7	9.7	256.1	256.1
" 26		22.4	22.4	290.9	290.9		.3	.3	199.3	199.3		3.7	3.7	259.8	259.8
" 27	Adult	23.7	23.7	314.6	314.6		1.4	1.4	200.7	200.7		1.3	1.3	261.1	261.1
" 28		22.8	22.8	337.4	337.4		5.0	5.0	205.7	205.7		.1	.1	261.2	261.2
" 29		19.5	19.5	356.9	356.9		8.3	8.3	214.0	214.0		1.8	1.8	263.0	263.0
" 30		11.0	11.0	367.9	367.9		11.6	11.6	225.6	225.6		3.3	3.3	266.3	266.3
May 1		8.8	8.8	376.7	376.7		12.3	12.3	237.9	237.9		3.0	3.0	269.3	269.3
" 2		10.8	10.8	387.5	387.5		1.8	1.8	239.7	239.7		4.6	4.6	273.9	273.9
" 3		19.1	19.1	406.6	406.6		2.2	2.2	241.9	241.9		1.5	1.5	275.4	275.4
" 4		8.4	8.4	415.0	415.0		4.6	4.6	246.5	246.5				275.4	275.4
" 5	Egg	6.8	6.8	421.8	421.8		12.0	12.0	258.5	258.5				275.4	275.4
" 6		9.0	9.0	430.8	430.8		15.5	15.5	274.0	274.0		.7	.7	276.1	276.1
" 7		12.1	12.1	442.9	442.9		24.0	24.0	298.0	298.0		.8	.8	276.9	276.9
" 8		7.5	7.5	450.4	450.4		22.0	22.0	320.0	320.0		3.3	3.3	280.2	280.2
" 9		5.2	5.2	455.6	455.6		13.4	13.4	333.4	333.4		5.6	5.6	285.8	285.8
" 10		7.0	7.0	462.6	462.6	Adult	23.0	23.0	356.4	356.4		6.6	6.6	292.4	292.4
" 11		10.8	10.8	473.4	473.4		15.0	15.0	371.4	371.4		5.3	5.3	297.7	297.7
" 12		15.0	15.0	488.4	488.4		8.5	8.5	379.9	379.9		4.3	4.3	302.0	302.0
" 13		20.0	20.0	508.4	508.4		9.5	9.5	389.4	389.4		4.3	4.3	306.3	306.3
" 14		23.0	23.0	531.4	531.4	Egg	25.5	25.5	414.9	414.9		5.5	5.5	311.8	311.8
" 15		25.3	23.7	556.7	555.1		19.2	19.2	434.1	434.1		11.1	11.1	322.9	322.9
" 16		24.6	24.6	581.3	579.7		11.2	11.2	445.3	445.3		14.3	14.3	337.2	337.2
" 17	Larva	5.0	5.0	586.3	584.7		5.8	5.8	451.1	451.1	Adult	17.6	17.6	354.8	354.8
" 18		2.2	2.1	588.5	586.8		5.5	5.5	456.6	456.6		19.3	19.3	374.1	374.1
" 19		1.4	1.4	589.9	588.2		8.4	8.4	465.0	465.0		23.2	23.2	397.3	397.3
" 20		10.4	10.4	600.3	598.6		14.1	14.1	479.1	479.1	Egg	22.4	22.4	419.7	419.7
" 21		21.0	21.0	621.3	619.6		13.9	13.9	493.0	493.0		18.5	18.5	438.2	438.2
" 22		15.3	15.3	636.6	634.9		20.4	20.4	513.4	513.4		12.6	12.6	450.8	450.8
" 23		11.0	11.0	647.6	645.9		21.5	21.5	534.9	534.9		3.6	3.6	454.4	454.4
" 24		16.0	16.0	663.6	661.9		21.3	21.3	556.2	556.2		9.0	9.0	463.4	463.4
" 25		15.5	15.5	679.1	677.4	Larva	26.5	25.0	582.7	581.2		10.6	10.6	474.0	474.0
" 26		14.1	14.1	693.2	691.5		28.9	27.6	611.6	608.8		14.4	14.4	488.4	488.4
" 27		7.3	7.3	700.5	698.8		27.2	27.2	638.8	636.0		17.8	17.8	506.2	506.2
" 28		13.3	13.3	713.8	712.1		18.8	18.8	657.6	654.8		7.3	7.3	513.5	513.5
" 29		12.8	12.8	726.6	724.9		18.6	18.6	676.2	673.4		11.3	11.3	524.8	524.8
" 30		8.8	8.8	735.4	733.7		17.8	17.8	694.0	691.2		15.0	15.0	539.8	539.8
" 31		12.3	12.3	747.7	746.0		13.5	13.5	707.5	704.7		18.3	18.3	558.1	558.1
June 1		14.8	14.8	762.5	760.8		17.0	24.1	748.6	745.8		17.1	17.1	590.2	590.2
" 2		15.6	15.6	778.1	776.4		24.1	17.0	724.5	721.7	Larva	15.9	15.0	573.1	573.1
" 3		17.3	17.3	795.4	793.7		16.3	16.3	764.9	762.1		11.9	11.9	602.1	602.1
" 4		21.1	21.1	816.5	814.8		14.0	14.0	778.9	776.1		14.4	14.4	616.5	616.5
" 5		23.7	23.7	840.2	838.5		15.6	15.6	794.5	791.7		18.8	18.8	635.3	635.3
" 6		23.6	23.6	863.8	862.1		14.5	14.5	809.0	806.2		24.8	24.8	660.1	660.1
" 7		23.3	23.3	887.1	885.4		12.4	12.4	821.4	818.6		19.3	19.3	679.4	679.4
" 8		8.4	8.4	895.5	893.8		11.1	11.1	832.5	829.7		23.3	23.3	702.7	702.7
" 9		11.2	11.2	906.7	905.0		11.7	11.7	844.2	841.4		19.6	19.6	722.3	722.3
" 10		14.9	14.9	921.6	919.9		15.2	15.2	859.4	856.6		18.2	18.2	740.5	740.5
" 11		22.6	22.6	944.2	942.5		16.2	16.2	875.6	872.8		20.1	20.1	760.6	760.6
" 12	Mature larva	25.6	25.6	969.8	968.1		18.0	18.0	893.6	890.8		23.2	23.2	783.8	783.8
" 13		27.0	26.5	996.8	994.6		20.2	20.2	913.8	911.0		24.7	24.7	808.5	808.5
" 14		22.1	22.1	1018.9	1016.7		21.0	21.0	934.8	932.0		11.9	11.9	820.4	820.4
" 15		18.9	18.9	1037.8	1035.6		20.0	20.0	954.8	952.0		3.6	3.6	824.0	824.0
" 16		18.8	18.8	1056.6	1054.4	Mature larva	15.0	15.0	969.8	967.0		5.2	5.2	829.2	829.2
" 17	Pupa	20.8	20.8	1077.4	1075.2		15.0	15.0	984.8	982.0		10.2	10.2	839.4	839.4
" 18		22.6	22.6	1100.0	1097.8		16.6	16.6	1001.4	998.6		16.8	16.8	856.2	856.2
" 19		21.6	21.6	1121.6	1119.4		17.0	17.0	1018.4	1015.6		21.9	21.9	878.1	878.1
" 20		23.6	23.6	1145.2	1143.0	Pupa	18.5	18.5	1036.9	1034.1		19.2	19.2	897.3	897.3
" 21		24.4	24.4	1169.8	1167.4		17.4	17.4	1054.3	1051.5		22.8	22.8	920.1	920.1
" 22		22.1	22.1	1191.7	1189.5		16.6	16.6	1070.9	1068.1		23.8	23.8	943.9	943.9
" 23		17.8	17.8	1209.5	1207.3		22.4	22.4	1093.3	1090.5	Mature larva	28.2	28.2	972.1	972.1
" 24		17.4	17.4	1226.9	1224.7		22.3	22.3	1115.6	1112.8		27.7	27.7	999.8	999.8
" 25		17.8	17.8	1244.7	1242.5		18.8	18.8	1134.4	1131.6		25.2	23.4	1025.0	1023.2
" 26		21.1	21.1	1265.8	1263.6		21.6	21.6	1156.0	1153.2		31.5	27.7	1056.5	1050.9
" 27		22.5	22.5	1288.3	1286.1		26.2	26.2	1182.2	1179.4	Pupa	28.4	27.9	1084.9	1078.8
" 28	Adult	23.1	23.1	1311.4	1309.2		23.6	23.6	1205.8	1203.0		28.4	28.4	1113.3	1107.2
" 29		22.6	22.6	1334.0	1331.8		24.9	24.9	1230.7	1227.9		23.2	23.2	1136.5	1130.4
" 30		21.5	21.5	1355.5	1353.3		27.8	25.5	1258.5	1253.4		22.6	22.6	1159.1	1153.0
July 1		21.1	21.1	1376.6	1374.4		28.7	28.2	1287.2	1281.6		24.6	24.6	1183.7	1177.1
" 2		21.5	21.5	1398.1	1395.9		29.8	26.5	1317.0	1308.1		26.8	25.2	1210.5	1202.3
" 3	Egg	19.5	19.5	1417.6	1415.4	Adult	30.3	29.0	1347.3	1337.1		18.5	18.5	1229.0	1220.8
" 4		15.2	15.2	1432.8	1430.6		25.1	25.1	1372.4	1362.2		16.4	16.4	1245.4	1237.2
" 5		11.1	11.1	1443.9	1441.7		23.6	23.6	1396.0	1385.8		20.5	20.5	1265.9	1257.7
" 6		15.6	15.6	1459.5	1457.3	Egg	23.9	23.9	1419.9	1409.7		22.6	22.6	1288.5	1280.3
" 7		19.4	19.4	1478.9	1476.7		26.8	25.3	1446.7	1435.0	Adult	28.8	26.3	1317.3	1306.6
" 8		18.4	18.4	1497.3	1495.1		28.2	26.2	1474.9	1461.2		29.5	27.3	1346.8	1333.9
" 9		18.3	18.3	1515.6	1513.4		25.0	25.0	1499.9	1486.2		25.7	24.5	1372.5	1358.4
" 10		22.2	22.2	1537.8	1535.6		26.2	26.2	1526.1	1512.4		23.7	23.7	1396.2	1382.1
" 11	Larva	21.7	21.7	1559.5	1557.3		28.4	27.1	1554.5	1539.5	Egg	21.3	20.8	1417.5	1402.9
" 12		23.7	23.7	1583.2	1581.0	Larva	26.5	26.5	1581.0	1566.0		24.7	24.7	1442.2	1427.6
" 13		27.4	27.1	1610.6	1608.1		25.7	25.4	1606.7	1591.4		21.6	20.4	1463.8	1448.0
" 14		30.3	28.8	1640.9	1636.9		27.2	27.2	1633.9	1618.6		24.2	24.2	1488.0	1472.2
" 15		32.6	30.3	1673.5	1667.2		31.6	28.6	1665.5	1647.2		22.5	22.5	1510.5	1494.7
" 16		32.3	30.6	1705.8	1697.8		32.2	28.9	1697.7	1676.1		18.4	18.4	1528.9	1513.1
" 17		30.2	29.7	1736.0	1728.5		31.1	27.4	1728.8	1703.5	Larva	19.0	19.0	1547.9	1532.1
" 18		30.5	29.7	1766.5	1757.2		31.3	28.4	1760.1	1731.9		22.2	21.8	1570.1	1553.9
" 19		27.2	27.2	1793.7	1784.4		30.1	28.6	1790.2	1760.5		25.7	25.4	1595.8	1579.3
" 20		26.6	26.6	1820.3	1811.0		27.7	26.9	1817.9	1787.4		26.0	25.9	1621.8	1605.2
" 21		18.9	18.9	1839.2	1829.9		26.4	26.4	1844.3	1813.8		30.2	25.8	1652.0	1631.0
" 22		18.8	18.8	1858.0	1848.7		25.6	24.4	1869.9	1838.2		28.0	27.6	1680.0	1658.6
" 23		20.2	20.2	1878.2	1868.9		28.3	24.6	1898.2	1862.8		30.0	28.4	1710.0	1687.0
" 24		21.3	21.3	1899.5	1890.2		29.2	25.0	1927.4	1887.8		28.3	26.3	1738.3	1713.3
" 25		22.4	22.4	1921.9	1912.6		31.0	25.0	1958.4	1912.8		27.4	25.4	1765.7	1738.7
" 26		25.5	25.5	1947.4	1938.1		32.3	27.1	1990.7	1939.9		28.4	28.4	1794.1	1767.1
" 27		27.4	27.4	1974.8	1965.5		33.9	26.4	2024.6	1966.3		29.1	27.8	1823.2	1794.9
" 28		27.2	26.0	2002.0	1991.5		33.6	27.0	2058.2	1993.3		31.2	27.7	1854.4	1822.6
" 29		29.1	29.1	2031.1	2020.6		35.6	27.4	2093.8	2020.7		33.0	27.8	1887.4	1850.4
" 30		29.3	29.3	2060.4	2049.9		34.3	28.8	2128.1	2049.5		34.0	25.8	1921.4	1876.2
" 31	Mature larva	32.0	29.5	2092.4	2079.4	Mature larva	35.7	29.7	2163.8	2079.2		36.6	29.3	1958.0	1905.5
Aug. 1		27.3	27.3	2119.7	2106.7		27.8	27.8	2191.5	2107.0		35.0	28.7	1993.0	1934.2
" 2		26.8	26.8	2146.5	2133.5		29.0	27.4	2220.5	2134.4		29.7	27.7	2022.7	1961.9
" 3	Pupa	25.8	25.8	2172.3	2159.3	Pupa	31.3	26.8	2251.8	2161.2		26.6	23.4	2049.3	1985.3
" 4		15.1	15.1	2187.4	2174.4		34.8	28.4	2286.6	2189.6	Mature larva	29.3	24.5	2078.6	2009.8
" 5		13.8	13.8	2201.2	2188.2		34.4	28.2	2321.0	2217.8		30.0	24.9	2108.6	2034.7
" 6		20.1	20.1	2221.3	2208.3		34.0	28.2	2355.0	2246.0		26.5	26.2	2135.1	2060.9
" 7		20.4	20.4	2241.7	2228.7		34.8	29.5	2389.8	2275.5		22.6	22.6	2157.7	2083.5
" 8		26.1	26.1	2267.8	2254.8		32.1	30.3	2421.9	2305.8	Pupa	22.8	22.8	2180.5	2106.3
" 9		25.3	25.3	2293.1	2280.1		28.7	28.2	2450.6	2334.0		18.4	18.4	2198.9	2124.7
" 10		22.7	22.7	2315.8	2302.8		31.1	27.9	2481.7	2361.9		16.2	16.2	2215.1	2140.9
" 11		18.8	18.8	2334.6	2321.6		33.0	29.0	2514.7	2390.9		16.5	16.5	2231.6	2157.4
" 12		18.8	18.2	2352.8	2339.8	Adult	27.9	27.4	2542.6	2418.3		19.2	19.2	2250.8	2176.6
" 13		20.3	20.3	2373.1	2360.1		23.4	23.4	2566.0	2441.7		20.9	20.9	2271.7	2197.5
" 14		21.4	21.4	2394.5	2381.5	Egg	13.6	13.6	2579.6	2455.3		21.0	21.0	2292.7	2218.5
" 15		20.7	20.7	2415.2	2402.2		20.6	20.6	2600.2	2475.9		24.1	24.1	2316.8	2242.6
" 16	Adult	27.3	27.0	2442.5	2429.2		27.2	27.2	2627.4	2503.1		24.8	24.8	2341.6	2267.4
" 17		24.1	24.1	2466.6	2453.3		27.6	26.4	2655.0	2529.5		22.8	22.1	2364.4	2289.5
" 18	Egg	17.3	17.3	2483.9	2470.6		33.1	28.9	2688.1	2558.4		21.4	20.2	2385.8	2309.7
" 19		14.7	14.7	2498.6	2485.3		33.0	29.2	2721.1	2587.6		20.8	20.8	2406.6	2330.5
" 20		15.8	15.8	2514.4	2501.1	Larva	33.8	30.3	2754.9	2617.9		24.1	24.1	2430.7	2354.6
" 21		16.1	16.1	2530.5	2517.2		30.0	27.3	2784.9	2645.2	Adults	22.8	22.8	2453.5	2377.4
" 22		16.8	16.8	2547.3	2534.0		24.8	24.8	2809.7	2670.0		23.5	23.5	2477.0	2400.9
" 23		18.7	18.7	2566.0	2552.7		19.8	19.8	2829.5	2689.8	Egg	23.5	23.5	2500.5	2424.4
" 24		22.7	22.7	2588.7	2574.5		19.3	19.3	2848.8	2709.1		18.0	18.0	2518.5	2442.4
" 25		13.8	13.8	2602.5	2589.2		22.1	22.1	2870.9	2731.2		17.3	17.3	2535.8	2459.7
" 26		12.0	12.0	2614.5	2601.2		21.1	21.1	2892.0	2752.3		20.3	20.3	2556.1	2480.0
" 27		15.8	15.8	2630.3	2617.0		16.8	16.8	2908.8	2769.1		25.8	25.8	2581.9	2505.8
" 28		13.8	13.8	2644.1	2630.8		13.8	13.8	2922.6	2782.9		20.3	20.3	2602.2	2526.1
" 29	Larva	13.9	13.9	2658.0	2644.7		13.9	13.9	2936.5	2796.8		14.3	14.3	2616.5	2540.4
" 30		[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]

TABLE 40—DATES OF THE APPEARANCE OF THE FIRST INDIVIDUALS OF THE BROODS OF THE CODLING-MOTH AT OZARK, OLNEY, AND SPRINGFIELD IN 1917

Generation	Stage	Ozark	Olney	Spring-field
Hibernating	Adults	May 12	May 17	May 17
First	Eggs	May 19	May 20	
	Larvæ	May 27	June 1	
	Mature larvæ	June 18	June 23	June 25
	Adults	July 1	July 7	July 9
Second	Eggs		July 11	
	Larvæ		July 17	

To show the relation between the time of the appearance of the first individuals of each of the broods throughout the season at Olney Table 41 has been prepared.

The same data were worked out for Ozark in 1915, Springfield in 1916 and 1918, and Siloam Springs, Arkansas, for 1908, and the results are summarized in Table 42.

From the averages in the last column of Table 42 we find, by a little calculation, that the average accumulation of effective day-degrees from the time of the appearance of the first individuals of the first brood of pupæ, adults, eggs, and larvæ to the time of appearance of the first individuals of the second brood of the same is 979, and that the average accumulation between the time of appearance of the first individuals of the second brood of pupæ, adults, eggs, and larvæ and the time of appearance of the first individuals of the third brood of the same is 1082, the average accumulation for the complete life cycle, that is, for the period between the time of the appearance of the first eggs, larvæ, pupæ, or adults of one generation and the first eggs, larvæ, pupæ, or adults of the next generation, being 1030.

From studies on the relation of temperature to the development of the different stages and to the whole development period in the life history, we know that there is practically no difference between the number of effective day-degrees which accumulate during these periods in the different generations. The differences shown by the data in the table are therefore undoubtedly due to the comparatively small number of observations on which the averages were based and to the fact that some of the observations were made in connection with breeding experiments in which comparatively small numbers of individuals were used. The dates on which the first larvæ of the first generation entered the fruit were determined by observations on individuals reared from hibernating larvæ, and since the number of individuals thus used was very small as compared with the whole number in the orchard, no doubt larvæ began to enter the fruit in the orchard before the first larvæ were secured in the experiments. The dates when the first larvæ of the second genera-

TABLE 42—ACCUMULATED EFFECTIVE DAY-DEGREE AT THE TIME OF THE OBSERVED APPEARANCE OF THE FIRST INDIVIDUALS OF EACH BROOD

Generation	Stage	Olney			Ozark	Springfield		Siloam Springs, Ark.*	Average
		1915	1916	1917	1915	1916	1918	1908	
Hibernating	Pupa		115	104		108	110		109
	Adult	315	356	355	364	313	345	324	339
First	Egg	422	415	420		400		371	406
	Larva	585	581	573	534	574		623	578
	Mature larva	968	967	972	860	1082			970
	Pupa	1075	1034	1079		1169	1066	1024	1074
	Adult	1309	1337	1307	1248	1399	1272	1285	1308
Second	Egg	1415	1410	1403		1454		1389	1414
	Larva	1557	1566	1532	1518	1602		1528	1551
	Mature larva	2079	2079	2009†	1999	2134		2034	2065
	Pupa	2168	2161	2106†	2100	2246			2169
	Adult	2429	2418	2377†	2321	2430	2302	2423	2387
Third	Egg	2471	2455	2424†		2490		2477	2471
	Larva	2645	2618	2576†	2568	2688		2643	2632

* Data in this column were obtained by the use of the 1908 records of the U. S. Weather Bureau for Fayetteville, Arkansas, and the seasonal history records of the codling-moth as given by E. L. Jenne in Bulletin No. 80, Part I, of the Bureau of Entomology, U. S. Department of Agriculture, 1909.

† Numbers followed by a dagger were computed.

tion entered the fruit was determined from observations on individuals secured from band collections. These were abundant enough to give us the dates with a fair degree of accuracy. The number of effective day-degrees, 1551, or, to use round numbers, 1550, given for this event in the table may be considered as approximately correct and will be used as a basis for making corrections in the table. The dates when the first larvæ of the third generation entered the fruit were determined from a comparatively small number of individuals isolated for the purpose of life history studies, and for this reason it is quite certain that the dates thus obtained were somewhat later than the true dates.

It is impossible to estimate with any degree of accuracy how much of an error was made in determining dates from a too limited amount of material, but we can, by using data procured by studies on the relation of temperature to the different stages and to the complete development period, determine the approximate minimum effective day-degrees which accumulate during the complete life cycle; and by using 1550 as the total effective day-degrees at the time when the first larvæ of the second generation appear we can determine the total effective day-degrees for the date on which the first egg, larvæ, pupæ, and adults of the three generations may be expected to appear.

From our studies on the relation of temperature to the development of the three stages we concluded (see page 280) that the minimum accumulation for the three stages was about 939, the average 1101, and the maximum about 1317; and from our studies on the life history of 348 individuals we concluded that the minimum accumulation for the period of development was about 950, the average 1120, and the maximum about 1350 (see page 259). To get the total accumulation for the complete life cycle, it will be necessary to add to these mimima, averages, and maxima about 50, 75, and 250, respectively, because the deposition of the first eggs, the time of maximum oviposition, and the laying of the last eggs do not occur until about the first, the third, and the tenth day, respectively, after the emergence of the female. (Table 43.)

None of the minima, 989, 1000, and 1030, obtained for the complete life cycle by the different methods was determined with absolute accuracy, but they were based on actual observations, and the fact that they do not differ very widely indicates that they are approximately correct. For practical purposes either one might be used as the minimum, but the second minimum, 1000, being nearly the average of the three is perhaps more nearly correct than the others, and it will be used as the basis for the discussion which follows.

By dividing the 1000 effective day-degrees into parts proportional to the minimum effective day-degrees required for the egg, larval, and pupal periods, making allowance for the period elapsing between the time of the emergence of the adult female and the deposition of the first eggs, and by taking 1550 (Table 42) as approximately the correct accumulation at the time when the larvæ of the second generation begin

to enter the fruit, we can construct a consistent table showing the approximate accumulations which indicate the time when the first pupæ, adults, eggs, and larvæ of the three generations may be expected to appear. Table 44, however, for the present, must be regarded as only a somewhat close approximation to the correct accumulations. It may be necessary to make some changes as a result of further observations.

TABLE 43—ACCUMULATION OF EFFECTIVE DAY-DEGREES DURING STAGES, DURING ENTIRE DEVELOPMENT PERIOD, AND DURING THE COMPLETE LIFE CYCLE

	Period	Accumulation		
		Minimum	Average	Maximum
Stages	Egg	156	163	170
	Larva	527	673	873
	Pupa	256	265	274
	(Total)	939	1101	1317
	Adult to egg	50	75	250
	Life cycle	989	1176	1567
Life history	Development period	950	1120	1350
	Adult to egg	50	75	250
	Life cycle	1000	1195	1600
Seasonal history	Life cycle	1030		

TABLE 44—ACCUMULATED EFFECTIVE DAY-DEGREES WHICH INDICATE THE TIME WHEN THE FIRST EGGS, LARVAE, PUPAE, AND ADULTS MAY BE EXPECTED TO APPEAR

Generation	Stage	Day-degrees
Hibernating	First pupæ	82
	First adults	340
First generation	First eggs	392
	First larvæ	550
	First pupæ	1082
	First adults	1342
Second generation	First eggs	1392
	First larvæ	1550
	First pupæ	2082
	First adults	2342
Third generation	First eggs	2392
	First larvæ	2550

TABLE 45—AVERAGE NORMAL DAILY EFFECTIVE DAY-DEGREES, ACCUMULATIONS OF THE SAME, AND DATES WHEN THE FIRST INDIVIDUALS OF THE DIFFERENT STAGES OF EACH GENERATION MAY BE EXPECTED TO APPEAR AT OLNEY IN A NORMAL SEASON

Date.	March.			April.			May.			June.			July.			August.		
	Daily effective day-degrees.	Total effective day-degrees.	Stage.	Daily effective day-degrees.	Total effective day-degrees.	Stage.	Daily effective day-degrees.	Total effective day-degrees.	Stage.	Daily effective day-degrees.	Total effective day-degrees.	Stage.	Daily effective day-degrees.	Total effective day-degrees.	Stage.	Daily effective day-degrees.	Total effective day-degrees.	Stage.
1	1	1		5	91		11	296		20	789		25	1465		26	2264	
2	1	2		5	96		11	307		20	809		25	1490		26	2290	
3	1	3		5	101		12	319		20	829		25	1515		26	2316	
4	1	4		5	106		12	331		20	849		25	1540	Larva	26	2342	Adult
5	1	5		5	111		13	344	Adult	20	869		25	1565		26	2368	
6	1	6		5	116		13	357		20	899		25	1590		25	2393	Egg
7	1	7		5	121		13	370		20	909		26	1616		25	2418	
8	2	9		5	126		14	384		20	929		26	1642		25	2443	
9	2	11		5	131		14	398	Egg	21	950		26	1668		25	2468	
10	2	13		5	136		14	412		21	971		26	1694		25	2493	
11	2	15		5	141		14	426		21	992		26	1720		25	2518	
12	2	17		5	146		15	441		21	1013		26	1746		25	2543	Larva
13	3	20		6	152		15	456		22	1035		27	1773		25	2568	
14	3	23		6	158		15	471		22	1057		27	1800		25	2593	
15	3	26		6	164		15	486		22	1079	Pupa	27	1827		26	2619	
16	3	29		6	170		15	501		22	1101		27	1854		26	2645	
17	3	32		6	176		16	517		22	1123		27	1881		26	2671	
18	3	35		7	183		16	533		23	1146		27	1908		26	2697	
19	3	38		7	190		16	549	Larva	23	1169		27	1935		26	2723	
20	4	42		7	197		17	566		23	1192		26	1961		25	2748	
21	4	46		7	204		17	583		24	1216		26	1987		24	2772	
22	4	50		8	212		17	600		24	1240		26	2013		24	2796	
23	4	54		8	220		18	618		25	1265		25	2038		24	2720	
24	4	58		9	229		18	636		25	1290		25	2063		24	2844	
25	4	62		9	238		18	654		25	1315		25	2088	Pupa	24	2868	
26	4	66		9	247		18	672		25	1340	Adult	25	2113		23	2891	
27	4	70		9	256		19	691		25	1365		25	2138		22	2913	
28	4	74		9	265		19	710		25	1390	Egg	25	2163		22	2935	
29	4	78		10	275		19	729		25	1415		25	2188		22	2957	
30	4	82	Pupa	10	285		20	749		25	1440		25	2213		22	2979	
31	4	86					20	769					25	2238		22	3001	

Method of Forecasting Dates when the Different Stages of the several Generations may be expected to appear at any given Place in a Normal Season

By ascertaining the normal daily effective day-degrees at any point in the state throughout the season and ascertaining the total sums of the daily accumulations for each day of the season and comparing the sums on the different dates with Table 44, we can ascertain the approximate dates when the different stages of each generation may be expected to appear. Table 45 gives the normal daily effective day-degrees, the total effective day-degrees, and the dates on which the first individuals of the stages of each generation normally appear at Olney, Illinois.

This table was computed from the maximum and minimum readings of the U. S. Weather Bureau at Olney from 1901 to 1916 inclusive by the formulæ given on page 283. In all of these computations the daily effective day-degrees were taken as the average degrees above 50° F. diminished by twice the average degrees above 86.

It is not to be expected that the first eggs, larvæ, pupæ, and adults will appear in any locality on the exact dates shown in a table of the normal accumulations of effective day-degrees for that locality. Such tables will give only the approximate dates. There are many factors which may influence the time of appearance: there are always periods during every season when the temperatures are not normal; there are situations in every locality in which the temperatures differ from those of the place where the recording instrument is located, such as steep northern and steep southern slopes, and differences in altitudes in hilly countries; and pupæ on the south side of the trunks of trees will be subjected to greater heat than those on the north side.

There is no practical method by which all the local factors may be taken into account, but the seasonal variations may be anticipated by keeping a daily record of the total accumulation of effective day-degrees in each of the fruit-growing sections; and dates when the first larvæ of each generation may be expected to enter the fruit may be anticipated however abnormal the weather may be. When the accumulations amount to 390, 1290, and 2280 the first larvæ of the first, second, and third generations, respectively, may be expected to enter the fruit in about 10 days. (See Table 51, p. 289.)

Table 43 (p. 280) shows that the average accumulation of effective day-degrees for the complete life cycle, as ascertained by a study of the different stages, is 1176, the maximum being about 1567, and that by a study of the life history the average accumulation is 1195, the maximum being about 1600. These differences arise partly from the fact that in the former case 86, 85, and 87 degrees F. were used as the degrees of maximum rate of development of the egg, larva, and pupa, respectively, whereas in the latter case 86 was used for each of the stages. Since it is much more convenient to use 86, 1195 should be used as the approximate average.

It follows that since the first and the second generations are almost complete in the southern half of Illinois, if the larvæ of the first generation are observed to be entering the fruit in large numbers on a certain date, larvæ of the second generation will be entering the fruit in large numbers after an interval during which the accumulated effective day-degrees have reached 1195, unless delaying factors, such as parasites, rainy weather at hatching time, or other cause which might occasion great mortality of eggs, larvæ, or pupæ, should intervene. This would not hold true for the third generation, since it is not complete, for, at best, only a small proportion of the larvæ of the second generation transform.

The maximum number of effective day-degrees which may accumulate between the deposition of an egg of one generation and the deposition of an egg of the next generation is about 1600. If a number of eggs are deposited on the same day the deposition of eggs by females developed from them will be extended over a period during which the accumulation of effective day-degrees ranges from 1000 to 1600, which corresponds to a period of about 20 days. This accounts largely for the overlapping of the second and third generations notwithstanding the fact that the first and second do not overlap.

How to compute Effective Day-degrees

One of the main objects of this investigation was to find, if possible, a single factor in terms of which the progress of the seasonal history of the insect could be followed and even predicted long enough beforehand to be of practical value. *Apparently we have found that factor in temperature expressed in terms of effective day-degrees as the unit.* Humidity, evaporation, and rainfall may affect the rate of development to some extent, but in the case of the codling-moth these factors have such a small influence under out-of-door conditions that for practical purposes they may be disregarded, leaving temperature as the single factor to be taken into account.

The temperatures that are to be taken into account are the temperatures above 50 degrees and those above 86. To ascertain the number of effective day-degrees that have accumulated during any given day, first find the average degrees above 50 degrees F., then the average degrees above 86 degrees, multiply the latter by two and subtract the product from the former. The result will be the effective day-degrees.

To compute the effective day-degrees, accurate thermograph records should be kept. The average daily temperatures above 50 degrees F. can be computed by adding together the hourly readings above 50 and dividing the sum by 24, and the average daily temperatures above 86 can be computed in the same manner. If the drum type of thermograph be used the temperature curve above 50 and above 86 may be integrated by means of a planimeter, expressing the result as hourly-degree units, then by dividing the totals for each day by 24, the average hourly-degrees above 50 and 86 may be ascertained, which are the day-degrees in each case. Subtracting from the day-degrees above 50 twice the day-degrees above 86 gives the number of effective day-degrees.

In case thermograph records are not available the effective day-degrees can be determined approximately from maximum and minimum readings by the use of the following formulæ proposed by Dr. S. A. Forbes.

Formulae for computing the average day-degrees above any given temperature, using the maximum temperature, and the minimum temperatures preceding and following it.

a = Number of degrees that the first minimum is above or below the given temperature.

b = Number of degrees that the second minimum is above or below the given temperature.

c = Number of degrees that the maximum is above the given temperature.

x = Number of day-degrees above the given temperature.

I. When both minima are at or above the given temperature,

$$x = \frac{a + b + 2c}{4}.$$

II. When the first minimum is below the given temperature,

$$x = \frac{b + c}{4} + \frac{c^2}{4(a + c)}.$$

III. When the second minimum is below the given temperature,

$$x = \frac{a + c}{4} + \frac{c^2}{4(b + c)}.$$

IV. When both minima are below the given temperature,

$$x = \frac{c^2}{4(a + c)} + \frac{c^2}{4(b + c)}.$$

When the thermograph is used it should be kept correct by checking it up daily with the maximum and minimum thermometers, and the recording instrument should be kept in a place which has the same conditions as to temperature as the orchards to which the records are to be applied. It is very evident that the maximum and minimum readings taken in the heart of a city would not give readings that would apply to adjacent country districts.

Relation of Temperature to Time when Larvae Hibernate

In the spring, hibernating larvæ will begin to transform as soon as temperatures rise above 52° F., but after midsummer, soon after the temperatures begin to fall, maturing larvæ cease to transform long before the temperatures fall below the 52 point.

Generally, larvæ that mature prior to August 1 transform; those that mature after September 1, hibernate; and of those that mature during August some hibernate and some transform, the percentage of those that hibernate usually increasing as the month advances, the rate of increase depending upon the temperatures.

The time when hibernation takes place is determined largely by the habit of the species, but it may be somewhat modified by temperatures. While at Olney hibernation did not usually take place until August, a few unusually cool days caused some larvæ to hibernate as early as the first week in July in 1915, and in 1916 hibernation was delayed till the middle of August by continuous warm weather. Some larvæ hibernate any time after midsummer when the minimum daily temperatures fall to 60° or below and the mean daily temperatures to about 70° or below; other larvæ do not hibernate until such temperatures have prevailed for two or three weeks. During the latter half of August hibernation is induced much more readily than earlier in the month, and with rare exceptions larvæ maturing after September 1 hibernate irrespective of temperatures.

Table 46 illustrates what has just been said concerning hibernation.

Note that in 1915, 4.4 per cent. of the larvæ which matured during the period from July 4 to July 7, at the close of a week of unusually cool weather, hibernated. Another period of cool weather ended with July 25, and 5 per cent. of the larvæ maturing during the period from July 25 to July 28 hibernated. The next period of cool weather began August 4, and 7 per cent. of the larvæ maturing during the period from August 4 to August 7 hibernated. From this time on, the mean daily temperatures remained near 70° or below, and the percentage of hibernating larvæ increased very rapidly until August 27. All larvæ under observation maturing after this date hibernated with the exception of two. The two larvæ which transformed, matured during a period of twelve exceptionally warm days following September 7.

In 1916 there were no cool days in July and none in August until the 14th. No larvæ hibernated in July. A few that hibernated prior to August 14, hibernated apparently purely from habit. The two cool days of August 14 and 15 may have hastened hibernation, but the percentage of those that hibernated increased rapidly from the 16th to the 22d, although the weather was unusually warm, showing that after the middle of August larvæ will yield to their habit regardless of temperatures. The delay in the time of hibernation in 1916, as compared with 1915, was undoubtedly due to the higher temperatures in 1916 during August.

Relation of Humidity and Evaporation to the Rate of Development of the Codling-moth

When we began the preliminary study of our accumulated data on this subject they indicated clearly that temperature was the controlling factor in determining the rate of development of the stages of the codling-moth, and that humidity and evaporation had at most only a very

TABLE 46—Percentage of Larvae collected at Olney from Bands at Intervals of 2–4 Days which Hibernated, with Record of Temperatures

Date of collection.	1915.						1916.					
	Temperature.			Per cent. hibernated.			Temperature.			Per cent. hibernated.		
	Max.	Min.	Mean	Male	Female	M. & F.	Max.	Min.	Mean	M.	F.	M.& F.
July 1	90	64	71				87	69	79			
" 2	83	61	72	.....	.....	.....	92	67	80			
" 3	72	63	70				89	71	80			
" 4	77	58	65				83	65	75			
" 5	74	50	61				85	61	74			
" 6	77	53	66	5.8	3.3	4.4	86	61	74			
" 7	81	62	69				89	64	77			
" 8	69	64	68				90	66	78			
" 9	73	60	68	.....	.....	.....	86	66	75			
" 10	84	67	72				87	65	76			
" 11	86	65	72				91	68	78			
" 12	81	68	74	.....	.....	.....	78	73	77			
" 13	87	69	77				88	68	76			
" 14	90	72	80				87	69	77			
" 15	91	74	83	.....	.....	.....	91	72	82			
" 16	90	75	82				94	71	82			
" 17	88	75	80				94	70	81			
" 18	89	73	81	.....	.....	.....	93	71	81			
" 19	86	71	77				92	71	80			
" 20	80	71	77				90	70	78			
" 21	78	58	69	.....	.....	.....	87	70	76			
" 22	79	58	69				90	61	76			
" 23	82	58	70	.....	.....	.....	94	65	79			
" 24	82	61	71				94	65	79			
" 25	84	64	72				96	67	81			
" 26	86	70	76				97	68	82			
" 27	87	70	77	.....	6.7	5.	99	70	84			
" 28	90	70	77				97	70	84			
" 29	82	72	79				98	75	86			
" 30	87	73	79	.....	.....	.....	95	73	84			
" 31	91	74	82				99	76	86			
Aug. 1	86	72	77				83	71	77			
" 2	84	71	76	.....	.....	.....	91	70	79			
" 3	80	73	76				95	70	81			
" 4	70	61	65				98	73	84			
" 5	75	56	64	7.	1.	7.	97	73	84			
" 6	82	60	70				97	74	84	2		1
" 7	84	57	70				97	73	85			
" 8	85	68	76	11.	.....	5.	90	72	82			
" 9	81	65	75				89	70	78	2		1
" 10	72	71	72				93	73	81			
" 11	71	67	68	39.	23.	27.	96	72	83			
" 12	77	60	69				87	72	78	2	3	3
" 13	83	60	70				73	67	73			
" 14	74	67	71	32.	19.	25.	71	56	64			
" 15	83	61	71				79	67	70		10	5
" 16	88	70	77				86	70	77			
" 17	82	69	74	83.	71.	77.	90	66	77			
" 18	65	62	67				94	74	83	44	61	53
" 19	72	59	64				94	74	83			
" 20	71	62	65	95.	86.	91.	95	74	84			
" 21	74	61	66				93	72	80	76	76	76
" 22	78	57	67				86	71	74			
" 23	79	60	69	98.	96.	97.	78	59	70			
" 24	80	67	73				83	56	70	88	88	88
" 25	72	54	63				87	62	87			
" 26	69	53	62	97.	100.	98.	80	63	71			
" 27	74	61	66				70	62	67	95	92	94
" 28	75	53	64				75	53	64			
" 29	71	59	64	100.	100.	100.	77	50	63			
" 30	65	55	60				80	53	65	100	99	99
" 31	70	46	56				85	57	69			
Sept. 1	74	49	61	100.	100.	100.	76	63	69	100	100	100
" 2	82	56	68				82	65	71			
" 3	80	58	69	100.	100.	100.	82	62	72			
" 4	81	62	69				85	61	72	100	100	100
" 5	75	63	69				89	71	79			
" 6	80	61	69	99.	99.	99.	90	68	74			
" 7	84	67	73				87	72	78			
" 8	87	68	77				78	68	72	100	100	100
" 9	85	67	76				78	56	68			
" 10	87	68	77	100.	100.	100.	82	58	68			
" 11	89	67	77				85	65	73	100	100	100
" 12	89	70	79				82	68	75			
" 13	90	71	79	100.	100.	100.	70	62	68			
" 14	90	75	81				75	60	65	100	100	100
" 15	89	74	79				63	47	58			
" 16	89	72	76	100.	100.	100.	68	35	50			
" 17	82	70	75				76	47	59	100	100	100
" 18	85	69	74				64	40	55			
" 19	84	40	71	100.	100.	100.	70	35	51	100	100	100
" 20	70	41	67				77	41	56			

slight influence. Our plan, therefore, was to make a study of our data with reference to temperature alone, and find as nearly as possible the temperature constant for each of the stages; then to study the data with reference to humidity and evaporation and ascertain what effects different humidities or different evaporation rates had on the temperature constant. Several statements have already been made to the effect that the influence of humidity and evaporation is too slight to make it necessary to take them into account. It remains now only to present the data upon which this conclusion was based.

It is hardly to be expected that the degree of humidity of the atmosphere or the rate of evaporation could have any effect on the larva, surrounded as it is by the juicy substance of the apple; therefore the data bearing upon the relation of these factors to the rate of larval development have not been brought together; but the data bearing upon their relation to the rate of development of the egg and pupa are summarized in the following tables (47–50). The ranges of temperature are given at the top of the tables and the ranges of humidity or the rate of evaporation in the first column at the left, and then, in their proper places, are inserted the average effective day-degrees of all the individuals whose periods were observed at the respective temperatures and humidities or rates of evaporation.

In the right-hand column are given the average effective day-degrees for the different degrees of humidity or evaporation regardless of temperature; and at the bottom of the tables, the average effective day-degrees for the different temperatures, regardless of humidity or evaporation. The smaller figures, above the numbers indicating the average effective day-degrees, record the number of observations on which the averages are based.

Tables 47–50 show that there is no consistent variation in the average total effective day-degrees corresponding to the different degrees of humidity or rates of evaporation. The variations are rather hit and miss, apparently depending more upon the number of individuals upon which the averages were based than upon any other factor. In all cases where the number of observations on which the averages were based is large, the average effective day-degrees vary only slightly from the total average. Possibly there is some slight indication that incubation proceeds at a greater rate at humidities between 70 and 74 than at higher or lower humidities and at rates of evaporation between 20 and 24 than at lower rates; but we are hardly warranted in basing any definite conclusion on this indication, and if we were, the variations are so slight that for practical purposes they could be disregarded, since the extreme variations where the number of observations from the average are 500 or more would amount to a variation of less than one eighth of a day in the period.

TABLE 47—RELATION OF HUMIDITY TO RATE OF DEVELOPMENT OF EGG AS SHOWN BY EFFECTIVE DAY-DEGREES

Temp. ☛ Humid. ☟	60°-64°	65°-69°	70°-74°	75°-79°	80°-84°	Average
65-69	138 171.2					138 171.2
70-74	53 153.0	81 164.3	251 161.4	114 161.0	256 163.4	755 161.7
75-79	169 156.3	847 164.5	703 162.9	275 160.3	206 162.7	2200 162.6
80-84	111 172.0	237 159.6	282 160.8	159 162.6	13 175.0	802 162.6
85-89	132 171.3	38 174.4	70 172.0	52 163.0		292 170.4
Average	593 165.6	1203 165.1	1306 162.6	600 161.3	475 163.4	4187 163.3

TABLE 48—RELATION OF EVAPORATION TO RATE OF DEVELOPMENT OF EGG AS SHOWN BY EFFECTIVE DAY-DEGREES

Temp. ☛ Evap. ☟	60°-64°	65°-69°	70°-74°	75°-79°	80°-84°	Average
5-9	32 150.0	85 160.9	217 160.4			334 159.9
10-14	398 165.8	807 164.4	431 165.8	353 161.4		1989 164.5
15-19	71 159.3	311 163.1	409 160.8	47 166.5	181 166.2	1019 162.6
20-24	102 172.9		249 161.3	177 157.6	112 156.0	640 161.2
25-29				23 176.2	182 165.4	205 166.6
Average	603 165.6	1203 163.9	1306 162.5	600 161.2	475 163.5	4187 163.3

TABLE 49—RELATION OF HUMIDITY TO RATE OF DEVELOPMENT OF PUPA AS SHOWN BY EFFECTIVE DAY-DEGREES

Temp. ☞ Humid. ☟	50°-54°	55°-59°	60°-64°	65°-69°	70°-74°	75°-79°	80°-84°	Average
60-64								
65-69		508 238.7			55 237.0		2 254.0	565 238.6
70-74	42 236.2	955 240.9			34 247.2	163 238.3	369 244.4	1563 241.5
75-79				31 236.0	125 248.3	586 242.7	18 239.9	760 243.3
80-84				167 234.7	339 235.0	357 237.3		863 235.9
Average	42 236.2	1463 240.1		198 234.4	553 239.0	1106 240.6	389 244.2	3751 240.1

TABLE 50—RELATION OF EVAPORATION TO RATE OF DEVELOPMENT OF PUPA AS SHOWN BY EFFECTIVE DAY-DEGREES

Temp. ☞ Evap. ☟	50°-54°	55°-59°	65°-69°	70°-74°	75°-79°	80°-84°	Average
5-9	42 236.0	1077 240.2	52 237.9	6 224.1			1177 239.8
10-14		174 243.7	146 233.3	395 236.4	380 238.3		1095 237.8
15-19				70 251.4	480 242.6		550 244.5
20-24		212 237.1		34 241.4	199 239.1	16 239.0	461 238.3
25-29				48 238.7	47 235.0	363 244.5	458 242.9
Average	42 236.0	1463 240.1	198 234.4	553 239.0	1106 240.6	379 244.2	3741 240.1

Spray Program for the Codling-moth

Spray programs heretofore outlined have been based on fixed dates or on time of the fall of the petals. It is better to follow programs of these kinds than to spray hit and miss, but these programs do not take into consideration seasonal variations and variations due to local peculiarities, to altitude, to latitude, or to other circumstances which might have an effect upon temperature.

The following program is based upon the relation of accumulated effective day-degrees to the time of the appearance of the different broods of larvæ. It provides for seven sprays, three for the first brood, two for the second, and two for the third. The table shows the accumulation of effective day-degrees at which the fruit-grower should begin to spray in order that he may complete the work in from one to ten days. This spray program (Table 51), like all others which have been proposed, must be tested thoroughly and proved reliable before it can be accepted as satisfactory.

Too much emphasis can not be placed upon the necessity of applying two sprays for the second brood of larvæ, and of making the first spray for the second brood very thorough. The second brood is much more numerous than the first and comes at a time when the fruit is increasing in size very rapidly; hence, one spray applied at the time when the first larvæ of the second brood enter the fruit will not suffice to check those that enter three or four weeks later. The second and third broods of larvæ overlap, consequently after the second brood begins to enter the fruit larvæ are entering it continuously in large numbers till all the third-brood larvæ have entered, hence the fruit should be well protected during this period.

The first larvæ of the second generation which enter the fruit during July transform and produce the third generation; hence the importance of making the first spray for the second brood (the fourth spray on the program) very thorough so as to destroy as many of the first larvæ of this brood as possible. To reduce the third brood still further the spraying should be supplemented by the destruction of larvæ under bands up to the first of September. Larvæ that leave the fruit after that date will not transform until the following spring, and may be destroyed any time after the season closes.

The seventh spray, or the second spray for the third brood, will not be necessary in case the sixth spray comes late in August. If it should come prior to the 15th of August the seventh spray will be advisable unless the latter part of August should be much cooler than normal.

TABLE 51—SPRAY PROGRAM

[redacted] spray	Brood of larvae	Average normal daily effective day-degrees†	Accumulation of effective day-degrees when spraying should begin, to be completed in:									
			1 day	2 days	3 days	4 days	5 days	6 days	7 days	8 days	9 days	10 days
1st*												
2d	1st	16	534	518	502	486	470	454	438	422	406	390
3d	1st	20	770	750	730	710	690	670	650	630	610	590
4th	2d	26	1524	1498	1472	1446	1420	1394	1368	1342	1316	1290
5th	2d	27	2023	1996	1969	1942	1915	1888	1861	1834	1807	1780
6th	3d	27	2523	2496	2469	2442	2415	2388	2361	2334	2307	2280
7th	3d	23	3027	3004	2981	2958	2935	2912	2889	2866	2843	2810

* The application of the first spray for the codling-moth should begin when the petals are about two-thirds off. The time of full bloom is not dependent upon effective day-degrees as defined in the preceding pages, and hence the time of the application of the first spray can not be determined by the accumulation of effective day-degrees.

† The figures in this column are the approximate number of effective day-degrees that are accumulating daily at the time when the various sprays are applied.