TB 242 (1931) USDA TECHNICAL BULLETINS UPDATA
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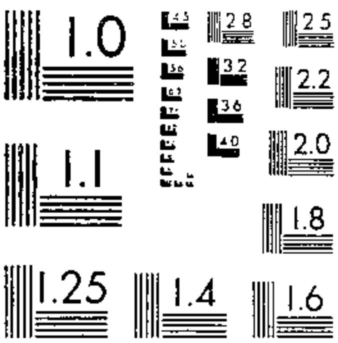

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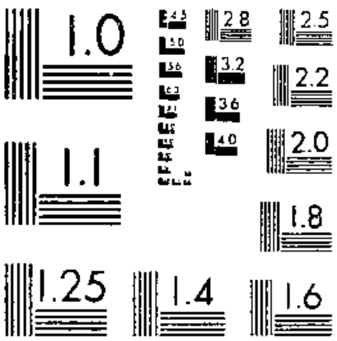

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TECHNICAL BULLETIN No. 242 September, 1931

UNITED STATES DEPARTMENT OF AGRICULTURE
WASHINGTON, D. C.

BIOLOGY OF THE INDIAN-MEAL MOTH ON DRIED FRUITS IN CALIFORNIA

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CONTENTS

INTRODUCTION

The Indian-meal moth (*Plodia interpunctella* Huebner)[3] is one of the most destructive pests attacking dried fruits in storage in California. It has been found in varying numbers in every dried-fruit packing establishment examined.

An economic investigation of the insect pests of dried fruits in California was undertaken in July, 1922. The general remedial measures needed were quite obvious in view of the conditions of storage, state of entomological sanitation, and packing-house routine encountered, and varied control experiments under different conditions were promptly initiated.

Later, in September, 1925, a study of the biology of the Indian-meal moth was undertaken to reveal any unusual features of its life which might be valuable from the control viewpoint, to determine its rate of multiplication, and to supply the literature with much-needed information on the life history of this important insect. During this study, which was completed in June, 1927, raisins, prunes, and figs were used as food.

[1] Doctor Hamlin, who was in charge of dried-fruit insect investigations in the Division of Stored Product Insects from July, 1924, to July, 1927, outlined and directed the study herein reported.
[2] Mr. Phillips was in charge of dried-fruit insect investigations from June, 1922, to November, 1923, when he resigned on account of ill health. The descriptions of the stages of the insect and valuable observations used in this bulletin are drawn from his work.
[3] Order Lepidoptera, family Phycitidae.

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Fresno, Calif., the center of the dried-fruit industry of the United States, was selected as the scene of operations. Fresno is situated in the San Joaquin Valley, an extensive district having unusual conditions of temperature and humidity. The summer temperatures are among the highest in the country, with a wide daily range, whereas the winter temperatures are moderate. Atmospheric moisture is extremely low during summer and extremely high in winter, its range between these seasons being greater than that in any other district of the United States. These conditions combine to make the valley suited to dried-fruit production and are likewise important factors in insect development.

HISTORY AND DISTRIBUTION

Working in the Sacramento Valley, the climate of which is very similar to that of the San Joaquin Valley, Parker (*20*)[4] published in 1915 brief notes on the biology of the Indian-meal moth. As early as 1895, Chittenden (*4, p. 285*) had recorded the species as a pest of dried fruits, and since that time further mention of its relationship to dried fruits has been made by De Ong (*6, 7*), Essig (*10; 11, p. 712*) and Lovett (*19*).

The identity of the Indian-meal moth has been confused in many early citations, so that references to it can not always be separated from those relating to *Ephestia kuehniella* Zell., the Mediterranean flour moth. This confusion led to an article by Riley and Howard (*22*) in 1889 setting forth the distinguishing characters of the two species. *Plodia interpunctella* was first described by Huebner in 1827 (*16, Pl. 45*). It was redescribed by Fitch (*12, p. 320*) in 1856 under the name of *Tinea zeae*, and by Gregson (*14, p. 318*) in 1873 as *Ephestia roxburghii*. Since that time it has also been known under the names of *Ephestia zeae* and *Ephestia interpunctella*.

Fitch was the first to refer to this species as the Indian-meal moth, giving it this name because he found the larvae feeding in corn meal. Other common names, such as peach worm and pantry moth, have been used by different writers.

The Indian-meal moth is a native of the Old World. Hulst (*17, p. 201*) says that it is found everywhere, and indeed its food habits and adaptability to varying conditions have assured an almost universal distribution.

DESCRIPTION OF STAGES OF THE INDIAN-MEAL MOTH

THE EGG

The egg is grayish-white, ranging from 0.3 to 0.5 millimeter in length and almost perfectly ovate. The surface, as seen through the binocular microscope, shows a granular texture which diffracts light in many colors. The wall itself is not wholly opaque, as the developing larva may often be seen inside.

THE LARVA

The larvae vary much in size and coloration. When full grown they average about 13 millimeters in length but range from about 9 to 19 millimeters. Most specimens are a dirty white, but many vary toward a pinkish-brown or greenish tinge. These color variations are doubtless due in large part to the nature of the food.

The well-defined prothoracic shield is pale brown and is distinctly divided into lateral halves by a line of lighter color. The anal segment bears a dorsal plate of about the same color as the prothoracic shield. Ten abdominal segments are

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[4] Italic numbers in parentheses refer to Literature cited, p. 26.

present, the third to the sixth, and the last, each bearing a pair of short prolegs. These are conical and terminate in an oval fringe of hooklets. Spiracles are present on the prothorax and on each abdominal segment except the ninth and tenth. The whole body is sparsely covered with long, fine hairs. The skin surface of the larva is slightly granular. Newly hatched larvae are only slightly over 1 millimeter in length, and this, together with their transparency, renders them very inconspicuous to the unaided eye.

THE PUPA

The light-brown pupa has a glossy surface throughout, the sutures being marked by fine lines of a darker color. Generally the posterior half is darker. During the early part of the period, the pupa is straw colored on the ventral surface and along the sides, ranging to light brown on the dorsal surface. In its later development there is a general darkening, especially in the wing regions, which become almost black just before emergence. The developing compound eyes are large and prominent, first showing dark brown and gradually changing to black. The pupae range in length from about 6 to 11 mm.

The pupae are ordinarily inclosed in silken cocoons, but naked individuals are occasionally found.

THE ADULT

The adult insect is of moderate size and distinctive coloration. The average wing expanse is about 16 mm. The basal half, or a little less, of the fore wings is a silvery white or gray with occasional minute dark spots; the outer portion is a reddish bronze with irregular dark bands. The hind wings are uniformly silver gray with a long silky fringe. This fringe is much longer on the inner margin, and its base shows a narrow band of lighter color, giving it a detached appearance. The abdomen is much the same color as the hind wings, and the thorax somewhat darker with a cloak of reddish scales anteriorly. The hind tibiae are robust. The slightly tapering antennae are slender and measure nearly two-thirds the length of the body.

This moth is easily distinguished from others of similar habits, with the possible exceptions of *Ephestia kuehniella* Zeller and *E. cautella* Walker; but these species are less strikingly marked and present much less color contrast in the fore wing. In cases where the color pattern of the wings does not suffice for distinguishing the species, the generic differences in the palpi provide an excellent means of separating the Indian-meal moth from the other two species. In the former the palpi extend forward horizontally and with a tuft of scales form a sort of beaklike cone about the length of the head, whereas in Ephestia they are erect.

FOOD HABITS

The Indian-meal moth is one of the most general feeders among insects attacking stored products. It has been reported as feeding upon grain and grain products, garden seeds, graham crackers, dried fruits, preserved fruits, nuts, edible acorns, dried vegetables, dandelion roots, garlic heads, dried botanical specimens, dried insects, beebread, yeast cakes, powdered milk, spices, cinnamon bark, cacao beans, sweetened chocolate, chocolate marshmallows, and other candies. Larvae introduced into a jar containing raisins, dates, dried peaches, apricots, and figs became uniformly distributed throughout the mass, with the exception that the raisins were somewhat less attacked.

Several instances of cannibalism have been observed. Most of the individuals fed upon were pupae or quiescent larvae in cocoons. The attack on pupae was more common, the contents of the abdomen being partially or entirely consumed. These cases of cannibalism occurred mainly in crowded rearings, and it is doubtless infrequent in nature except in packing houses supporting very heavy larval infestations, such as prevailed at Fresno in 1926 and 1927.

Immediately after hatching, even upon suitable food, the tiny larvae begin to disperse. Within a few hours they begin feeding and establish themselves in various ways upon different types and conditions of dried fruits. On raisins and prunes they place themselves in crevices of the wrinkled exterior, where they puncture the skin and feed superficially within or near a tunnellike case formed of frass thrown out and webbed together with silk. An individual may construct more than one such tunnel. On processed figs, also, which are relatively soft and moist and form a compact mass, the attack is made chiefly upon the exterior in small crevices between individual figs. Thus the insect is essentially a superficial feeder, although on processed raisins small larvae occasionally enter at the point from which the stem has been removed and burrow into the center of the berry, and also on stored raw-stock figs they enter through the "eye"[5] of the fruit, which is externally tough and dry, and infest chiefly the interior.

After feeding is completed the grown larvae crawl to the surface of masses of dried fruit stored in piles or in bins, where they are conspicuous against a dark background. Some larvae spin cocoons near the surface of the fruit mass, and others in near-by cracks of bins, walls, stored box shooks, and elsewhere.

NATURE OF DAMAGE

The Indian-meal moth causes serious losses to the dried-fruit industry each year. These losses arise not so much from the quantity eaten by the insect as from the lowering of quality and the extra expense involved in processing the fruit before it is marketed. Fruit infested by this species not only contains living worms, but is increasingly polluted by excrement, cast skins, webbing, dead individuals, and often the cocoons of parasites. Back and Cotton (*1, p. 23*) have illustrated webs spun on corn made by well-grown larvae. Production expense is increased by the need of fumigation and the extra handling involved, and sometimes great loss results from the rejection or seizure of shipments.

Beyond these more or less direct losses is the greater, though less tangible, detriment to the industry through curtailment of the market for dried fruits by public discrimination against wormy fruit (*8*). Even a few larvae in a package may by their profuse webbing give to the contents a very repulsive appearance. These contaminated packages are usually not returned, the housewife discarding them and taking the immediate loss. These, however, become practically direct losses to the dried-fruit producers through subsequent discrimination against the brand involved.

During a period of exceptional abundance of the Indian-meal moth in the spring of 1927, figs in carried-over crops from three packing houses showed contamination by this species alone of 12, 19, and 23.2 per cent, with an average of 18 per cent. Lovett (*19, p. 119*) reported that English walnuts held in storage for eight months have developed as high as 95 per cent infestation. Such injury results in serious loss to the owners of the infested material.

PLAN OF BIOLOGICAL STUDIES

Before undertaking the biological study it had been noted that much variation in the intensity of infestation existed between different packing houses. These differences were due in part to conditions of handling and storage of the fruit, and appeared also to be related to

[5] The entire fig is a modified hollow stem bearing the flowers on the inside, and the so-called eye is the orifice at the outer end of this inflorescence receptacle.

the kind of fruit stored. Figs seemed to be more abundantly infested by this species than the other dried fruits. Accordingly the study was designed to reveal differential rates of development on raisins, prunes, and figs, these being the more important products in the San Joaquin Valley; as well as the rate of multiplication of the species and its life history and seasonal relations.

For convenience in determining the rate of multiplication the successive generations [6] were segregated in the laboratory. Thus, except in one instance, rearings for each generation were made from among the earlier emerged moths of the preceding generation. But, while useful for determining theoretical increase, the generational data are of secondary practical importance, since there is no separation of generations in nature. The data are therefore arranged primarily with reference to seasonal conditions.

The study was initiated with larvae hatched in the fall of 1925, which were reared through the winter in individual containers. In the spring of 1926 several of the earlier emerged female moths were mated shortly after emergence with males that emerged at very nearly the same time. Records were made of the longevity of mated pairs, the daily deposition of eggs by individual females, and of the hatching of the daily lots of eggs laid by each female. This general procedure was followed in all of the subsequent laboratory generations.

The dried fruits used as food in this study were seedless raisins, prunes, and Calimyrna figs (commercial name for the Lob Ingir or common Smyrna fig as grown in California), all processed. The data on raisins, being most complete, are presented in detail and comparison is made, where warranted, with the corresponding data on prunes and figs.

When moths from a particular generation and fruit were unobtainable, others of similar generational status from parallel or bulk rearings on the other fruits were substituted.

The excessively low humidity in the open air during the summer in the San Joaquin Valley is doubtless tempered somewhat within the masses of dried fruit, near the surface of which the larvae live. It was not practicable, however, to provide such masses of fruit in the individual laboratory rearings. Therefore, all rearings were conducted in a tightly closed laboratory room in which the atmospheric moisture was slightly increased by evaporation from a water surface of approximately 2 square feet. Effort was made to maintain the relative humidity at about 40 per cent, and this was fairly closely approximated. This procedure was employed from April 15, 1926, when the natural humidity began to decrease severely, until the following fall, when the outside humidity again increased above 40 per cent. The temperature in this room deviated but slightly from that in the other, unhumidified, parts of the laboratory.

The temperature and humidity in the rearing room were recorded by a hygrothermograph. Both conditions have been recorded in the accompanying tables, but, since the relative humidity varied inversely with the temperature, only the latter factor will be mentioned in discussing the various activities of the insect.

REARING METHODS

Oviposition and hatching took place in "capsule vials," 4⅛ inches in length and 1 inch in diameter, fitted with compression metal caps. In each vial a pair of moths was confined with a small quantity of

[6] The term "generation" refers to a complete egg-larva-pupa-adult cycle.

uninfested fruit for one day. On the following day the fruit was examined for eggs, and if any were found it was replaced in the same vial, which then served as an incubation cage. The moths were transferred to a similar vial for the succeeding day's oviposition. A covering of batiste, a thin, closely woven cloth, held in place by a rubber band now replaced the metal cap. The counting of eggs was facilitated and danger of their displacement lessened by handling the prunes and figs with forceps and by impaling the raisins upon insect pins.

Hatching records were made by daily count and removal of all larvae from the incubation vials. Examination was discontinued after 21 days from the initial hatching in each instance because it was established that eggs not hatched in that interval became so severely shriveled and discolored as to preclude the possibility of hatching.

Larval rearings were established with newly hatched larvae from the incubation vials. The larvae were confined with fruit in white, opaque glass jars 2 inches deep and 2 inches in diameter, fitted with metal screw tops.

SEASONAL HISTORY

The Indian-meal moth passes the mild California winter in the larval stage in unheated situations. The rate of development is irregular, the larvae ranging from one-eighth to five-eighths of an inch in length by midwinter, when all become inactive for a period of approximately three weeks. Pupation of the overwintered larvae begins early in March and ends during the latter half of May, the adults emerging from late March to the end of May. Eggs laid by the moths that were among the first to issue in the spring hatched, and the larvae from these matured during the latter half of May. Thus at the very outset there is opportunity for the mixing of generations, since both the more retarded overwintered individuals and the more advanced ones of the first summer generation issue as adults during the latter half of May.

This irregularity of development obtains with succeeding generations, with the result that in nature the generational status of individuals is thoroughly confused. All stages of the insect may be found in stored dried fruit from spring to fall.

All eggs hatching as late as June produce adults the same summer. Of those which hatch later, an increasing percentage, and virtually all of those hatching in the fall, overwinter as larvae and produce the spring brood of moths the following year.

In the fall of 1925, individual rearings were started with newly hatched larvae on raisins, prunes, and figs, 200 on each fruit. These larvae hatched in the period from September 25 to October 3.

The overwintering larvae were examined five times at approximately 3-week intervals from December 9, 1925, to March 3, 1926. When examined January 20 to 22, 1926, all were inactive and were of approximately the same size as when examined December 31, 1925, to January 2, 1926, at which time also nearly all were inactive. The mean temperature between these examinations was 47° F. There is thus a period of at least three weeks in midwinter when the larvae do little, if any, feeding. Some of the inactive larvae were in cocoons, whereas others were dormant in their feeding tunnels. Bioletti (*2, p. 3*) has said, "It is probable that the insect passes the winter in this [the pupal] stage, but in warm situations the larvae may live over the winter." The writers have observed no pupae overwintering.

The rate of development was very uneven. Thus, on March 3, 1926, a considerable percentage of larvae on each fruit was only one-fourth inch in length, and on prunes one individual was one-eighth inch long, while the great majority on each fruit were from three-eighths to one-half inch, and a very few specimens five-eighths inch in length. The larvae feeding on figs averaged slightly larger at each examination than those on raisins and prunes. This more rapid development on figs is discussed on page 17.

PUPATION OF THE OVERWINTERED LARVAE

Table 1 shows the dates of pupation of the 293 overwintered individuals which later produced adults. This table also shows the cumulative percentages which had pupated on each date of the pupation period, extending from March 6 to May 20, 1926. The great majority of these larvae pupated during March.

TABLE 1.—*Pupation of overwintered larvae of the Indian-meal moth reared on raisins, prunes, and figs, Fresno, Calif., 1926* [1]

Date of pupation [2]	Pupation record: Reared on raisins: Larvae hatched Sept. 25-26, 1925		Reared on prunes: Larvae hatched Sept. 26-30, 1925		Reared on figs: Larvae hatched Sept. 30-Oct. 3, 1925		Daily temperature			Mean relative humidity
	Number pupated	Cumulative percentage pupated	Number pupated	Cumulative percentage pupated	Number pupated	Cumulative percentage pupated	Maximum	Minimum	Mean	
							°F.	°F.	°F.	Per cent
Mar. 6	1	0.9					74	55	65	73
Mar. 9	1	1.8	2	2.2	1	1.1	66	55	61	68
Mar. 10			6	8.9	7	9.0	72	50	61	64
Mar. 11	5	6.1	6	15.6	4	13.5	76	52	64	61
Mar. 12	4	9.6	4	20.0	7	21.3	77	53	65	61
Mar. 13	2	11.4	2	22.2	8	30.3	80	53	67	60
Mar. 14	3	14.0	3	25.6	4	34.8	83	56	70	66
Mar. 15	3	16.7	9	35.6	7	42.7	81	57	69	58
Mar. 16	4	20.2	8	44.4	8	51.7	78	58	68	57
Mar. 17	5	24.6	4	48.9	2	53.9	72	59	66	54
Mar. 18	6	29.8	2	51.1	1	55.1	71	56	64	58
Mar. 19	3	32.5	1	52.2	4	59.6	74	60	67	54
Mar. 20	3	35.1	5	57.8	1	60.7	77	59	68	54
Mar. 21	6	40.4	4	62.2	5	66.3	77	59	68	48
Mar. 22	5	44.7	5	67.8	1	67.4	85	57	71	42
Mar. 23	3	47.4	3	71.1	5	73.0	86	58	72	43
Mar. 24	3	50.0	2	73.3	2	75.3	86	61	74	46
Mar. 25	7	56.1	2	75.6	3	78.7	82	59	71	44
Mar. 26	3	58.8	3	78.9	2	80.9	80	58	69	37
Mar. 27	2	60.5	6	85.6	2	83.1	83	56	70	40
Mar. 28	3	63.2	1	86.7	4	87.6	80	57	69	43
Mar. 29	10	71.9	1	87.8	2	89.9	83	58	71	43
Mar. 30	3	74.6	1	88.9	2	92.1	85	57	71	40
Mar. 31	2	76.3	4	93.3	2	94.4	86	59	73	46
Apr. 1	1	77.2	1	94.4	1	95.5	74	61	68	45
Apr. 2	1	78.1	1	95.6	1	96.6	70	58	64	46
Apr. 5	3	80.7					71	62	67	66
Apr. 6	2	82.5			1	97.8	72	62	67	67
Apr. 8	1	83.3					66	58	62	70
Apr. 12	1	84.2					81	55	68	61
Apr. 13	1	85.1					85	60	73	60
Apr. 14	2	86.8					86	63	75	61
Apr. 15	2	88.6			1	98.9	85	67	76	56
Apr. 16	4	92.1	1	96.7			85	65	75	49
Apr. 19			1	97.8	1	100.0	76	58	67	62
Apr. 21	1	93.0	1	98.9			84	64	74	62
Apr. 22	1	93.9					84	65	75	58
Apr. 24	1	94.7					91	68	80	57
Apr. 27	3	97.4					93	74	84	52
Apr. 28	1	98.2					92	74	83	52
May 5			1	100.0			77	65	71	49
May 9	1	99.1					78	57	68	45
May 10	1	100.0					84	60	72	41
Total	114		90		89					

[1] Approximately 5 per cent of those which pupated did not emerge. These have been omitted.
[2] Dates on which no larvae pupated have been omitted from the table.

From Table 1 it is also apparent that pupation of individuals reared on raisins lagged considerably behind that of larvae reared on prunes and figs; for instance, on March 31, over 93 per cent of the latter had pupated as compared with 76.3 per cent of the former.

EMERGENCE OF SPRING ADULTS

Table 2 shows the emergence of spring adults resulting from overwintered individuals. Here it is seen that emergence was very uneven, being spread over a period of two months.

TABLE 2.—*Emergence of spring adults of the Indian-meal moth, Fresno, Calif., 1928*

Date of emergence[1]	Emergence of spring adults from larvae reared on—						Daily temperature			Daily mean relative humidity
	Raisins		Prunes		Figs					
	Number emerged	Cumulative percentage emerged	Number emerged	Cumulative percentage emerged	Number emerged	Cumulative percentage emerged	Maximum	Minimum	Mean	
							°F.	°F.	°F.	Per cent
Mar. 30	1	0.9	-----	-----	-----	-----	85	57	71	40
Mar. 31	2	2.6	2	2.2	3	3.4	86	59	73	46
Apr. 1	2	4.4	8	11.1	1	4.5	74	61	68	45
Apr. 2	1	5.3	5	16.7	2	6.7	70	58	64	46
Apr. 3	1	6.1	1	17.8	5	12.4	73	58	66	50
Apr. 4	1	7.0	2	20.0	2	14.6	66	60	63	55
Apr. 5	3	9.6	3	23.3	6	21.3	71	62	67	66
Apr. 6	1	10.5	1	24.4	-----	-----	72	62	67	67
Apr. 7	3	13.2	3	27.8	1	22.5	67	62	65	68
Apr. 8	3	15.8	6	34.4	9	32.6	66	58	62	70
Apr. 9	5	20.2	9	44.4	3	36.0	72	52	62	68
Apr. 10	3	22.8	4	48.0	13	50.6	75	56	66	67
Apr. 11	4	26.3	-----	-----	3	53.9	69	57	63	67
Apr. 12	8	33.3	6	55.6	5	59.6	81	55	68	61
Apr. 13	5	37.7	4	60.0	7	67.4	85	60	73	60
Apr. 14	6	43.0	4	64.4	2	69.7	86	63	75	61
Apr. 15	5	47.4	7	72.2	6	76.4	85	67	76	56
Apr. 16	8	54.4	2	74.4	4	80.9	85	65	75	49
Apr. 17	5	58.8	9	84.4	5	86.5	75	66	71	53
Apr. 18	3	61.4	-----	-----	3	89.9	71	61	66	57
Apr. 19	5	65.8	1	85.6	-----	-----	76	58	67	62
Apr. 20	6	71.1	1	86.7	-----	-----	81	61	71	62
Apr. 21	4	74.6	3	90.0	3	93.3	84	64	74	62
Apr. 22	3	77.2	2	92.2	1	94.4	84	65	75	58
Apr. 23	3	79.8	3	95.6	2	96.6	88	65	77	59
Apr. 26	2	81.6	-----	-----	-----	-----	98	73	86	53
Apr. 27	5	86.0	-----	-----	1	97.8	93	74	84	52
Apr. 28	6	91.2	1	96.7	1	98.9	92	74	83	52
Apr. 30	2	93.0	1	97.8	-----	-----	86	69	78	51
May 1	-----	-----	-----	-----	1	100.0	83	66	75	51
May 5	2	94.7	1	98.9	-----	-----	77	65	71	49
May 11	2	96.5	-----	-----	-----	-----	90	65	78	42
May 12	1	97.4	-----	-----	-----	-----	93	67	80	44
May 14	1	98.2	-----	-----	-----	-----	88	65	77	44
May 19	-----	-----	1	100.0	-----	-----	94	76	85	42
May 20	1	99.1	-----	-----	-----	-----	90	70	80	42
May 30	1	100.0	-----	-----	-----	-----	96	74	85	40
Total	114	-----	90	-----	89	-----	-----	-----	-----	-----

[1] Dates on which no moths emerged have been omitted from the table.

The period of emergence of individuals reared on raisins began earlier and ended later than that of those reared on prunes and figs. During the major emergence period, from March 30 to April 21, only 74.6 per cent of the raisin-fed individuals emerged, as compared with 90 per cent or more of those fed on prunes and figs. These figures agree reasonably well with observations upon the emergence of moths in packing houses.

Although emergence was slower in the raisin rearings, it was more complete, 57 per cent of them producing adults, as compared with approximately 45 per cent of those reared on prunes and figs. The earlier emerged of these spring moths produced the eggs used in initiating the life-history studies.

LIFE-HISTORY STUDIES

THE ADULT

COPULATION

Copulation may occur in 1 hour after emergence and ordinarily does occur within 24 hours. When an unmated male and female are placed together in a vial some hours after emergence they usually copulate readily, the observed interval ranging from one-half to 255 minutes. The moths remain in copulation from 10 to 120 minutes.

PREOVIPOSITION PERIOD

The interval from the emergence of female moths to initial oviposition ranged from less than a day [7] to 9 days in the period between March 31 and October 20, 1926.

Females which emerged during the cool weather from March 31 to April 8 laid their first eggs after intervals of 1 to 9 days from mating (Table 3), the preoviposition period averaging 2.9 days. During the period from June to August, inclusive, marked by high temperatures, the preoviposition period ranged from 0 to 2 days (Table 4), and averaged 0.5 day. Females which emerged in September and October, when the temperatures were intermediate between those of spring and midsummer, oviposited initially after intervals of 0 to 3 days from mating (Table 5), the average preoviposition interval being 1.1 days.

TABLE 3.—*Oviposition of the Indian-meal moth on dried fruits, Fresno, Calif., spring observations, 1926*

Female No.	Fruit placed with moths	Date female mated [1]	Number of eggs deposited on specified number of days after mating [2]															Total number eggs laid	Mean temperature [3]	Mean relative humidity [3]
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15			
																			°F.	*Per cent*
1	Raisins	Mar. 31				83	0	17	16	0	9	12	0	0	5	4	0	146	67	60
2	Prunes	do				103	17	28	30	27	0	28	9	0	12	4		258	66	60
3	do	Apr. 1			101	0	24	14	8	0	8	0						155	65	60
4	do	do			61	26	0	45	18	2	12	10	1	9	5	4	3	196	67	60
5	do	do									91	18	0	11	3	0		123	66	61
6	do	Apr. 2				114	0	56	8	22	0	13	11	9				233	65	62
7	Figs	Apr. 3										62	58	117	2	0		239	68	62
8	do	do				94	47	5	6	47	24	13	6	5	3			250	67	63
9	do	Apr. 8		73	0	47	32	8	7	0								167	68	63
10	do	do		16	46	4	36	30	0	0	0							132	69	62
11	Raisins	do.[4]		28	7	10	15	28	22	10	6	0						126	69	61
12	do	do.[4]			55	0	24	22	11	13	0	0						125	69	61
13	do	do.[5]		72	0	0	10	16	17	9	0							124	69	62
14	do	do			21	0	25	32	16	0	0							94	69	62
	Average number eggs per female																	169.1		
	Average eggs per female per day (for entire life)																	14.6		

[1] Females mated on day of emergence except as noted.
[2] Last record (either significant figures or zero) made on day of death.
[3] From date mated to date of death.
[4] Female emerged day before mated.
[5] Female emerged two days before mated.

The preoviposition period of the 70 females from which the ranges and averages were derived may be found in Tables 3, 4, and 5 by noting the number of blank spaces preceding the first egg record for each moth.

[7] When oviposition occurred during the first day after mating that day was included in the oviposition period, and the preoviposition period was recorded as zero.

OVIPOSITION

The eggs are placed singly or in rough clusters or chains, aggregating as many as 30 eggs, over the surface of dried fruits, being mostly deposited in crevices of the wrinkled skins. In the case of figs, eggs are occasionally deposited inside the eye. Under laboratory conditions the eggs were especially abundant on the sides of the fruit just above the supporting surface. Lovett (*19, p. 119*) stated that eggs are deposited also on food cartons or containers, or on walls, floors, or similar situations adjacent to the food product. Oviposition is chiefly nocturnal, as reported by Parker (*20, p. 4*); however, during the first three days of egg laying the female is likely to deposit some eggs in the daytime.

TABLE 4.—*Oviposition of the Indian-meal moth on dried fruits, Fresno, Calif., summer observations, 1926*

Female No.	Fruit placed with moths	Date female mated [1]	Number of eggs deposited, on specified number of days after mating [2]									Total number eggs laid	Mean temperature [3]	Mean relative humidity [3]
			1	2	3	4	5	6	7	8	9			
													° F.	Per cent
1	Raisins	June 3		58								58	87	41
2	do	do	39	0								39	87	41
3	do	June 7	37	17	11	7	0					72	82	46
4	do	do		101	28							120	82	46
5	Prunes	June 8[4]	57	19	63	0	15	0				154	81	43
6	do	do.[4]	58	20	19	13	0	0				119	81	43
7	do	do.[4]		70	7	0	0					77	82	44
8	do	do		77	31	0	17	0	0			125	81	43
9	Figs	June 10	134	16	35	0	0					185	81	41
10	do	June 11		128	3	0	0	0				131	79	41
11	do	June 12	97	71	78	0	0	29	0	0	0	275	79	41
12	Raisins	June 14	32	28	0	0	0					60	79	42
13	Prunes	June 15		48	28	21	0	14				111	79	42
14	Raisins	July 9[4]	12	98	39	0						149	87	42
15	do	do.[4]		88	28	5	0					121	87	43
16	do	July 19		85	15	0	0					100	87	35
17	do	July 21	81	45	23	0	0					149	86	37
18	do	do		52	15	1	0					68	86	37
19	Prunes	July 24	89	42	33	6	0	0				170	85	39
20	do	do	19	24	14	5	5	0				67	85	39
21	do	July 25			51	11	9					71	85	39
22	Figs	do	10	20	59	14	0					103	85	39
23	do	July 27	52	73	34	0						159	85	42
24	do	July 31		79	40	12						131	90	39
25	do	Aug. 8		61	18	8	0	0	0			87	85	40
26	Prunes	Aug. 13	14	9	28	21	8	7	0	0		87	85	40
27	Raisins	Aug. 16	62	64	24	9	0					159	84	41
28	do	Aug. 20		132	44	9	0					185	85	42
29	do	Aug. 21	120	69	40	17	0					246	84	41
30	Prunes	Aug. 25		27	32	26	8	2	6	0		101	80	43
31	Raisins	Aug. 28	4	104	26	9	7	0				150	80	43
32	Figs	do			109	40	32	9	0	0		190	80	43
33	Raisins	Aug. 30	74	24	39	22	6	0	0			165	80	43
	Average number eggs per female											127.1		
	Average eggs per female per day (for entire life)											23.3		

[1] Females mated on day of emergence except as noted.
[2] Last record (either significant figure or zero) made on day of death.
[3] From date mated to date of death.
[4] Female emerged day before mated.

The eggs are seldom firmly attached to the fruit surface. A slight shake will usually dislodge them from dried fruits that are not sticky. It is especially important in the processing of seedless raisins, which involves no heat treatment, that the usual mechanical agitation and washing in a stream of water may suffice to dislodge the great majority of eggs of this species.

The egg laying of 70 females which emerged between March 31 and October 20 is recorded in Tables 3, 4, and 5. Here it may be noted that on the last of March and in early April (Table 3) the oviposition lasted from the second to the fifteenth day after mating, approximately 90 per cent of the eggs, however, being laid from the second to the eleventh day, inclusive. These moths, living under mean temperatures in the 60's, laid from 94 to 258 eggs each, the average being 169.1, an average of 14.6 eggs per day during entire life.

The females which emerged in the period from June to August, inclusive (Table 4), lived under means of temperature mostly in the 80's. During this hot, dry season the oviposition period was reduced to about one-half that of the spring months, and ranged from the first to the seventh day after mating. Approximately 90 per cent of the eggs were deposited during the first three days. Individual production decreased, the moths laying from 39 to 275 eggs, with an average of 127.1, whereas the rate of deposition, expressed as the average number of eggs per female per day for the entire life, was approximately 60 per cent higher than the average during the spring months, being 23.3.

During September and October (Table 5) the means of temperature were intermediate between those of spring and those of midsummer, being mostly in the 70's. Under these conditions the females oviposited from 1 to 20 days after mating. Approximately 90 per cent of the eggs were laid during the first 6 days. Individual totals ranged from 80 to 246 eggs, with an average of 178.3 eggs. The average number of eggs per female per day for the entire life was 15.7. Thus, in general, the activities of moths at this season may be regarded as intermediate between those of spring and midsummer.

TABLE 5.—*Oviposition of the Indian-meal moth on dried fruits, Fresno, Calif., fall observations, 1926*

Female No.	Fruit placed with moths	Date female mated [1]	Number of eggs deposited, on specified number of days after mating [2]																				Total number eggs laid	Mean temperature [3]	Mean relative humidity [3]
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20		°F.	Per cent
1	Figs	Sept. 4	--	144	32	19	3	4	0	--	--	--	--	--	--	--	--	--	--	--	--	--	202	81	40
2	Prunes	Sept. 11	--	90	51	36	18	4	4	2	2	0	--	--	--	--	--	--	--	--	--	--	207	75	40
3	Figs	Sept. 16	--	74	24	37	0	28	0	0	0	--	--	--	--	--	--	--	--	--	--	--	163	73	46
4	Prunes	do	--	96	39	21	11	8	8	3	2	0	--	--	--	--	--	--	--	--	--	--	188	73	45
5	do	Sept. 18	--	30	34	26	15	20	0	4	0	0	0	0	0	0	0	0	0	2	0	--	131	72	49
6	Figs	Sept. 23	--	--	93	15	23	12	0	4	0	0	0	0	--	--	--	--	--	--	--	--	147	71	40
7	Prunes	Sept. 24	--	--	76	52	16	4	6	0	0	0	--	--	--	--	--	--	--	--	--	--	154	71	48
8	do	Sept. 26	--	73	40	0	32	9	12	12	6	4	0	0	--	--	--	--	--	--	--	--	188	72	51
9	do	do	--	30	64	7	21	14	19	5	8	3	0	0	--	--	--	--	--	--	--	--	171	72	51
10	do	Oct. 5	31	46	35	19	14	0	7	2	3	0	0	0	0	0	--	--	--	--	--	--	157	71	56
11	do	do	83	134	0	20	2	0	0	--	--	--	--	--	--	--	--	--	--	--	--	--	239	70	54
12	Raisins	do	22	30	7	16	0	5	0	0	0	--	--	--	--	--	--	--	--	--	--	--	80	70	55
13	do	Oct. 7	--	--	52	31	12	30	24	13	9	5	0	1	0	0	0	0	0	0	0	[4]2	179	69	60
14	do	Oct. 8[4]	--	40	23	13	16	11	19	7	0	0	0	0	--	--	--	--	--	--	--	--	129	70	57
15	do	do	--	--	56	21	23	23	32	0	7	21	13	5	4	4	4	0	--	--	--	--	213	69	59
16	Prunes	do.[5]	--	88	27	20	24	17	14	4	0	0	0	--	--	--	--	--	--	--	--	--	198	70	57
17	do	Oct. 11	--	68	65	24	17	9	3	0	--	--	--	--	--	--	--	--	--	--	--	--	186	71	59
18	Raisins	do	--	--	--	39	10	20	24	0	0	0	0	--	--	--	--	--	--	--	--	--	152	70	60
19	do	Oct. 14	63	60	37	7	21	1	0	0	--	--	--	--	--	--	--	--	--	--	--	--	189	71	61
20	do	Oct. 17	70	27	36	35	23	12	15	11	9	8	0	0	--	--	--	--	--	--	--	--	246	69	64
21	do	Oct. 19	--	--	104	31	30	21	27	12	14	5	0	1	0	0	--	--	--	--	--	--	245	67	63
22	Figs	Oct. 20	--	34	71	12	10	12	0	--	--	--	--	--	--	--	--	--	--	--	--	--	139	68	66
23	do	do	--	61	70	17	23	21	6	1	--	--	--	--	--	--	--	--	--	--	--	--	199	68	66
	Average number eggs per female																						178.3		
	Average eggs per female per day (for entire life)																						15.7		

[1] Females mated on day of emergence except as noted.
[2] Last record (either significant figure or zero) made on day of death.
[3] From date mated to date of death.
[4] Lived 3 days more without depositing additional eggs.
[5] Female emerged day before mated.

The number of eggs deposited by individual moths throughout the season ranged from 39 to 275, both the minimum and the maximum occurring in June. The seasonal average for the 70 females was 152.3 eggs. Several writers have placed the egg capacity much higher. Parker (*20, p. 4*) reported the average of 6 females as 221.3, the range being from 156 to 286. Chittenden (*5, p. 119*) reported the egg capacity as high as 350, and Essig (*11, p. 712*) stated that each female may deposit from 300 to 400 eggs.

The eggs may be extruded very rapidly. One female laid 144 eggs in one day (Table 5), and in the earlier work Phillips observed a female to deposit 115 eggs in a single hour.

The length of life of the female moths after oviposition was completed ranged from 0 to 5 days, with an average of 1.6 days.

LONGEVITY

The adult life of the Indian-meal moth is comparatively brief, and that it is profoundly influenced by seasonal conditions is evidenced by the data in Table 6. The length of life of mated males and females which emerged from March 31 to April 8 and lived under a mean temperature of 67° F. averaged 19.1 and 11.9 days, respectively. Mated moths which emerged from June to August experienced hot, dry weather, the mean temperature being 86°. The longevity then averaged but 5.8 and 5.2 days for males and females, respectively. During October, when the temperature averaged 68° F., the longevity of mated males averaged 13.3 days and that of mated females 11.6 days. Unmated males and females lived on the average 2.4 and 2.7 days longer, respectively, than mated individuals of corresponding sex and males 2 to 3 days longer than females, but analysis shows that these differences are not significant.

TABLE 6.—*Longevity of mated and unmated adults of the Indian-meal moth, Fresno Calif., 1926*

Period of emergence	Condition of moths	Males			Females			Mean temperature [1]	Mean relative humidity [1]
		Number	Days of life		Number	Days of life			
			Range	Mean		Range	Mean		
								°F.	*Per cent*
Mar. 31–Apr. 8	Mated	14	14–25	19.1	14	8–15	11.9	67	54
Mar. 31–Apr. 12	Unmated	30	14–24	19.1	30	9–20	15.2	66	60
June 3–Aug. 30	Mated	23	2–12	5.8	23	2–9	5.2	86	40
June 5–Aug. 31	Unmated	23	1–11	6.1	25	2–12	8.3	85	40
Oct. 5–Oct. 20	Mated	7	9–18	13.3	14	7–23	11.6	68	58
Oct. 2–Oct. 16	Unmated	9	8–18	13.7	7	8–21	14.3	70	60
	Mated	44	2–25	11.2	51	2–23	8.8		
	Unmated	62	1–24	13.6	62	2–21	11.5		

[1] For the period between extreme dates covered by the lives of all moths in each group.

HABITS

The adults avoid the light. During the day they rest quietly on walls, ceilings, and boxes in poorly lighted situations near stored dried fruit, in storage rooms, and between sweat boxes in storage sheds. When disturbed they fly readily in an irregular, zigzag course. The moths are chiefly night fliers; this tendency is readily apparent at dusk, for then the moths begin to fly about.

THE EGG

INCUBATION

The data presented in Table 7 deal with the larger daily groups of the eggs shown in Tables 3, 4, and 5. They show the range and weighted average of the incubation period for several lots of eggs deposited during each month, except May, from April to November, together with the means of temperature and relative humidity for the interval from egg deposition to initial hatching in each instance.

TABLE 7.—*Incubation periods of eggs of the Indian-meal moth, Fresno, Calif., 1926*

Date eggs were deposited	Eggs hatched	Incubation period		Mean temperature [1]	Mean relative humidity
		Range	Weighted mean		
	Number	*Days*	*Days*	*°F.*	*Per cent*
Apr. 4	330	10-13	10.4	65	65
Apr. 6	152	9-12	9.2	67	65
Apr. 7	154	9-12	9.2	68	64
Apr. 8	98	8-10	8.4	68	63
Apr. 10	270	7-14	7.9	71	60
Apr. 11	150	6-12	7.0	72	59
Apr. 13	225	5-12	6.4	74	56
Apr. 14	177	6-11	6.4	72	56
Apr. 15	153	6-12	7.1	71	56
Summary, Apr. 4-15	1,709	5-14	8.0	70	60
June 9	204	3- 8	4.5	82	47
June 10	225	2- 8	4.0	83	45
June 11	159	4- 7	4.9	80	40
June 13	163	3-10	4.7	78	41
June 15	48	4- 8	5.0	79	42
June 17	44	3- 5	3.3	81	42
June 19	13	4	4.0	82	36
Summary, June 9-19	856	2-10	4.3	81	42
July 11	166	3- 4	3.1	89	43
July 12	41	3- 4	3.4	90	43
July 21	77	3- 6	4.3	86	38
July 22	90	3- 5	4.0	85	38
July 23	55	4- 5	4.1	87	37
July 25	79	3- 5	3.2	86	37
July 26	52	3- 5	3.2	84	40
July 28	131	3- 6	3.9	85	43
July 29	45	3- 5	3.7	88	42
Summary, July 11-29	736	3- 6	3.7	87	40
Aug. 2	60	3- 5	3.3	90	40
Aug. 3	39	3- 6	3.9	90	39
Aug. 10	39	4- 5	4.2	84	42
Aug. 17	68	3- 5	3.6	84	43
Aug. 18	70	3- 6	3.3	84	45
Aug. 20	9	2- 4	2.9	84	43
Aug. 22	209	3- 5	3.5	85	42
Aug. 23	77	3- 5	3.5	86	41
Aug. 30	47	4- 8	4.6	79	43
Aug. 31	157	4- 7	4.2	81	43
Summary, Aug. 2-31	775	2- 7	3.7	85	42
Sept. 1	40	3- 6	4.1	82	43
Sept. 2	46	4- 5	4.2	82	44
Sept. 6	103	3- 4	3.6	81	46
Sept. 13	77	4- 9	5.1	76	45
Sept. 18	118	5- 6	5.1	73	46
Sept. 20	66	5- 9	6.0	73	44
Sept. 22	56	5- 7	5.3	74	43
Sept. 27	75	5- 8	5.7	70	46
Sept. 28	133	6- 8	6.6	69	52
Sept. 29	109	6- 8	6.5	69	55
Summary, Sept. 1-29	823	3- 9	5.2	75	46

[1] For the interval from egg deposition to initial hatching.

TABLE 7.—*Incubation periods of eggs of the Indian-meal moth, Fresno, Calif., 1926*—Continued

Date eggs were deposited	Eggs hatched	Incubation period		Mean temperature	Mean relative humidity
		Range	Weighted mean		
	Number	*Days*	*Days*	*°F.*	*Per cent*
Oct. 6	113	6–11	6.5	69	53
Oct. 7	149	6–11	7.1	68	54
Oct. 10	128	6– 9	6.3	70	58
Oct. 13	110	5– 7	5.4	72	59
Oct. 15	160	4– 9	5.4	72	59
Oct. 18	100	6– 8	6.2	68	64
Oct. 22	155	6– 8	6.3	68	66
Oct. 23	109	6– 7	6.1	69	66
Oct. 25	40	7– 9	7.1	67	62
Oct. 28	8	9–10	9.6	65	56
Oct. 31	1	12	12.0	63	54
Summary, Oct. 6–31	1,073	4–12	7.1	68	59
Nov. 17	19	14–15	14.1	60	75
Nov. 18	12	14–15	14.1	60	76
Nov. 20	16	14–15	14.2	60	79
Nov. 21	1	15	15.0	60	81
Nov. 22	5	16–17	16.2	59	83
Summary, Nov. 17–22	53	14–17	14.7	60	79

Table 7 shows clearly the great variation in the incubation period and its relationship to temperature. Thus, the average mean incubation period fell to 3.7 days during July and August when the means of temperature were mostly in the 80's, but with mean temperatures approximating 60° F. during November, the average mean incubation period rose to 14.7 days. During other months, temperatures intermediate between the above coincided with intermediate incubation periods.

The seasonal extremes of incubation were 2 and 17 days, the minimum occurring in June and again in August, and the maximum in November. It is worthy of note that the minimum occurred under the more moderate mean temperatures of from 83 to 84° and not at the higher temperature means ranging up to 90° F. Herms (*15*) has reported the incubation period as about 48 hours at a maintained temperature of 22 to 26° C. (72 to 79° F.). Lovett (*19, p. 119*) stated that the eggs hatch in about 4 to 8 days.

PERCENTAGE OF HATCH

Table 8 gives the percentage of hatch of 10,690 eggs, some of which were laid each month, except May, from April to early December. The record of each monthly group is compared with the mean temperature and humidity during its incubation period, measured from the oviposition of the first-laid eggs to the first hatch of the last laid daily group.

TABLE 8.—*Percentage of hatch of daily batches of eggs of the Indian-meal moth, Fresno, Calif., 1926*

Period of egg deposition	Total eggs laid	Percentage of eggs hatched		Mean temperature [2]	Mean relative humidity [2]
		Range [1]	Average		
		Per cent	*Per cent*	° *F.*	*Per cent*
Apr. 4-17	2,368	50.0-100.0	78.3	69	61
June 4-21	1,535	14.3-100.0	68.8	81	42
July 10-30	1,152	43.7- 94.0	73.7	88	39
Aug. 2-31	1,307	42.9-100.0	75.8	84	41
Sept. 1-30	1,588	19.6-100.0	72.3	75	47
Oct. 1-31	2,529	32.1- 90.8	70.8	68	58
Nov. 17-Dec. 4	211	0 - 67.9	25.1	59	78
Apr. 4-Oct. 31	[3] 10,479	14.3-100.0	73.4		

[1] Range here refers to percentages of hatch of daily batches of eggs (in excess of 10) laid by one or more moths from which the present group totals were derived.
[2] For the period from date of first oviposition to initial hatching of last laid eggs for each group.
[3] This total omits the 211 eggs laid in November and December under exceptional conditions.

From Table 8 it appears that the percentage of hatch was not greatly affected by the very high temperatures of midsummer, but was drastically reduced by low temperature. The eggs deposited in November were laid by a single exceptionally late-emerged female and are included solely to show the influence of temperature on hatching. The eggs of this moth hatched to the extent of only 25.1 per cent under a mean temperature of 59° F. During the main hatching period from April to October the maximum hatch of 78.3 per cent was in April under a mean temperature of 69°, and the minimum, 68.8 per cent in June, with a mean temperature of 81°.

Throughout the season the percentage of hatch of daily batches of eggs ranged from 0 to 100. Excluding the eggs laid in November, the average percentage of hatch for the season was 73.4 per cent.

THE LARVA

DURATION OF LARVAL PERIOD ON RAISINS

The length of larval life of the Indian-meal moth is highly variable, both individually and seasonally. The seasonal variations, however, appear to have no direct relation to the prevailing temperature.

The feature of Table 9 is the unequal rate of larval development. This inequality is expressed in two ways: (1) In the wide range of the larval period of those individuals which started life at the same time and all of which pupated during the same year; and, (2) in the fact that of larvae having the same parentage and hatching on or about the same date in one year, some individuals pupated that year whereas others wintered as larvae and pupated the following year. Thus, all the 114 larvae which hatched in September, 1925, pupated the following year, having larval periods ranging from 162 to 227 days. Here the slower individuals lived nearly half again as long in the larval stage as did the more advanced ones. The 20 larvae which hatched in April, 1926, pupated in 28 to 56 days, one extreme being just twice as long as the other, and the range of 16 individuals which hatched in June was 21 to 61 days, the extremes being nearly in the ratio of 3 to 1.

TABLE 9.—*Duration of larval life of the Indian-meal moth on raisins, Fresno, Calif., 1925–1927*

Date eggs hatched	Total larvae	Transforming individuals					Wintering individuals				
		Larvae	Days of larval life		Mean temperature [1]	Mean relative humidity [1]	Larvae	Days of larval life		Mean temperature [1]	Mean relative humidity [1]
			Range	Average				Range	Average		
					°F.	Per cent				°F.	Per cent
1925											
Sept. 25–26	114	0					114	162–227	183.1	59	72
1926											
Apr. 14–17	20	20	28–50	39.9	76	48	0				
June 9	16	16	21–61	36.2	85	39	0				
July 14	23	22	29–74	44.1	86	40	1	282	282.0	66	64
Aug. 20–21	16	5	34–48	40.4	78	45	11	231–267	249.1	63	67
Oct. 16	14	0					14	159–188	172.6	58	74
Total, range, and average	203	63	21–74	40.5			140	159–282	[2] 209.2		

[1] This mean is an average of the means for all larval periods within each group.
[2] This average excludes the 114 individuals reared in 1925 and is weighted in accordance with the seasonal trend exemplified by the three 1926 rearings.

When part of the group wintered as larvae, the range was of course greatly extended. Of 23 larvae hatching in July, 22 pupated in 29 to 74 days, but one passed the winter as a larva and pupated the following year, remaining 282 days in the larval stage. This approaches the maximum larval period encountered in the present study. From 16 larvae which hatched in August, 5 completed the larval stage in 34 to 48 days, and the remaining 11 required 231 to 267 days, pupating the following year. Finally, the 14 individuals which hatched in October all wintered as larvae, the range of the larval period being 159 to 188 days. Four of the larvae which hatched from August 20 to 21, 1926, pupated during May, 1927, whereas all the larvae which hatched nearly two months later on October 16, 1926, had pupated by April 22, 1927.

For purposes of comparison the larvae have been grouped according to the period in which they hatched (Table 9), but the reader has access to the larval period of each individual, except those overwintering in 1925–26, by reference to Table 12.

The lack of any relationship between the length of larval life and temperature should be obvious if attention were confined to the transforming individuals shown in Table 9. However, the mean larval period of individuals hatched in April was 39.9 days, and the average of the mean temperatures for all larval periods in this group was 76° F. With the much higher average of mean temperatures of 85°, the mean larval period of individuals hatched in June was only slightly reduced, being 36.2 days. Those larvae which hatched in July lived under an average of mean temperatures (86°) approximating that of the June hatch, but the mean larval period (44.1 days) was considerably longer than that of either the June or the April hatch. Finally, those which hatched in August had a mean larval life of 40.4 days, the average of mean temperatures in this case being 78°.

Lovett (*19, p. 119*) reported the average larval stage as about 60 days.

It thus appears that temperature, while probably influencing the length of larval life to some extent, is of distinctly secondary importance to other factors governing the length of the larval period. For instance, all the 23 larvae which hatched on July 14 lived under similar temperature conditions during the first 29 days of life; yet one individual pupated on the twenty-ninth day, whereas another continued 253 days longer in the larval stage (Table 10).

COMPARATIVE LENGTH OF PERIOD ON DIFFERENT FRUITS

Table 10 is arranged to show the comparative duration of larval life of individuals reared on raisins, prunes, and figs. Despite the smaller number of rearings on prunes and figs, the indications regarding the effect of different fruits are of much interest. Only the first four series are roughly comparable in point of time at which the larvae started life on the different fruits.

TABLE 10.—*Comparison of length of larval life of Indian-meal moth reared on raisins, prunes, and figs, Fresno, Calif., 1925–1927*

Date eggs hatched	Larvae reared on raisins			Date eggs hatched	Larvae reared on prunes			Date eggs hatched	Larvae reared on figs		
	Larvae	Larval life			Larvae	Larval life			Larvae	Larval life	
		Range	Average			Range	Average			Range	Average
1925		*Days*	*Days*	1925		*Days*	*Days*	1925		*Days*	*Days*
Sept. 25–26	114	162–227	183.1	Sept. 26–30	90	163–221	174.3	Sept. 30–Oct. 3	89	157–199	168.0
1926				1926				1926			
Apr. 14–17	29	28– 56	39.9	Apr. 14–16	13	33– 70	47.5	Apr. 16–17	3	25– 41	31.3
June 9	16	21– 61	36.2	June 10–14	20	25– 68	39.4	June 15	11	13– 48	29.5
July 14	22	29– 74	44.1	July 26	4	47– 58	50.8	July 31	2	35– 37	36.0
Do	1	282	282.0	do	3	255–288	266.3				
Aug. 20–21	5	34– 48	40.4								
Do	11	231–267	249.1								
								Sept. 23	1	32	32.0
								Sept. 23–24	15	170–199	186.2
Oct. 16	14	159–188	172.0	Oct. 2	9	172–246	210.4				
								Dec. 1	1	144	144.0

From the rearings begun in the fall of 1925 the longest average larval period (183.1 days) occurred with larvae fed on raisins. On prunes and figs it was 8.8 and 15.1 days shorter, respectively. In the case of the larvae hatched in April, 1926, the average larval period on prunes, 47.5 days, was longest, and those on raisins and figs were 7.6 and 16.2 days less, respectively. Larvae hatched in June also showed the maximum average larval period on prunes, 39.4 days; on raisins the average was 3.2 days less, and on figs 9.9 days less. Again, in the case of larvae hatched in July, the maximum average larval period of 50.8 days was on prunes; on raisins it was 6.7 days less, and on figs 14.8 days less.

The three lots of larvae hatched in April, June, and July, 1926, showed their longest average larval period on prunes, with raisins second, whereas in the case of larvae hatched the preceding fall the maximum was on raisins with prunes second. Thus the evidence that feeding on prunes resulted in slower development is not constant.

In all the comparisons, however, the larvae reared on figs developed more rapidly on the average than those reared on raisins or prunes. The reduction in the average larval period on figs as compared with the longest average period in each series ranged from 9.9 to 16.2 days. The constancy of this tendency offsets in some measure the smaller number of rearings on figs.

Doubtless these variations in larval development are correlated with such differences in the fruits as sugar and moisture content. Levulose and dextrose, in approximately equal parts, predominate in all these fruits, and dried prunes and figs contain small quantities of sucrose in addition to the reducing sugar. The sugar content varies considerably with variety, locality, and method of curing, but among the dried fruits used the fig is highest in sugar content, raisins next, and prunes lowest. The sugar content thus bears an inverse relationship to the length of life of larvae reared on these dried fruits.

The earlier work of Phillips showed that there is no doubt as to the influence of moisture content of food upon larval development. Larvae under observation during the dry season, which were fed upon artificially moistened food, thrived, whereas other individuals, fed upon the same kind of food which was allowed to dry out, either died or developed much more slowly.

The moisture content of each kind of dried fruit is very variable, and it was not determined for the fruit used in the present study. Raisins, however, are ordinarily cured to a lower water content than are prunes and figs; Chace and Church (*3, p. 15*) report that 16 per cent of water is the upper limit at which raisins can be stored without danger of sugaring or molding. Jones and Bullis (*18, p. 5*) state that prunes for best keeping should not have a moisture content in excess of 20 per cent. Like data for the fig are not available. These figures are not pertinent to the larval periods determined in the laboratory, because processed fruit, with somewhat increased moisture, was there used in rearings. Nevertheless, there can be no doubt of the importance of this factor in the larval life of the insect in stored, raw stocks of dried fruits.

THE PREPUPAL STAGE

There is a more or less definite prepupal stage, passed inside the silken cocoon. In early spring it lasts from 0 to 23 days, averaging about 4 days. During the summer the period ranges from 0 to 7 days, with an average of about 1 day. Herms (*15, p. 563*) recorded the duration of the prepupal stage as 9 to 12 days at temperatures ranging from 22° to 26° C.

THE PUPA

DURATION OF THE PUPAL STAGE

Marked variation in the pupal stage in accordance with prevailing temperatures may be noted in Table 11 which is based upon 203 individuals reared on raisins. The means of temperature and relative humidity cover the interval from initial pupation to the last emergence for each group.

TABLE 11.—*Duration of the pupal stage of individuals of the Indian-meal moth reared on raisins, Fresno, Calif., 1926–27*

Date larvae pupated	Pupae	Days of pupal life		Mean temperature[1]	Mean relative humidity[1]
		Range	Average		
1926				° F.	Per cent
Mar. 6–31	87	18–33	23.3	69	56
Apr. 1–28	25	7–21	14.4	72	54
May 9–31	18	7–20	10.5	80	42
June 3–30	5	8–9	8.6	84	39
July 2–28	14	4–9	7.1	88	39
Aug. 9–29	17	4–9	6.9	83	42
Sept. 1–28	9	8–16	12.9	74	48
Oct. 3–7	2	12–14	13.0	71	57
1927					
Mar. 24–28	4	29–31	30.0	64	63
Apr. 5–27	18	14–25	19.0	69	55
May 1–14	4	15–18	16.8	72	48
Summary	203	4–33	14.8		

[1] For the period in each group from the initial pupation to the last emergence.

The larvae in Table 11, pupating from March 6 to October 7, 1926, and from March 24 to May 14, 1927, showed as extremes of the pupal period from 4 to 33 days. The shorter periods were during July and August, averaging 7.1 and 6.9 days, respectively. The respective mean temperatures applying to these two groups were 88° and 83° F. The longer pupal periods occurred in the spring with mean temperatures below 70°. Thus, in March, 1927, the average pupal period was 30 days and the mean temperature 64°, whereas in March, 1926, with a mean temperature of 69°, the pupal stage averaged 23.3 days.

The pupal periods of 137 individuals reared on prunes and 112 reared on figs approximated those reared on raisins, except that one prune-fed individual showed a pupal period of 26 days in June.

This range of the pupal period is approximated by records in literature. Popenoe (*21, p. 3*) found that adults emerged as early as 5 days after pupation, and Herms (*15, p. 563*) reported the period as from 24 to 28 days under fluctuating room temperatures of from 15 to 19° C. (59 to 66° F.). On the other hand the 12-day pupal period in the studies of Parker (*20, p. 4*) covering the period from June to August is very much longer for that season than that observed in the present investigation. The same is true of the report of Bioletti (*2, p. 3*) that the pupal stage lasts about 16 days at an average summer temperature of 80° F. Lovett (*19, p. 119*) stated that from 10 to 20 days are passed in the pupal stage.

LENGTH OF LIFE CYCLE

The present study has shown that the life cycle of the Indian-meal moth in the San Joaquin Valley of California is more variable and somewhat longer than is generally indicated in literature. Thus Back and Cotton (*1, p. 16*), Essig (*11, p. 712*), Dietz (*9, p. 84*), and Girault (*13, p. 66*) have indicated that the life cycle is completed in from 4 to 5 weeks. DeOng (*7, p. 241*), having reference to California conditions, states that egg-to-adult development occurs in from 5 to 6 weeks at a temperature of 70° F. or more, and in from 6 to 8 weeks at temperatures below 70°.

Data on the life cycles of 89 individuals from deposition of the egg to emergence of the adult, together with data of temperature and relative humidity for each such period, are contained in Table 12. These individuals were reared on raisins. Eggs laid from April 4 to 10 produced adults emerging from May 22 to June 21, in 47 to 72 days, the mean egg-to-adult period being 58 days. The mean temperatures for these cycles averaged 76° F. From eggs deposited June 5, adults developed and emerged from July 8 to August 16, the range being 33 to 72 days, and the mean 47.4 days. The average of mean temperatures applying to these individual periods was 85°. Eggs laid July 11 produced mostly transforming individuals, but one was of the wintering type. Adults of the former category emerged August 16 to October 8, ranging from 36 to 89 days and averaging 55.4 days under mean temperatures for the individual periods of from 82 to 88°. The one wintering individual emerged on May 9 the following year, this egg-to-adult period of 302 days being the longest among raisin-fed individuals encountered in the present study. Eggs laid August 17 produced both transforming and wintering individuals. The former emerged from October 7 to 19, with a mean period of 57.6 days and a range of 51 to 63 days, the average of mean temperatures being 77°. The latter emerged from May 1 to June 1 the following year, with a mean egg-to-adult period of 270.1 days. Eggs laid October 10 produced only wintering individuals, emergence occurring the following year from April 24 to May 11, with a mean period of 201.3 days.

TABLE 12.—*Developmental periods of the Indian-meal moth on raisins, Fresno, Calif., 1926–27*

Rearing No.	Date egg was laid	Incubation period	Larval period	Pupal period	Date adult emerged	Interval egg to adult	Sex	Temperature[1]		Mean relative humidity[1]
								Mean	Range, mean minimum to mean maximum	
	1926	*Days*	*Days*	*Days*	*1926*	*Days*		*°F.*	*°F.*	*Per cent*
1	Apr. 4	10	31	7	May 22	48	Male	74	18	53
2	do	10	40	9	June 2	59	do	75	19	51
3	do	10	40	10	June 3	60	do	75	18	51
4	do	10	43	9	June 5	62	do	75	19	50
5	do	10	36	20	June 9	66	do	76	18	50
6	do	10	52	9	June 14	71	Female	76	19	49
7	Apr. 7	10	28	9	May 24	47	Male	74	19	52
8	do	10	34	11	June 1	55	Female	75	20	50
9	Apr. 9	8	37	10	June 3	55	Male	76	20	49
10	do	8	39	8	do	55	Female	76	20	49
11	do	8	39	8	do	55	do	76	20	49
12	do	8	42	9	June 7	59	do	77	20	49
13	do	8	41	10	do	59	Male	77	20	49
14	do	8	49	9	June 14	66	do	77	20	48
15	Apr. 10	7	30	10	May 27	47	do	75	20	50
16	do	7	32	12	May 31	51	do	75	19	50
17	do	7	37	9	June 2	53	do	76	20	49
18	do	7	44	7	June 7	58	Female	77	20	48
19	do	7	47	8	June 11	62	do	77	20	48
20	do	7	56	9	June 21	72	Male	78	20	47
Average	Apr. 4–10	8.5	39.9	9.7		58		76	19	50
21	June 5	4	23	6	July 8	33	Female	84	22	39
22	do	4	21	8	do	33	do	84	22	39
23	do	4	27	4	July 10	35	Male	84	22	40
24	do	4	30	7	July 16	41	do	85	22	40
25	do	4	34	6	July 19	44	Female	85	23	40
26	do	4	33	8	July 20	45	Male	85	22	39
27	do	4	34	8	July 21	46	Female	85	23	39
28	do	4	34	8	do	46	do	85	23	39
29	do	4	35	7	do	46	do	85	23	39
30	do	4	37	6	July 22	47	do	86	23	39

[1] For the interval from deposition of the egg to emergence of the adult.

TABLE 12.—*Developmental periods of the Indian-meal moth on raisins, Fresno, Calif., 1926–27*—Continued

Rearing No.	Date egg was laid	Incubation period	Larval period	Pupal period	Date adult emerged	Interval egg to adult	Sex	Temperature: Mean	Temperature: Range, mean minimum to mean maximum	Mean relative humidity [1]
	1926	*Days*	*Days*	*Days*	*1926*	*Days*		*°F.*	*°F.*	*Per cent*
31	June 5	4	37	7	July 23	48	Female	85	23	39
32	do	4	39	8	July 26	51	Male	86	23	39
33	do	4	40	8	July 27	52	do	86	23	39
34	do	4	45	9	Aug. 2	58	Female	86	23	39
35	do	4	49	8	Aug. 5	61	do	86	23	39
36	do	4	61	7	Aug. 16	72	Male	86	23	39
Average		4	36.2	7.2		47.4		85	23	39
37	July 11	3	29	4	Aug. 16	36	Female	88	24	39
38	do	3	31	6	Aug. 20	40	do	87	24	39
39	do	3	31	6	do	40	Male	87	24	39
40	do	3	30	8	Aug. 21	41	Female	87	24	39
41	do	3	32	8	Aug. 23	43	Male	87	24	39
42	do	3	36	6	Aug. 25	45	do	87	24	39
43	do	3	36	7	Aug. 26	46	Female	87	24	39
44	do	3	39	6	Aug. 28	48	Male	87	23	39
45	do	3	39	6	do	48	do	87	23	39
46	do	3	38	7	do	48	Female	87	23	39
47	do	3	40	5	do	48	Male	87	23	39
48	do	3	37	9	Aug. 29	49	Female	87	23	39
49	do	3	39	8	Aug. 30	50	Male	86	23	40
50	do	3	39	8	do	50	Female	86	23	40
51	do	3	42	9	Sept. 3	54	Male	86	24	40
52	do	3	46	7	Sept. 5	56	do	86	24	40
53	do	3	49	8	Sept. 9	60	Female	85	23	40
54	do	3	60	13	Sept. 25	76	Male	83	23	41
55	do	3	63	13	Sept. 28	79	do	83	24	41
56	do	3	68	14	Oct. 4	85	do	82	23	42
57	do	3	72	13	Oct. 7	88	Female	82	23	43
58	do	3	74	12	Oct. 8	89	do	82	23	43
Average	do	3	44.1	8.3		55.4		86	23	40
59	do	3	282	17	*1927* May 9	302	Female	66	17	63
60	Aug. 17	4	34	13	*1926* Oct. 7	51	do	78	23	46
61	do	3	38	14	Oct. 11	55	do	77	22	46
62	do	4	38	16	Oct. 14	58	Male	76	22	47
63	do	3	44	14	Oct. 17	61	Female	76	22	47
64	do	3	48	12	Oct. 19	63	do	76	22	48
Average	do	3.4	40.4	13.8		57.6		77	22	47
65	do	3	231	23	*1927* May 1	257	Female	63	16	66
66	do	3	240	18	May 5	261	Male	63	17	66
67	do	4	239	18	do	261	Female	63	17	66
68	do	3	246	17	May 10	266	do	63	17	66
69	do	3	247	17	May 11	267	do	63	17	66
70	do	4	248	16	May 12	268	do	63	17	66
71	do	3	250	19	May 16	272	Male	64	17	66
72	do	4	253	15	do	272	do	64	17	66
73	do	3	257	18	May 22	278	Female	64	17	65
74	do	3	262	16	May 25	281	do	64	16	65
75	do	3	267	18	June 1	288	Male	64	17	64
Average	do	3.3	240.1	17.7		270.1		63.5	17	66
76	Oct. 10	6	160	30	Apr. 24	196	Female	59	14	73
77	do	6	159	31	do	196	Male	59	14	73
78	do	6	161	30	Apr. 25	197	do	59	14	73
79	do	6	163	29	Apr. 26	198	Female	59	15	73
80	do	6	172	21	Apr. 27	199	do	59	15	72
81	do	6	173	21	Apr. 28	200	do	59	15	72
82	do	6	172	22	do	200	Male	59	15	72
83	do	6	172	23	Apr. 29	201	Female	59	15	72
84	do	6	171	25	Apr. 30	202	Male	59	15	72
85	do	6	180	17	May 1	203	do	60	15	72
86	do	6	177	20	do	203	do	60	15	72
87	do	6	184	15	May 3	205	Female	60	15	72
88	do	6	185	14	do	205	do	60	15	72
89	do	6	188	19	May 11	213	Male	60	16	71
Average	do	6	172.6	22.6		201.3		59	15	72

The range of the life cycle is broadened slightly by including the rearings on figs and prunes. During the same period in which the minimum of 33 days for raisin rearings was established, two egg-to-adult cycles of 27 days each occurred among the insects reared on figs. During very nearly the same period in which the maximum of 302 days was obtained on raisins, one prune-fed individual required 305 days for egg-to-adult development.

NUMBER OF GENERATIONS PER YEAR

In the rearings reported upon, the generations were kept separate and were begun with eggs laid by the earlier emerged females of the preceding generation. The data thus served to indicate the maximum number of egg-to-adult cycles which may occur during the year. In the case of the first generation the first adult emerged May 22, whereas the first female issued June 1, and a female which emerged

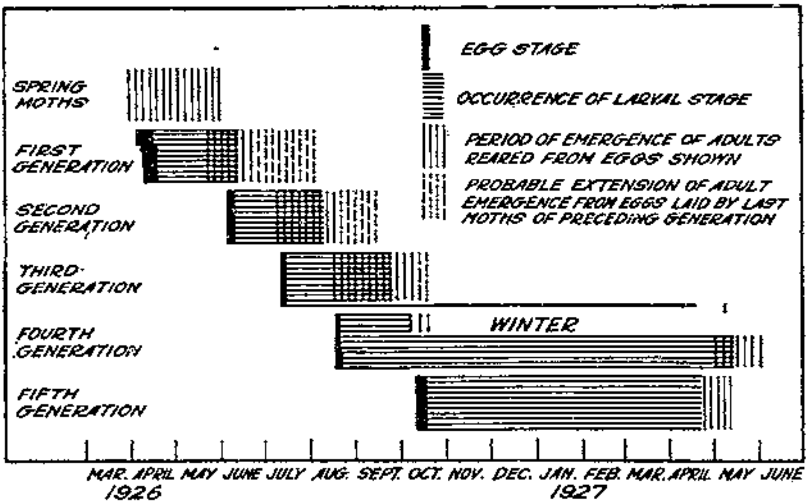

FIGURE 1.—Chart showing generations of the Indian-meal moth reared on raisins in the laboratory from the more advanced females of each generation, and the consequent overlapping of generations

June 3 laid the eggs which produced the second generation. Such delays, however, had no important effect upon the number of generations reared, except in the case of figs.

The relation of the egg stage in each generation to the period of adult issuance in the preceding broods is shown in Figure 1, as is also the occurrence of larvae and emergence of adults actually reared from these eggs. The probable extension of adult emergence which would have resulted from eggs laid by the more retarded moths of the preceding brood is shown for each generation by broken vertical lines.

It may be seen (fig. 1) that all individuals of the first two summer generations completed their development the same year the eggs were laid. Likewise the third generation was very largely completed the same season; only one individual passed the winter in the larval stage and issued as an adult the following year. A small part of the fourth generation emerged during the year of oviposition, but the majority overwintered as larvae and emerged the following year.

All individuals of the fifth generation passed the winter in the larval stage and emerged the next year. There were thus five generations started during the year, composed of two complete and two partial summer generations and the one entirely overwintering generation. Owing to the rearing methods employed these results are indicative of the maximum potentialities of the insect in the San Joaquin Valley when fed on raisins.

Four generations were reared on prunes, beginning with the first spring generation of 1926, as compared with five on raisins and a possible six on figs. Only 33 individuals were reared on figs as compared with 50 on prunes, and besides, all the fig-reared generations except the second were too small in number to permit prompt starting of the succeeding generations. The five generations actually reared upon figs are therefore a less trustworthy index than the six computed from the shortest cycles in each generation.

The vertical lines, both solid and broken, in Figure 1 show the long periods of adult emergence in the several generations and explain the overlapping of generations bred on a single kind of fruit. The tendency to faster development on figs and slower development on prunes would increase this overlapping in packing houses storing all these dried fruits. Furthermore, different rates of development due to varying conditions in different situations in packing houses would result in still further overlapping. Indeed, Figure 1 shows that individuals of three of the segregated generations overwintered and emerged the following spring, so even the spring brood of moths in nature has no common generational status.

PARASITES

Three parasites of the Indian-meal moth have been encountered about dried-fruit packing houses in the San Joaquin Valley. Only one of these, *Habrobracon juglandis* (Ashm.), is abundant. A larger wasp-like insect, *Nemeritis canescens* Grav., is only an occasional parasite. A single female of *Drepanoglossa floridensis* Tns., a small tachinid fly, was collected, and four specimens were reared from Indian-meal moth larvae.

The braconid *Habrobracon juglandis* is often exceedingly abundant about infested stored fruit and destroys very large numbers of Indian-meal moth larvae, but not enough to control the situation without remedial measures. Data obtained in October, 1926, under natural conditions at a packing plant having a very heavy infestation of the Indian-meal moth, serve to emphasize this point.

This particular infestation showed many grown larvae of the Indian-meal moth crawling from sacked dried figs and an abundance of the braconid adults. Many larvae had already been paralyzed by the parasites, and many of them had parasite eggs on them. From a representative area of 40 square feet of the burlap-sack surface, all larvae, except the old, dark-colored, dried-out ones, were collected and placed in individual vials. This collection, including living and recently parasitized larvae, totaled 143. Another collection from 44 square feet of wall and window surface netted 157 larvae. The density of larvae in both cases was 357 per 100 square feet. Of the 143 placed in individual containers, 139 were apparently parasitized and 4 were apparently normal. The four living larvae and one of the apparently dead ones produced moths. Of the remaining 138 larvae, 91 shriveled and died and produced no adult parasites, although many of them supported parasites which did not develop to the adult stage. It is possible either that the parasite eggs were detached from the larvae at the time of collection or that some of them were overparasitized. There is, however, little doubt that their death resulted from the activities of Habrobracon. The other 47 larvae each produced from 1 to 8 Habrobracon adults, the average per larva being 2.5. The estimate of death due to parasitism is thus 96.5 per cent. Notwithstanding this, adults of the Indian-meal moth were exceedingly abundant that fall, and a very abundant larval population overwintered.

Cocoons of *Habrobracon juglandis* are of frequent occurrence inside figs, where, under the pure food law, they constitute contamination just as the original inhabitant would. Taken all in all, this parasite must be considered of no practical value.

SUMMARY

The Indian-meal moth, *Plodia interpunctella* Huebner, originally an Old World pest but now found everywhere, is the most destructive insect attacking stored dried fruits in California, where its presence in packing houses is well-nigh universal. It is a general feeder upon dried vegetable matter, and its cast skins, webbing, and excrement pollute the dried fruits upon the surface of which it feeds. Because of the great quantities of fruit damaged in this way a knowledge of its larval habits, and to a lesser degree its oviposition, incubation, and other activities, are of considerable importance.

This species begins each year with a promiscuous brood of overwintering larvae, some of which date from as early as July and others as late as October of the previous year, and which are the offspring of any generation from the third to the fifth of that year. They pupate mostly in March and emerge as adults in April. As the season proceeds, the blending of generations continues, until eggs, larvae, pupae, and adults of several generations are all present at the same time.

The moths studied in the present instance began ovipositing usually not more than 3 days after emergence and continued ovipositing from 1 to 18 days, the longer periods occurring during the cooler weather of spring and fall. The length of time given to these two activities, especially the lengthy emergence period of the spring brood of moths, resulted in a very considerable extension of the time occupied by the first generation; indeed, adults of the first generation had emerged before the issuance of the last adults of the spring brood. The eggs, which are deposited chiefly at night and attached loosely to the surface of the dried fruit, ranged in number from 39 to 275 for each female, the average for the entire season being 152.3. Moths living in the fall deposited the greatest number, averaging 178.3, as compared with 127.1 during the hot midsummer period, although the oviposition was much faster at the latter time.

In summer, approximately 90 per cent of the eggs were laid during the first three days after mating, instead of during the first 11 as in the spring, and the first 6 in the fall. The eggs may be extruded very rapidly; the greatest number laid in one day was 144, and there is one record of 115 eggs laid in a single hour.

The female moth survived, at the most, only five days after finishing oviposition; and the total term of life, shortest during the hot summer weather, ranged from 2 to 23 days. Males lived from 2 to 25 days.

The blurring of generation lines is much increased by the range of the normal period of incubation from 2 to 14 days, depending directly upon the temperature. The eggs laid in July and August hatched in the shortest time, the average being 3.7 days, whereas those laid by one exceptional female from November 17 to 22 required from 14 to 17 days.

The percentage of hatch, also, though little affected by the heat of summer, was drastically reduced by low temperatures. Thus, of 10,479 eggs deposited from April 4 to October 31, 73.4 per cent hatched, the monthly average ranging from 68.8 to 78.3 per cent as the monthly temperature mean ranged from 68 to 88° F.; whereas of 211 eggs laid exceptionally late in the season and incubated at temperatures averaging 59° F., only 25.1 per cent hatched.

Still more variable than the periods of preoviposition, oviposition, and incubation, and more potent as a cause of confusion, is that of larval development. The shortest individual period was 13 days and the longest 288. Although this extreme range is that of individuals hatched and fed under extremes of environment, and includes, moreover, the semiinactive winter season, it does not greatly exceed that of offspring of a common parent, hatched simultaneously and reared in the same environment, whose larval period ranged from 29 to 282 days. The larval period of individuals, all fed upon raisins, ranged from 21 to 282 days. The inclusion of the winter period is not taking in an exceptional feature, for a small percentage of the larvae which hatched even as early as July, and an increasing proportion of the later ones, remained in the larval stage over winter. Excluding the winter season, however, the shortest average larval period of 36.2 days was established by those hatched in June, and the average larval life of those hatching in July and maturing before winter was longest, being 44.1 days.

Superimposed upon this variation in larval period of individuals, often of common parentage, is an additional variation due to different foods which further confuses the generations. The extreme periods of 13 and 288 days mentioned above were taken from fig-fed and prune-fed larvae, respectively. The average larval period upon figs is shorter than upon raisins or prunes, probably because of the higher sugar and moisture content of figs. Possibly the variations observed in length of life of larvae reared upon a single kind of fruit are attributable to similar differences in the individual fruits.

The pupal period of 203 individuals reared upon raisins ranged from 4 to 33 days, varying inversely with the temperature; and the pupae of those reared upon figs and prunes have approximately the same periods.

The shortest egg-to-adult cycle encountered in this study was 27 days on figs, and the longest, 305 days upon prunes. The cycle of individuals reared on raisins ranged from 33 to 302 days. This resulted in a maximum of five generations in a single year on raisins and four on prunes. More than five probably mature on figs in nature, but in this experiment, although the growth was rapid, the small number of specimens issuing delayed the start and prevented the production of the maximum number of generations.

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U. S. GOVERNMENT PRINTING OFFICE: 1931

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