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BIOLOGY OF THE RAISIN MOTH
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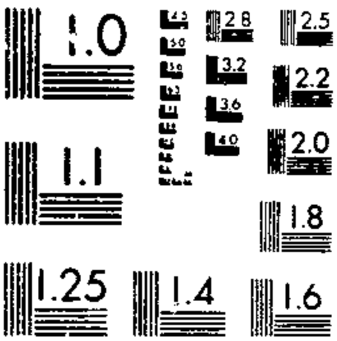


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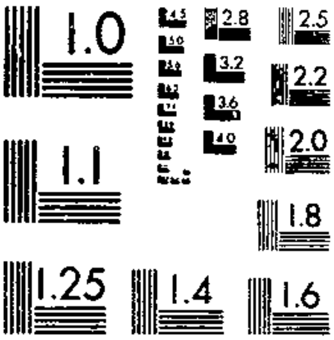


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# Biology of the Raisin Moth [1]

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## CONTENTS





## INTRODUCTION

The production and storage of dried fruits probably have been affected by insect infestations since the beginning of the industry. In recent years one of the major insect pests in California has been *Ephestia figulilella* Gregson, which has been given the common name "raisin moth." This species has been the subject of biological and control studies since its first recorded appearance in California raisins in 1928.[5]

The raisin moth is found in most of the fruit-growing sections of California (fig. 1) [6] and in the Salt River Valley and the Yuma district of Arizona. Most of these areas are arid, with hot, clear, rainless summers and mild winters. In the central San Joaquin Valley of California, where damage by the raisin moth is heaviest, the rainfall

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[1] Submitted for publication Dec. 23, 1947.

[2] Transferred January 1938 to Division of Control Investigations. Resigned Jan. 22, 1944.

[3] Transferred October 1948 to Division of Cereal and Forage Insect Investigations.

[4] Technical descriptions were prepared by Mr. Heinrich, who retired June 30, 1949. Plate I was drawn by Mrs. Eleanor Carlin.

[5] This report includes information obtained to October 1947.

[6] Many of the distribution records were provided by H. H. Keifer, California Department of Agriculture.

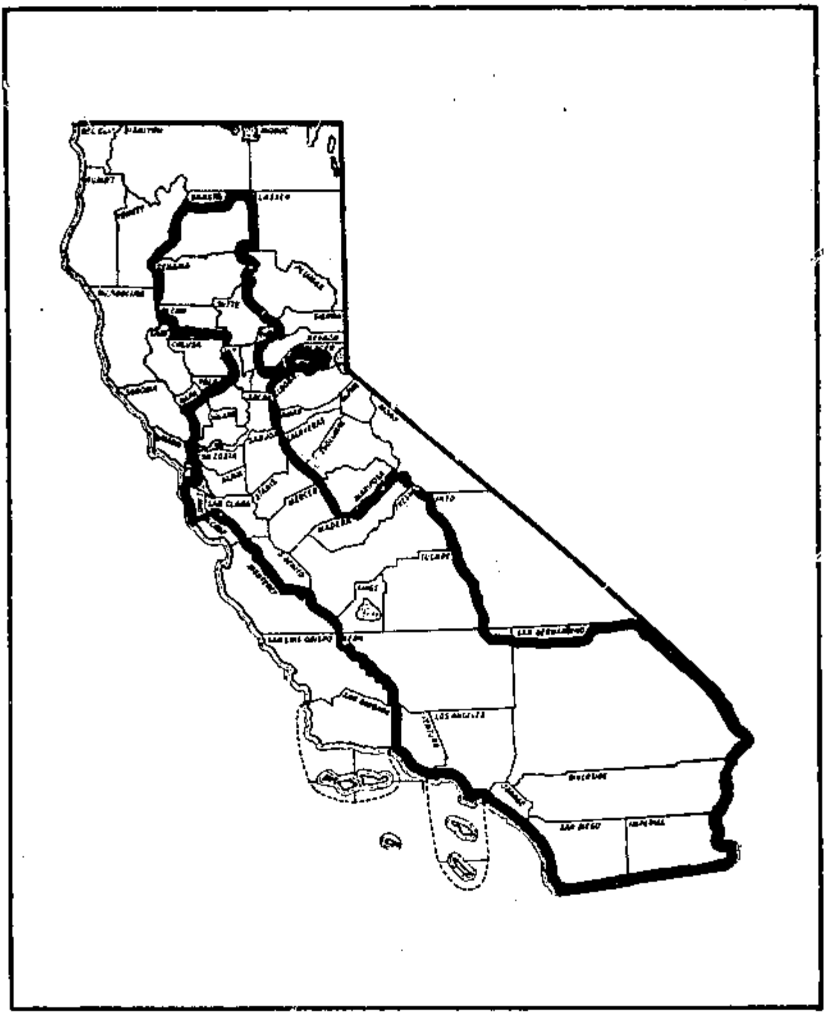


FIGURE 1.—Map of California, showing the counties in which the raisin moth occurs.

averages about 10 inches per year and nearly all crops are grown by irrigation. At Fresno the normal daily maximum temperature in July is 100° F. In midsummer maximum temperatures often exceed 100° but rarely reach 110°. Relative humidities and wind velocities are low.

## HISTORICAL REVIEW

*Ephestia figulilella* (fig. 2) was described in 1871 by Gregson (*20*) [7] from specimens collected in a warehouse in Liverpool, England. Because this species resembles other closely related moths, mistaken identifications have been common, and probably some of the published

[7] Italic numbers in parentheses refer to Literature Cited, p. 21.

records of host materials and of distribution are erroneous. To aid in identifying members of the *Ephestia* group, including *E. figulilella*, keys have been made available by Curran (*9*) and more recently by Richards and Thomson (*28*). The latter authors have assembled the following list of synonyms: *Ephestia figulilella* Gregson (*20*), *E. ficulella* Barrett (*6*); *E. milleri* Zeller (*38*); *E. desuetella* Meyrick (*24*); *E. kühniella* Riley (not Zeller) (*29*); *E. figuliella* Forbes (*18*); *E. figulella* Curran (*9*), *E. venosella* Turati (*35*); and *E. ernestinella* Turati (*36*).

The same writers stated that the species had been confused with *Ephestia afflatella* (Mn.), *E. calidella* Gn., *E. cautella* (Wlkr.), and *E. kühniella* Zell. Early in their work on this insect in California, Simmons and Reed (*33, 34*) referred to it as *E. cautella*.

In the course of their examinations of museum specimens, Richards and Thomson (*28*) verified the following geographical sources of *Ephestia figulilella*: British Isles, Central Europe, West Africa (Gambia), Algeria, Cyrenaica, Syria, Persia, India, and Ceylon. There are references also to collections made in Madeira (*1*), Hawaii (*25*), Canada (*9, 19*), Australia (Victoria) (*3*), Trinidad (*22*), Colombia (*27*), Jamaica (*29*), Egypt (*31*), the Canary Islands (*7*), and the United States (*18*).

Most records of the occurrence of the species at widely separated points refer to infestations in stored products. These materials include a cargo of cottonseed cake (Atmore *2*); dried fruit, East African corn, and earth nut (*Lathyrus tuberosus*) (Zacher *37*); cacao beans (Knapp *22*); a cargo of rice fodder meal (Schaffnit *30*); dates (Shafik *31*); currants and figs (Barrett *6*); cashew kernels (Zacher *37*); oatmeal (Chittenden *8*); grapes (Mackie *23*); and peach pits (Gregory *et al. 19*). The species probably maintains itself out of doors throughout the year in Egypt (Shafik *31*) and Australia (Austral. Council Sci. and Indus. Res. *3*), as it habitually does in California.

Aside from the data included in this bulletin and in a series of progress reports that have preceded it (Barnes *et al.* (*4*), Donohoe and Barnes (*15, 16*), Donohoe *et al.* (*17*), Kaloostian *et al.* (*21*), Simmons and Donohoe (*32*)), observations of *Ephestia figulilella* appear to be those of Schaffnit (*30*). He described the habits of the species in rice fodder meal in Germany, and outlined control measures.

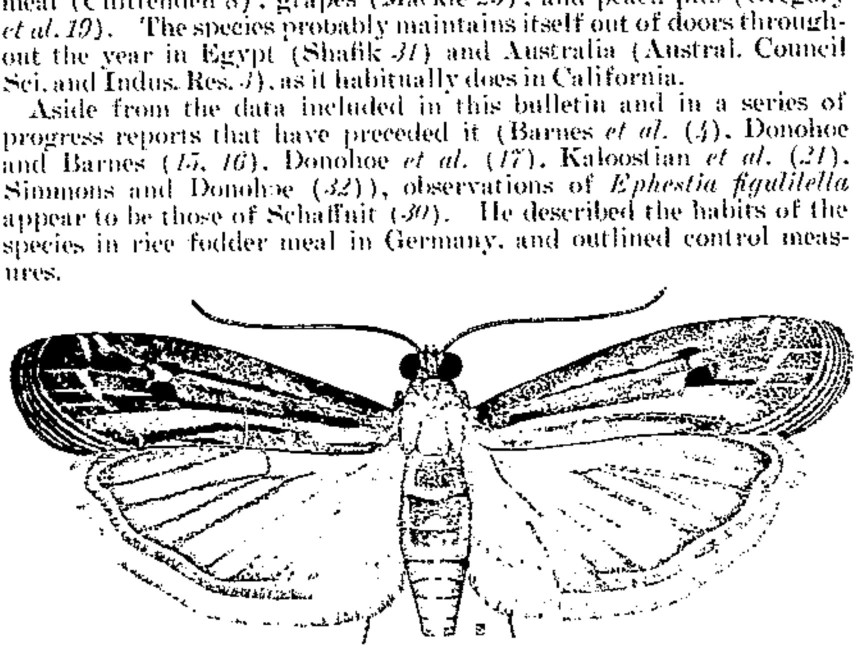


FIGURE 2.—Raisin moth, adult female. (×7.)

## TECHNICAL DESCRIPTION

ADULT.—Tongue developed; basal portion scaled. Labial palpus upcurved, reaching nearly to level of top of head; clothed with appressed scales; apical segment pointed. Maxillary palpus filiform. Antenna of male with the shaft swollen for a short distance from basal segment, shortly pubescent; antenna of female, simple. Forewing elongate, narrow, with costa slightly curved toward apex and (in male) with a strong fold on underside at base of costa, enclosing two tufts of long hairlike scales; veins 3 and 5 absent; vein 10 from the cell; vein 1c absent. Hind wing with vein 2 from cell well before outer angle; 4 absent; 3 and 5 connate or closely approximate basally; 8 fused with 7 for its entire length beyond cell, 1c present; cell short, only slightly more than one-third as long as wing; a fringe of pecten on lower median vein at base; in male another tuft of hairs on base of vein *1c;* frenulum of female simple (a single strong spine).

Color of forewing light drab or drab gray, showing under magnification an irregular dusting of pinkish scales; markings obscure; transverse antemedial line, when distinguishable, nearly straight and very slightly darker than the ground color, indicated chiefly by some pale shading on its inner margin; subterminal line nearly absent, when present very faint, the pale border along its inner margin sometimes fairly distinct; a pair of obscure, dark discal dots at outer end of cell; some very faint dark scaling at the vein ends along termen; cilia paler than ground color of wing, the ends of the scales distinctly white. Hind wing whitish, semihyaline, with a narrow black line along termen and some fuscous shading on the veins and the apical cilia, and in the costal area between costa and upper vein of cell and vein 7; in the male, basal third of costal area between costa and cell overlaid with yellow sex scaling; cilia white shading to yellowish white at anal angle of wing.

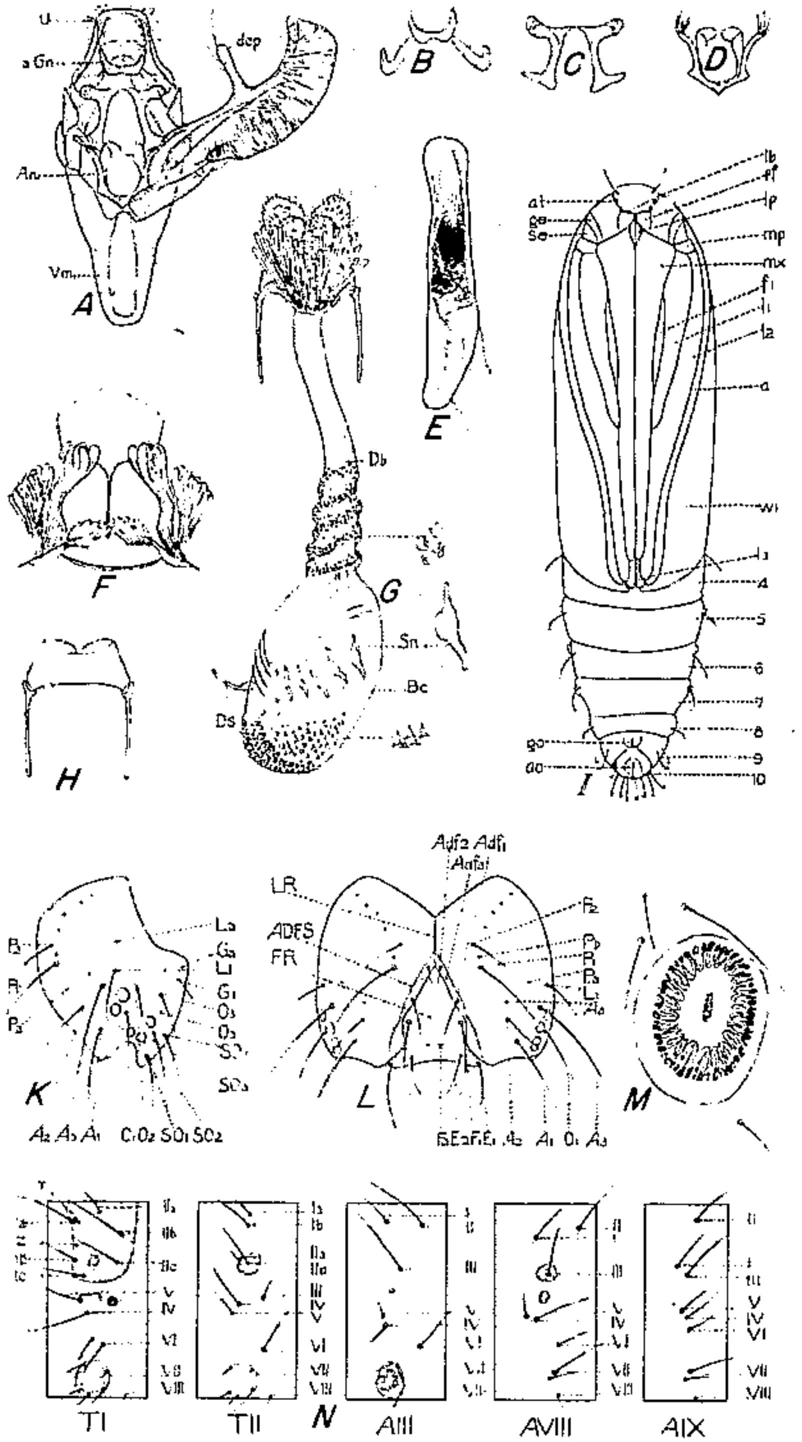
Eighth abdominal segment of male with compound latero-dorsal scale tufts on eighth segment (pl. 1, *F*).

Male genitalia (pl. 1, *A–E*) with apical prongs of gnathos widely separated, rather short, and nearly straight. Transtilla complete, but with its elements weakly united at their apices; a short, knoblike lateral lobe from near apex of each element. Harpe with costa strongly sclerotized, slightly produced at apex and with a long, digitate, postmedian costal projection. Anellus a narrow sclerotized band partially encircling the aedeagus and produced ventrolaterally into a pair of short, sparsely haired lobes. Vinculum elongate-triangular; terminal margin rounded. Aedeagus straight, tapering, moderately stout; penis bearing a small cluster of flattened, curved spines included in a sclerotized and wrinkled area.

Female genitalia (pl. 1, *G*) with a fanlike scale tuft at the genital opening. Signa a series of 4 to 7 spindle-shaped sclerotized plates set on edge in the bursa. Bursa copulatrix with a dense cluster of short, strongly sclerotized thornlike spines at anterior end. Similar spines arranged in a band spiraling the ductus bursae for nearly half its length from its junction with bursa. Ductus seminalis from near middle of bursa. Collar (pl. 1, *H*) of eighth abdominal segment evenly sclerotized.

EXPLANATION OF PLATE 1.—*A*, male genitalia of moth with aedeagus and one harpe omitted; *B*, gnathos; *C*, transtilla; *D*, anellus; *E*, aedeagus; *F*, tufts on eighth abdominal segment of male; *G*, female genitalia of moth, ventral view; *H*, collar of eighth abdominal segment of female, dorsal view; *I*, pupa, ventral view; *K*, head capsule of larva, lateral view showing setal arrangement; *L*, head capsule of larva, dorsal view showing setal arrangement; *M*, crochets of abdominal proleg of larva; *N*, setal maps of prothoracic and mesothoracic segments and third, eighth, and ninth abdominal segments of larva. Explanation of symbols applied to genitalia: *An*, anellus; *afAn*, forked apical process of gnathos; *Bc*, bursa copulatrix; *Db*, ductus bursae; *dcp*, digitate process from costa of harpe; *Ds*, ductus seminalis; *Sa*, signa in bursa copulatrix of female; *U*, uncus; *Vm*, vinculum. Explanation of symbols applied to pupa; *a*, antenna; *ao*, anal opening; *at*, pits indicating attachment of tentorial arms of epicranium; *fl*, femur of prothoracic leg; *ge*, glazed eyepiece; *go*, genital opening; *l1*, prothoracic leg; *l2*, mesothoracic leg; *l3* metathoracic leg; *lb*, labrum; *lp*, labial palpus; *mp*, maxillary palpus; *mx*, maxilla; *pf*, pilifer; *se*, sculptured eyepiece; *wi*, fore wing; 4–10 fourth to tenth abdominal segments. Explanation of symbols applied to larval head capsule: *A1*, *A2*, *A3*, *Aa*, setae and puncture of anterior group of epicranium; *Adf1*, *Adf2*, *Adfa*, adfrontal setae and puncture of epicranium; *ADFS*, adfrontal

PLATE I



Structural details of the adult, larva, and pupa of *Ephestia figulilella* Greg.

suture of epicranium; *E1*, *E2*, epistomal setae; *F1*, *Fa*, frontal setae and punctures; *FR*, frons; *L1*, *La*, lateral seta and puncture of epicranium; *LR*, longitudinal ridge of epicranium; *O1*, *O2*, *O3*, *Oa*, setae and puncture of ocellar group of epicranium; *P1*, *P2*, *Pa*, *Pb*, setae and punctures of posterior group of epicranium; *SO1*, *SO2*, *SO3* *SOa*, setae and puncture of subocellar group of epicranium.

Alar expanse 14 to 17 mm.

Larva (pl. 1, *K–N*).—Body white; legs and prolegs normal; crochets of abdominal prolegs biordinal and arranged in a complete ring; primary setae only; two setae on prespiracular shield of prothorax; IV and V approximate and under the spiracle on abdominal segments 1 to 8; on the proleg-bearing segments, IV below and a trifle caudad of V and both setae normally on a single very small pinaculum and slightly forward of a vertical line through the spiracle; on eighth abdominal segment IV almost directly caudad of V; a sclerotized, darkly pigmented ring encircling the tubercle of seta I*b* on mesothorax and a similar ring encircling the tubercle of seta III of eighth abdominal segment; on ninth abdominal segment setae I and ~~III~~ closely approximate and on a single dark pinaculum; group VII bisetose on eighth and ninth abdominal segments; dorsal tubercles darkly pigmented. Prothoracic shield divided; brown, more or less shaded with blackish fuscous posteriorly and with a blackish spot on each side between setae I*b* and II*b*. Anal shield yellowish.

Head brown, nearly square in outline viewed from above, and slightly wider than long (pl. 1, *L*). Frons (Fr., the clypeus of Snodgrass) a trifle longer than wide, reaching to middle of head; frontal punctures ($F_a$ close together and well forward of frontal setae ($F_1$). Adfrontal sutures (*ADFS*) meeting longitudinal ridge (*LR*) well behind middle of head. Epicranial setae and punctures as figured (pl. 1, *K*, *L*); anterior setae ($A_1$, $A_2$, $A_3$) arranged in an obtuse angle; puncture $A_a$ posterior to seta $A_2$; posterior setae ($P_1$, $P_2$) approximate; seta $P_1$ on the level of seta $Adf_2$ and behind the level of $L_1$; setae $O_2$, $O_1$ and ocellus III in a line. Ocelli normal.

Length of full-grown larva 13 to 15 mm.

Pupa (pl. 1, *H*).—Moderately stout, smooth. Pilifers present and well developed. Maxillary palpi present. Labial palpi present but very small. Prothoracic and metathoracic legs not extending cephalad between sculptured eyepiece and antenna. Labrum, frontoclypeal suture, and invaginations for anterior arms of tentorium clearly indicated. Maxillae extending to within a short distance from tips of wings, leaving only a small portion of metathoracic legs exposed. Wings extending to caudal margin of fourth abdominal segment. Metathoracic and mesothoracic legs and antennae extending to tips of wings. Femora of prothoracic legs exposed. Cremaster absent. Caudal setae moderately long, hairlike with their ends curled or hooked. Genital and anal openings slitlike in both sexes. Spiracles nearly circular and slightly protruding.

Length 5.5 to 7 mm., width 1.5 to 2 mm.

Remarks.—The foregoing descriptions of the larva and pupa should identify them as belonging to the *Ephestia* group but will not serve for specific identification. As yet we have no satisfactory characters for differentiating the several *Ephestia* species in their larval or pupal stages. Richards and Thomson (*28*) professed to find significant differences among larvae and pupae of some of the species; but they do not seem to hold except for occasional specimens and therefore have no taxonomic value. The adults (male and female) of *figulilella* are easily distinguished from all other Phycitidae by their genitalia.

## LIFE HISTORY

### Fecundity and Longevity of Adults; Incubation and Fertility of Eggs [5]

Details of the life history of the raisin moth were obtained in the laboratory by observations on mated pairs of moths of known age, confined in celluloid vials. Some of the pairs were given diluted honey; others received water. The liquids were dispensed in glass

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[5] These records and those on larval development and pupation were made by Oscar G. Bacon, formerly biological aide.

feeders embedded in large raisins, as described by Donohoe (*11*). The minute sculptured white eggs (fig. 3) were deposited loosely on and near the raisins, to which they did not adhere. Since the moths given water were somewhat more prolific than those given 25-percent honey solution, some data on the former group are presented here.

Twenty-five pairs held at room temperature in August, September, and October produced an average of 351 eggs, of which 75 percent hatched. The total number of eggs laid by individual females ranged from zero to 692. Preoviposition, oviposition, and postoviposition

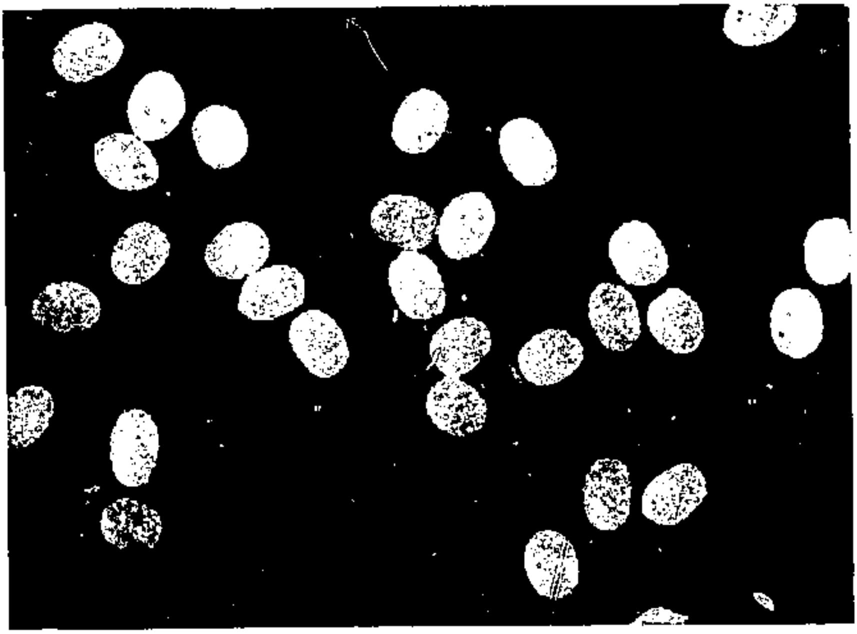

FIGURE 3. Eggs of the raisin moth. X 28.

periods averaged 1.1, 13.6, and 1.3 days. The males lived for an average of 11.3 days, the range being 3 to 22 days, and the females for an average of 16.1 days, the range being 3 to 24 days.

Hatching of the eggs, in an incubator at 82° to 84° F., required an average of 4.4 days, with extremes of 3 to 6 days.

Some of the egg-laying records are shown in table 1. During the period covered by the data the temperatures in the laboratory ranged from 64° to 82° F.

## Development of Larvae and Pupae

Individual larvae were reared in an incubator at 82°-84° F. Newly hatched larvae were fed fragments of partly dried mulberry fruit. They were confined in celluloid vials, which one of the authors (Donohoe) had found to be more favorable for the purpose than vials of glass.

The number of instars ranged from 4 to 8. The average number of days required for larval development was 32 days, the minimum 23,

**TABLE 1.**—*Number of eggs laid daily by females of paired raisin moths given water*

| Date of oviposition | No. 14 | No. 15 | No. 16 | No. 17 | No. 18 | No. 19 | No. 20 | No. 21 | No. 22 | No. 23 | No. 24 | No. 25 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Oct. 4 | 1 | | | | | | | | | | | --- |
| 5 | 84 | 3 | | | | | | | | | --- | --- |
| 6 | [1] 5 | 105 | | | | | | | | | --- | --- |
| 7 | 59 | 94 | 0 | | | | | | | | | --- |
| 8 | 36 | 64 | 108 | 7 | | | | | | | --- | --- |
| 9 | 1 | 44 | 43 | 23 | 0 | | | | | | | --- |
| 10 | 53 | 57 | 57 | 50 | 0 | 1 | 2 | | | | | --- |
| 11 | 32 | 50 | 41 | 30 | [1] 0 | 0 | 81 | 0 | 0 | | | -- |
| 12 | 35 | 57 | 35 | 30 | | [2] 19 | 62 | 33 | 26 | 0 | 6 | 0 |
| 13 | 23 | [1] 49 | 34 | 35 | | | 73 | 63 | 33 | 55 | 73 | 66 |
| 14 | 3 | 14 | 0 | 24 | | | 37 | 12 | 37 | 40 | 41 | 35 |
| 15 | 31 | 33 | [1] 22 | 32 | | | 40 | 61 | 29 | 69 | 51 | 82 |
| 16 | 8 | 29 | 22 | 21 | | | 45 | 40 | 48 | 67 | 43 | 1 |
| 17 | 22 | 19 | 17 | 26 | | | 26 | [1] 33 | [1] 15 | 28 | 43 | 48 |
| 18 | 8 | 10 | 0 | 18 | | | 32 | 27 | 29 | 37 | 34 | 13 |
| 19 | 4 | 5 | 13 | 9 | | | 10 | 28 | 17 | 18 | 34 | 37 |
| 20 | 2 | 6 | 2 | 2 | | | [1] 10 | 1 | 5 | 5 | 2 | 4 |
| 21 | [2] 0 | 13 | 1 | 13 | | | 16 | 23 | 12 | [1] 16 | 43 | 37 |
| 22 | | 9 | 18 | 8 | | (1) | 10 | 15 | 17 | 9 | 16 | 18 |
| 23 | | 7 | 3 | 4 | | | 3 | 8 | 10 | 12 | 16 | 11 |
| 24 | | 8 | 3 | 6 | | | 9 | 5 | 7 | 5 | 13 | 7 |
| 25 | | 9 | 10 | [2] 0 | | | 11 | 5 | 12 | 12 | [1] 13 | 19 |
| 26 | | 4 | 0 | | (2) | | 2 | 0 | [2] 0 | 0 | 8 | 5 |
| 27 | | [2] 3 | 5 | | | | 5 | [2] 0 | | 10 | 1 | 8 |
| 28 | | | [2] 0 | | | | 3 | | | [2] 0 | 12 | 10 |
| 29 | | | | | | | 1 | | | | 7 | 2 |
| 30 | | | | | | | 0 | | | | 0 | 5 |
| 31 | | | | (1) | | | 2 | | | | 4 | 3 |
| Nov. 1 | | | | | | | 0 | | | | 3 | 6 |
| 2 | | | | | | | [2] 0 | | | | 0 | [1] 0 |
| 3 | | | | | | | | | | | [2] 0 | [2] 0 |
| Total | 407 | 692 | 434 | 338 | 0 | 20 | 480 | 354 | 297 | 383 | 463 | 417 |

[1] Male died.
[2] Female died.

and the maximum 53 days. A prepupal period of about 1 day was the rule. The pupal stage averaged 10 days, with extremes of 8 and 12 days. Development from hatching to emergence required from 33 to 59 days, or an average of 43 days.

Records of the development of 24 individuals that hatched in June are given in table 2.

The most satisfactory medium for the mass rearing of raisin moths in the laboratory has been made of dog meal, Zante raisins ("currants"), honey, and glycerol. Equal parts by weight of the meal and raisins moistened with a mixture of equal parts honey and glycerol made a granular, slow-drying mixture, which produced large larvae. At room temperatures in summer, adults emerged in a culture 29 days after newly laid eggs had been introduced.

TABLE 2.—*Days required for development of larvae and pupae of the raisin moth at 82°–84° F.*

| Larva No. | Instar | | | | | | | | Larval period | Pre-pupal period | Pupal period | Hatching to emergence |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | | | | |
| 1 | 9 | 3 | 4 | 3 | 4 | 4 | 2 | 8 | 36 | 1 | 11 | 48 |
| 2 | 8 | 4 | 4 | 3 | 3 | 9 | -- | -- | 30 | 1 | 10 | 41 |
| 3 | 8 | 4 | 4 | 5 | 11 | -- | -- | -- | 30 | 2 | 10 | 42 |
| 4 | 8 | 3 | 4 | 4 | 13 | -- | -- | -- | 30 | 2 | 10 | 42 |
| 5 | 7 | 5 | 3 | 2 | 2 | 2 | 2 | 13 | 34 | 2 | 10 | 46 |
| 6 | 7 | 3 | 3 | 4 | 3 | 7 | -- | -- | 26 | 1 | 9 | 36 |
| 7 | 8 | 4 | 4 | 4 | 3 | 8 | -- | -- | 29 | 2 | 10 | 41 |
| 8 | 8 | 3 | 3 | 3 | 3 | 11 | -- | -- | 30 | 1 | 11 | 42 |
| 9 | 6 | 4 | 3 | 4 | 8 | -- | -- | -- | 24 | 1 | 8 | 33 |
| 10 | 7 | 4 | 3 | 3 | 3 | 19 | -- | -- | 27 | 2 | 8 | 37 |
| 11 | 8 | 4 | 3 | 3 | 4 | 4 | -- | -- | 34 | 2 | 11 | 47 |
| 12 | 9 | 4 | 3 | 4 | 6 | 22 | -- | -- | 47 | 1 | 11 | 59 |
| 13 | 8 | 4 | 3 | 3 | 4 | 12 | -- | -- | 32 | 2 | 11 | 45 |
| 14 | 7 | 4 | 3 | 4 | 4 | 8 | -- | -- | 29 | 1 | 9 | 39 |
| 15 | 9 | 4 | 4 | 4 | 10 | -- | -- | -- | 30 | 1 | 10 | 41 |
| 16 | 8 | 3 | 4 | 3 | 4 | 10 | -- | -- | 31 | 1 | 10 | 42 |
| 17 | 8 | 3 | 4 | 4 | 12 | -- | -- | -- | 30 | 1 | 10 | 41 |
| 18 | 8 | 3 | 4 | 5 | 13 | -- | -- | -- | 31 | 2 | 10 | 43 |
| 19 | 4 | 4 | 3 | 4 | 3 | 7 | 4 | -- | 26 | 3 | 10 | 39 |
| 20 | 5 | 3 | 3 | 3 | 3 | 8 | -- | -- | 23 | 2 | 8 | 33 |
| 21 | 4 | 4 | 4 | 4 | 2 | 11 | -- | -- | 28 | 1 | 9 | 38 |
| 22 | 5 | 4 | 4 | 4 | 11 | -- | -- | -- | 26 | 2 | 9 | 37 |
| 23 | 6 | 3 | 4 | 3 | 3 | 13 | -- | -- | 31 | 1 | 11 | 43 |
| 24 | 7 | 4 | 3 | 4 | 8 | -- | -- | -- | 24 | 2 | 11 | 37 |

## THE RAISIN MOTH ON FRUIT FARMS

### HABITS

Although, in California, raisin moth larvae are most evident in locations where dried fruits are concentrated in storage, the species is primarily a permanent out-of-doors resident on fruit farms. In storages there is some reinfestation, but the raisin moth does not do well on fruit that has undergone the changes that long storage brings about. After the infestation brought in from the field reaches maturity, the population dwindles until by the following summer it has become comparatively small.[9] Fruit that is being dried in the shade on the farms where it is produced is in a condition most favorable to the development of raisin moth larvae.

The diet of larvae of *Ephestia figulilella* on California farms (Donohoe and Barnes *16*) includes nearly all the fruits grown there—ripe grapes and raisins; figs on the ground and, uncommonly, on the trees; and fallen peaches, apricots, nectarines, prunes, plums, apples, pears, cherries, loquats, and mulberries (Donohoe *et al. 17*). Larvae have been found in wild grapes, fallen dates, dates on the palms, jujubes, and almonds.

[9] Among those who have contributed to the study of the field origin of raisin moth infestations are W. D. Reed and A. W. Morrill, Jr.

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Large populations were frequently found in some of these foods. However, waste fruit exposed to the high temperatures, sometimes 140° F. or higher, that occur on the surface of the ground in the sun is not likely to be infested.

Larvae of the raisin moth damage drying fruits by feeding on the surface and tunneling through the flesh. In their wake they leave excreta and webbing. Much of the feeding on raisins consists in chewing the crests of the ridges, but pits are formed also. Newly hatched larvae often enter raisins at the cap stem, or pedicel, by which the berry is attached, and as the insects grow they may penetrate to the seeds. Examination of 12,376 raisins in 23 samples collected from the field and held in the laboratory until the insects had reached or passed the full-grown larval stage indicated that about 20 Thompson Seedless, 20 Sultana, and 9 Muscat raisins were fed upon by each larva during its development.

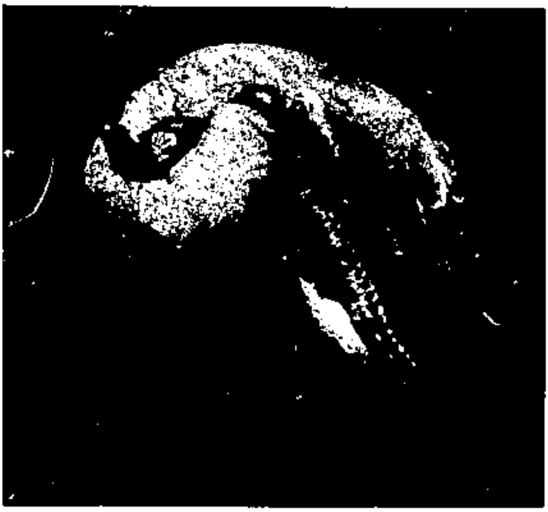

FIGURE 4.—Well-grown larva of the raisin moth and feeding injury on a grape (× 3). Photograph by courtesy of California Department of Agriculture.

Attack on drying cut fruits—peaches, apricots, nectarines, and pears that are halved before being spread on trays for drying—is usually made in crevices of the dried cut surface. In figs feeding is almost wholly within the receptacle, a protected environment frequently made more secure with a barrier of silk spun by the larva across the eye of the fruit. Grapes are generally attacked at the cap stem, but larvae may penetrate the unbroken skin at other points (fig. 4).

When they have finished feeding, the larvae usually leave the host material and seek a tight, dry, dark location in which to pupate. In vineyards many larvae hide under the rough bark of the vine trunks, within a foot or two of the ground, but a greater number enter the soil beneath the vines and pupate near the surface. In fruit orchards well-grown larvae pass the winter in the top 4 inches of soil, where infested waste fruit was present in the fall. Larvae that are not well grown in the fall rarely survive the winter.

## Populations in Host Materials

Examples of heavy infestations of raisin moth larvae and pupae found in various food materials are given in table 3. The figures were obtained by examining weighed samples of fruit and calculating the number of larvae and pupae per ton. The insects were removed from raisins by vigorous shaking in a sifter (Donohoe *12*).

**Table 3.**—*Infestations of raisin moth larvae and pupae found in various fruits on farms*

| Date | Source | Average infestation per ton (calculated) |
|---|---|---|
| | | *Number* |
| *1932* | | |
| Sept. 20 | First-crop Mission figs, on ground | 492, 900 |
| | First-crop Mission figs, buried by cultivation | 440, 000 |
| Oct. 4 | First-crop Mission figs, on ground | 372, 500 |
| | First-crop Mission figs, buried by cultivation | 138, 100 |
| *1933* | | |
| Oct. 19 | Calimyrna figs, on ground after harvest | 85, 800 |
| 30 | Adriatic figs, on ground after harvest | 89, 400 |
| Aug. 10 | Waste Santa Rosa plums | 992, 000 |
| | Waste apricots, on ground | 5, 264, 000 |
| | Waste nectarines, on ground | 294, 400 |
| June 6 | Fallen mulberries | 1, 024, 000 |
| *1935* | | |
| Sept. 21 | Thompson Seedless raisins, on wooden trays | 116, 400 |

There is a period in the spring when food for larvae of the raisin moth is scarce. During this period the species would suffer a set-back if it were not for the presence of mulberries. In 1934, 1935, 1936, and 1937 fallen mulberries were found on April 9, May 5, April 14, and May 4, respectively. Emergence of the spring brood of adults in storages had begun, during those years, by April 6, April 25, April 14, and May 4. Since little or no other host material becomes available until the first part of June, when early plums, peaches, and figs begin to drop, it is evident that mulberries are important in the life of the raisin moth. Many large trees, chiefly useful for shade, are to be found in the San Joaquin Valley. One survey of about 3 square miles in Fresno County revealed the presence of 347 mulberry trees. Large quantities of fruit go to waste under these trees. Under a tree that covered an area 35 feet in diameter it was estimated that there were 550 pounds of dry mulberries. On the other hand, some trees bear little or no fruit. Table 4 records the populations estimated to be present under a tree in Tulare County from May 14 to August 2, 1940.

The presence of raisin moth larvae in bunches of grapes that were decayed and fermented—a condition sometimes called bunch rot—led to a suspicion that this insect was largely responsible for the trouble. This type of spoilage was studied in 1938, 1939, and 1940 by Kaloostian

TABLE 4.—*Estimated raisin moth populations under a mulberry tree, 1940*

| Date | Average per square foot | Total under tree |
|---|---|---|
| | *Number* | *Number* |
| May 14 | 21.0 | 59,367 |
| 24 | 200.0 | 590,843 |
| 31 | 136.0 | 384,472 |
| June 7 | 54.8 | 154,728 |
| 14 | 72.0 | 203,544 |
| 21 | 50.5 | 142,763 |
| 28 | 48.0 | 135,696 |
| July 5 | 61.0 | 172,447 |
| 12 | 44.5 | 125,801 |
| 18 | 23.0 | 65,021 |
| 26 | 6.0 | 16,962 |
| Aug. 2 | 1.5 | 4,240 |

*et al.* (*21*). Artificial infestation of bagged bunches showed that black mold and other micro-organisms grew readily on the pulp exposed by larval feeding. In 1939 larvae established themselves on all bunches that had been bagged and infested on and after June 30. Of about 5,000 clusters of grapes examined in 1940, 14 percent showed spoilage. Only 15 percent of the spoiled bunches showed evidence of raisin moth infestation. The evidence justified the conclusion that the leading cause of bunch rot was exposure of pulp by crushing and cracking of berries from causes incompletely understood, infestation by the raisin moth being usually of a secondary nature. However, the ability of *Ephestia figulilella* to maintain itself on growing grapes tends to increase the population of adults present when the grapes are being dried, and thus promotes attack on raisins.

The extent to which waste early plums contribute to the increase of the raisin moth was investigated in 1939 and 1940. Samples of the fallen fruit, both natural drops and pickers' culls, were collected. A maximum population of 204,000 per acre, not including larvae that were parasitized, was indicated on July 24, 1939. Because well-ripened dropped plums favorable for larval development were not abundant until the latter part of June, it was evident that plums were less important than mulberries as early-season hosts. Emergence of adults from the 1940 crop was prolonged and was still in progress from the early Beauty variety in August, although the crop was harvested from May 27 to June 1.

The supply of raisin moth adults capable of causing severe infestations in drying fruits is always plentiful because of the variety and abundance of waste fruits on farms. The infestation tends to increase as the fruit remains on stacked trays or in boxes on the farm, as indicated in table 5. Samples were taken (1) from trays that were about to be stacked for further drying, in the shade, of fruit that had been partially dried in the sun; (2) when the fruit was boxed, at the completion of drying in stacks; and (3) after storage on the farm premises in open-topped boxes, shortly before the fruit was delivered to the packer.

TABLE 5.—*Raisin moth infestation in apricots, peaches, and nectarines sampled after different periods of exposure*

| Fruit | Time of sampling | Samples | Fruit halves | Average infestation |
|---|---|---|---|---|
| | | *Number* | *Number* | *Percent* |
| Apricots | At stacking | 7 | 700 | 2 |
| | At boxing | 9 | 900 | 20 |
| | Before delivery | 9 | 900 | 50 |
| Nectarines | At stacking | 5 | 500 | 0 |
| | At boxing | 5 | 500 | 57 |
| | Before delivery | 4 | 400 | 80 |
| Peaches | At stacking | 13 | 1,300 | 3 |
| | At boxing | 13 | 1,300 | 53 |
| | Before delivery | 13 | 1,100 | 77 |

Examinations of fruit samples collected on farms have shown that most of the small larvae present in the fall are killed during the winter. In Muscat raisins examined on December 15, 1933, the larvae that were less than half grown totaled 55,900 per ton, or 89 percent of the infestation. By February 1, 1934, the number of these small larvae had declined to 7,500 per ton. Migration and mortality had likewise reduced the number of full-grown larvae during the same interval from 7,100 to 500 per ton.

## ABUNDANCE AND SEASONAL CHANGES

To determine the abundance of overwintering larvae in vineyards late in the winter and early in the spring, vines were stripped of bark with a mason's trowel, and larvae found were recorded. In addition, soil samples taken from measured areas against the trunks and along the rows of vines were examined by sifting them in the field with a treadle sifter (Donohoe *10*) or, if the soil was heavy, by bringing samples to the laboratory and washing out the insects in a soil washer. Table 6 shows the presence of rather low populations in seven vineyards surveyed in 1940.

TABLE 6.—*Estimated populations of overwintering raisin moth larvae in seven vineyards, January 4 to February 9, 1940*

| Vineyard | Larvae per acre | | Larvae in soil |
|---|---|---|---|
| | On trunks | In soil | |
| | *Number* | *Number* | *Percent* |
| 1 | 261 | 3,008 | 92 |
| 2 | 211 | 1,814 | 90 |
| 3 | 770 | 0 | 0 |
| 4 | 906 | 2,176 | 71 |
| 5 | 2,129 | 3,991 | 65 |
| 6 | 1,191 | 2,539 | 68 |
| 7 | 1,398 | 362 | 21 |

In a vineyard of the Zante variety of "currant" raisins, as many as 100,000 larvae per acre were found under the bark and in the soil on February 12, 1934. The earliest pupation under bark was observed in 1934, on March 22.

Larvae are found under bark as late as June, although in the spring the population is decimated both by overwintering and by parasitization. Examinations of vine trunks in 1932 showed the following numbers of living larvae and pupae per acre: [illegible],144 on March 4; 1,709 on April 4; 1,036 on April 19; 1,347 on May 11; 419 on May 25; and 207 on June 8.

The most favorable locations for overwintering raisin moth larvae on farms are vineyards and fig orchards, both of which produce late-maturing crops, in contrast with apricot and peach orchards. Sampling of the soil of fig orchards has revealed that the hibernating larvae are concentrated largely in 6-inch bands of soil around the trunks of the trees. In vineyards, also, larvae hibernate in the soil near the trunks as well as in the soil along the rows.

Liquid baits were used to obtain information about the spring emergence of adults, their relative abundance in various localities throughout the growing season, and the time they stop flying in the fall (Donohoe and Barnes *15*). The baits were exposed in 3-quart enamel saucepans 9 inches in diameter, supported among the foliage of vines or orchard trees. The bait was a fermenting solution containing one-fourth to one-half pint of malt sirup, a small amount of bread yeast, and 2 quarts of water per trap. As a rule the baits were renewed twice a week.

Flight of spring-brood adults was recorded in 1939 as early as April 7 and persisted until about November 15. In 1932 emergence was at its peak about May 20, and in 1934 about May 11. There was evidence of three overlapping broods and a partial fourth. In 1931, 1932, and 1933 the high points of moth abundance for the year were reached late in September or early in October.

Table 7 shows the catches of *Ephestia figulilella* and other storage moths taken on farms from 1931 to 1933. The dominance of the raisin moth is apparent.

TABLE 7.—*Relative abundance of raisin moths and other moths infesting stored foods, taken in malt-sirup baits on farms, 1931–1933*

| Species | Common name of insect | Total catch | Percentage of total | Percentage of females |
|---|---|---|---|---|
| *Ephestia figulilella* Greg. | Raisin moth | 53,480 | 96.80 | 44.5 |
| *Ephestia elutella* (Hbn.) | Tobacco moth | 248 | .45 | 68.1 |
| *Ephestia kühniella* Zell. | Mediterranean flour moth | 178 | .32 | 42.9 |
| *Ephestiodes nigrella* Hulst | | 447 | .81 | 80.1 |
| *Plodia interpunctella* (Hbn.) | Indian-meal moth | 433 | .78 | 55.6 |
| *Pyralis farinalis* (L.) | Meal snout moth | 457 | .83 | 33.9 |
| *Vitula serratilineella* Rag. | Dried-fruit moth | 6 | .01 | |
| All species | | 55,249 | 100.00 | |

A general idea of the numbers of adults present in fig-drying yards was obtained by counting the moths that rose from trays of fruit when the figs were disturbed. The counts were made in the evening, since the moths are inactive during the day. Some of the estimates are shown in table 8. Moths that were in the air at the time of the counts are not included.

TABLE 8.— *Raisin moth adults in Mission fig drying yards in the evening (estimates)*

ON 2½- BY 6-FOOT TRAYS

| Date | Spread trays in yard | Average moths per tray | Total moths in yard (calculated) |
|---|---|---|---|
| | *Number* | *Number* | *Number* |
| Sept. 15, 1932 | 651 | 5.17 | 3,366 |
| 21, 1932 | 216 | 7.70 | 1,664 |
| 8, 1933 [1] | 296 | 3.19 | 944 |
| ON 2- BY 3-FOOT TRAYS | | | |
| Sept. 13, 1933 | 586 | 3.84 | 2,251 |
| Aug. 14, 1934 | 676 | .50 | 338 |
| 22, 1934 | 760 | .47 | 357 |

[1] Collections on this date included moths from Adriatic figs.

Figure 5 summarizes information about the presence of the various host materials of the raisin moth throughout the year and gives some facts concerning its status in fall, winter, and spring. Breeding is continuous from April, when mulberries begin to fall, through November. Low temperatures and rains generally halt development late in November. The larvae are dormant or feebly active from December through March, during which time adults and eggs are absent out of doors. Pupation begins in March or early in April.

## THE RAISIN MOTH IN STORAGES

### FALL MIGRATION, OVERWINTERING, EMERGENCE

Concentrations of dried fruits in commercial storages late in the fall after harvest offer good opportunities for the study of certain habits of the raisin moth. Raisins are especially useful for this purpose, because they are usually stacked out of doors in the boxes in which they are received from growers. As a rule the stacks are built on timbers laid on the ground, and there is a roof but little or no protection at the sides or ends.

Evidence of migration of full-grown larvae from the fruit to winter quarters consists of deposits of silk webbing on the sides of the stacks and on the adjacent soil of actively crawling larvae, and of larvae killed or paralyzed by parasites. Larvae that have reached winter

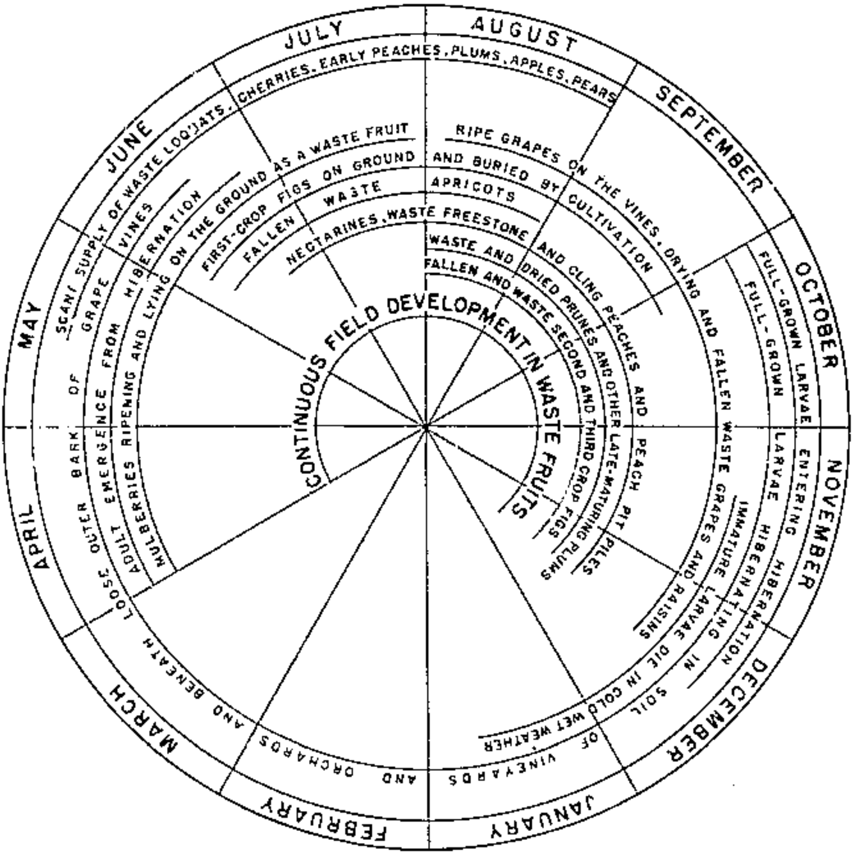


FIGURE 5.—Chart of host materials and seasonal status of the raisin moth throughout the year.

quarters may be found in the top 4 inches of soil beside or beneath the stacks, under foundation timbers, loose boards, paper, or stones, and in similar places. Those that enter the soil or crawl beneath timbers construct rather substantial cocoons; in certain other locations, as in the folds of paper, they weave a light protection of silk. A few pass the winter in the boxes, usually against the sides or bottom.

In the fall of 1934 the peak of migration was reached on October 27. Movement of larvae from the boxes then declined until it came practically to an end by December 7.

Mortality of full-grown larvae during the winter depends largely on the location chosen by the insects. This is indicated in table 9. Only 13 percent of the larvae in a dry location were found to be dead on March 19, 1936, whereas 100 percent of those taken from a wet area were dead.

Small larvae of *Ephestia figulilella* that are present in raisins in storage stacks at the beginning of cold weather become much depleted in numbers during the winter. A record made from samples of raisins

TABLE 9.—*Weekly record of winter mortality of raisin moth larvae in an outdoor raisin storage, 1936*

| Date | In moderately dry soil | | In wet soil | | In dry webbing beneath timbers | |
|---|---|---|---|---|---|---|
| | Larvae | Mortality | Larvae | Mortality | Larvae | Mortality |
| | *Number* | *Percent* | *Number* | *Percent* | *Number* | *Percent* |
| Feb. 13 | 120 | 22 | 57 | 40 | 580 | 19 |
| 20 | 80 | 27 | 41 | 58 | 639 | 16 |
| 27 | 125 | 22 | 45 | 73 | 508 | 24 |
| Mar. 5 | 72 | 32 | 35 | 91 | 395 | 17 |
| 12 | 59 | 61 | 10 | 100 | 436 | 17 |
| 19 | 54 | 81 | 26 | 100 | 572 | 13 |
| 26 | 61 | 74 | 26 | 96 | [1] 367 | 30 |

[1] Includes 12 pupae, 11 well advanced in development.

collected on March 18, 1935, indicated a population of 1,576 small larvae (less than half grown) per ton, only 30 percent of which were alive.

Migration of full-grown larvae in search of pupation quarters is resumed with the return of warm days in the spring. This movement is comparatively light.

Pupation and emergence of adults in storage premises in the spring no doubt are influenced by weather and by the location in which the larvae passed the winter. In the spring of 1935 records were made, in the laboratory, of emergence from cocoons removed from a raisin-storage shed on May 9. Adults began to appear by May 16 but, as shown in table 10, emergence was not at an end until July 24. About 80 percent emerged during the first 12 days of June. The percentage of females was about 47.

The moths that develop from overwintered larvae are able to reinfest raisins to a limited extent only. Populations of larvae in the fruit decline to low levels during the summer after the year of produc-

TABLE 10.—*Emergence of raisin moths from overwintered cocoons, 1935*

| Date | Moths emerging | Date | Moths emerging | Date | Moths emerging | Date | Moths emerging |
|---|---|---|---|---|---|---|---|
| | *Number* | | *Number* | | *Number* | | *Number* |
| May 15 | 0 | May 28 | 22 | June 10 | 42 | July 3 | 2 |
| 16 | 2 | 29 | 9 | 11 | 10 | 5 | 2 |
| 17 | 1 | June 3 | 70 | 12 | 11 | 8 | 1 |
| 18 | 0 | 4 | 40 | 13 | 3 | 13 | 1 |
| 20 | 10 | 5 | 47 | 14 | 2 | 18 | 0 |
| 23 | 15 | 7 | 142 | 15 | 3 | 22 | 1 |
| 24 | 4 | 8 | 49 | July 1 | 15 | 24 | 1 |

tion, the raisin moth being replaced as the dominant species by the saw-toothed grain beetle (*Oryzaephilus surinamensis* (L.)) (Simmons *et al.* *32*). Figs and prunes sometimes retain infestations longer than do raisins, but the trend in these fruits also is toward lower populations. Apricots, peaches, nectarines, and pears rarely are found infested by the raisin moth during the summer after harvest.

## Flight Habits

Information about the flight habits of the raisin moth was obtained by means of a rotary net (Barnes *et al.* *4, 5*) operated in a raisin storage from April 14 to October 31, 1938. Except for a few days, the apparatus was in service day and night during the 6½ months. As a rule the catches were taken from the net each morning, but five series of short-interval collections were made at night, the insects being removed every 15 minutes. The net was run in a 12-foot circle at a speed of 50 revolutions per minute, at an elevation of about 3 feet.

During the season raisin moths comprised 79 percent of the small moths recorded. They reached a seasonal peak of abundance between May 31 and June 8, when the nightly catches averaged 4,500. On nights when temperatures were favorable, flight began about one-half hour after sunset. The males were active throughout the night, but the flight of the females was concentrated largely in the first few hours of darkness. The moths did not fly at temperatures below 55° F. and flight was much restricted between 55° and 60°.

Table 11 shows the season's catch of the raisin moth and other small moths that infest stored foods.

Table 11.—*Numbers of raisin moths and other moths responsible for infestation of stored foods, taken in a rotary net in a raisin-storage yard in 1938*

| Month | *Ephestia figulilella* | *Ephestia elutella* | *Ephestia kühniella* | *Ephestiodes nigrella* | *Plodia interpunctella* | Miscellaneous | Total moths |
|---|---|---|---|---|---|---|---|
| April 14–30 | 457 | 0 | 6 | 633 | 41 | 80 | 1,217 |
| May | 42,122 | 147 | 76 | 6,473 | 3,039 | 684 | 52,541 |
| June | 96,481 | 148 | 10 | 2,850 | 3,043 | 554 | 103,086 |
| July | 48,861 | 1,611 | 0 | 1,569 | 11,055 | 170 | 63,266 |
| August | 29,276 | 1,273 | 0 | 454 | 11,247 | 124 | 42,374 |
| September | 14,095 | 843 | 0 | 257 | 11,690 | 63 | 26,948 |
| October | 15,552 | 293 | 0 | 69 | 7,215 | 39 | 23,168 |
| Totals | 246,844 | 4,315 | 92 | 12,305 | 47,330 | 1,714 | 312,600 |

In addition to the moths listed in table 11, substantial populations of beetles commonly found infesting food materials in storage were taken from the air by the net during the same period, as follows: The foreign grain beetle (*Ahasverus advena* (Walt)), 20,053; silken fungus beetles (*Cryptophagus* sp.), 9,470; hairy fungus beetle (*Typhaea stercorea* (L.)), 39,427; *Laemophloeus* sp., 9,749; dried-fruit beetle

(*Carpophilus hemipterus* (L.)), 158,675; miscellaneous nitidulid beetles, 6,472; dermestid beetles, 125,929; saw-toothed grain beetle, 180; red flour beetle (*Tribolium castaneum* (Hbst.)), 3,461.

A further discussion of the beetles found associated with the raisin moth has been published by Donohoe (*14*).

## PARASITES AND PREDATORS

Infestation by the raisin moth in the San Joaquin Valley of California increased rapidly after it was first recognized in 1928. By 1930 the insect had reached its greatest abundance, and since that year, when the swarming larvae invaded office papers, time clocks, and light sockets in storage plants, the population has tended toward stabilization at considerably lower levels. Although the species may have experienced a burst of reproductive energy in 1930 and the years immediately thereafter, a more probable explanation has to do with its parasite relationships. Conceivably its insect enemies, mostly wasp-like parasites, required several years in which to establish a measure of control. Of these enemies the leading one is the braconid *Microbracon hebetor* (Say). Secondary in importance are the ichneumonids *Idechthis canescens* (Grav.) and *Mesostenus gracilis* Cress. All three attack only well-grown larvae, and as a rule their victims have completed their feeding.

*Microbracon hebetor* passes the winter chiefly in the adult stage. The species is quiescent in cold weather, but on warm days it is active, stinging and paralyzing raisin moth larvae. However, egg laying on paralyzed hosts does not begin until spring.

Host larvae in cocoons under grapevine bark are attacked in considerable numbers by the parasite. It is less able to reach larvae that are spun up in the surface layers of soil. Under bark, parasitization has been observed as early as April 19.

In storages full-grown larvae that leave the fruit in search of pupation quarters in the spring are parasitized in considerable numbers. Such larvae may be seen limply hanging from the sides of fruit boxes, often with *Microbracon hebetor* larvae feeding externally upon them. Large numbers of the parasites are noted flying about dried fruits in storage in the fall, when the parasites and their hosts from large areas of countryside are concentrated in a few locations.

In laboratory rearings (Morrill *26*) the average number of eggs laid by the female *Microbracon* parasites was about 90; the number deposited beneath or beside each host was about 5. The larvae fed for about 6 days, then cocooned and pupated near the shriveled host. In summer the developmental period from egg to adult was only 10 or 12 days.

*Idechthis canescens* and *Mesostenus gracilis*, both internal parasites, have been reared from larvae of the raisin moth removed from soil and from vine bark in January and February, an indication that eggs of the parasites had been deposited in the hosts the preceding fall. The latter species is not common, but *I. canescens* sometimes occurs in moderate numbers in the field and in storages. In July 1940 raisin moth larvae in samples of waste plums collected on July 5, 12, 19, 26, and 30 were parasitized by *I. canescens* to the extent of 1, 16, 11, 10, and 19 percent. On the same dates *Microbracon hebetor* was attacking 26, 26, 0, 22, and 0 percent of the raisin moth larvae in the samples.

According to records obtained from laboratory rearings, *Idechthis canescens* requires, at about 82° F., approximately 23 days for development from egg to adult.

Catches of *Ephestia figulilella*, some of its parasites, and other moths that infest stored foods, made in malt-sirup traps in vineyards are recorded in table 12. Captures of *Microbracon* were not recorded. Catches of *Desmia funeralis* (Hbn.), the grape leaf folder, the larvae of which sometimes attack clusters of grapes, are also shown in the table.

TABLE 12.—*Numbers of moths that infest stored foods, adults of the grape leaf folder, and parasites of moth larvae taken in malt-sirup traps in seven vineyards, 1939*

| Month | *Ephestia figulilella* | *Ephestia elutella* | *Plodia interpunctella* | *Ephestiodes nigrella* | *Desmia funeralis* | *Idechthis canescens* | *Mesostenus gracilis* |
|---|---|---|---|---|---|---|---|
| April | 514 | 3 | 4 | 44 | 1, 195 | 173 | 0 |
| May | 3, 928 | 53 | 3 | 132 | 927 | 1, 400 | 1 |
| June | 2, 548 | 12 | 2 | 240 | 616 | 147 | 7 |
| July | 2, 075 | 1 | 1 | 608 | 249 | 6 | 0 |
| August | 860 | 0 | 7 | 27 | 2, 577 | 3 | 0 |
| September | 1, 824 | 0 | 5 | 87 | 236 | 42 | 0 |
| October | 1, 333 | 0 | 0 | 46 | 13 | 41 | 1 |
| November 1-14 | 80 | 0 | 0 | 4 | 0 | 28 | 0 |
| Total | 13, 162 | 69 | 22 | 1, 188 | 5, 813 | 1, 840 | 9 |

Raisin moth larvae and adults are taken as live prey by a number of predators, but the aggregate reduction of the population is difficult to estimate. In certain raisin storages the ant *Formica fusca argentea* Whlr. occurs in great abundance and has been observed carrying living larvae. Of the carabid beetles found in the same locations, the most common appears to be *Plochionus pallens* (F.), a species that has consumed raisin moth larvae in the laboratory. Ant lion larvae and crickets of the genus *Stenopelmatus* likewise occur in raisin storages and have fed upon larvae of *Ephestia figulilella* in the laboratory. The black widow spider (*Latrodectus mactans* (F.)) feeds readily on full-grown larvae, and this spider has been found to occur commonly in vineyards (Donohoe *13*). On farms poultry consume large numbers of migrating raisin moth larvae, especially when boxed raisins are piled in the farm yard.

## SUMMARY

The insect described by Gregson in 1871 as *Ephestia figulilella* first became an important pest of raisins in California in 1928. Because of its widespread occurrence in raisins, the name "raisin moth" was applied to it. The larvae are also general feeders on drying, dried, and decaying fruits, including ripe grapes, raisins, figs on the ground, fallen peaches, apricots, nectarines, prunes, plums, and dates. They have also been found in cottonseed cake, cacao beans, cashew kernels, and other materials.

In the central San Joaquin Valley, where the insect is most plentiful, mulberries are the earliest host foods, and these waste fruits enable the raisin moth to survive a period of food scarcity.

Some records of the raisin moth occurring at scattered places throughout the world refer to infested materials that were imported; others are of infestations established in storages. In California and Arizona, and probably in Egypt and Australia, however, the species maintains itself out of doors throughout the year.

Pairs of raisin moths provided with water and kept under observation at room temperature during the summer produced an average of 351 eggs, of which 75 percent hatched. The males lived for an average of 11 days and the females for 16 days.

Eggs held in an incubator at about 83° F. hatched in 3 to 6 days. At the same temperature the larvae reached full growth in an average of 32 days. The prepupal period lasted about 1 day and the pupal stage about 10 days. Development from egg to adult averaged 43 days.

After attaining full size the larvae usually crawl away from their food and spin a cocoon in which to pupate. Most of them enter the soil, but many seek crevices under the rough bark of grapevines.

Winter is passed as larvae. Those that survive transform to pupae in the spring. Adults begin to emerge in April and they reach a spring peak of abundance in May.

Where large quantities of new-crop fruit are brought together, as in raisin-storage yards, larvae that began growth where the fruit was produced continue to develop. As they attain full size they migrate away from the host materials. Under such conditions large numbers of larvae that have completed their damage to the fruit appear late in October or early in November. The adults that emerge the following spring are of no great importance in storages, because the species is not very successful in reinfesting dry, stored fruit during the summer following harvest.

The moths begin flight on warm nights about one-half hour after sunset and continue until sunrise. Flight and egg laying of the females is concentrated largely in the first few hours of darkness.

Of the three parasites of raisin moth larvae—*Microbracon hebetor* (Say), *Idechthis canescens* (Grav.), and *Mesostenus gracilis* Cress.—only the first is abundant. Since it ordinarily attacks only larvae that have completed their feeding, it is in that respect ineffective.

## LITERATURE CITED

(1) ALPHÉRAKY, S.
1883 NOTES LÉPIDOPTÉROLOGIQUES. Rev. Mens. Ent. Pure Appl. 1: 15-20. [From Richards and Thompson (37).]

(2) ATMORE, E. A.
1884 IMPORTATION OF EPHESTIA PASSULELLA AND E. FICULELLA AT KING'S LYNN. Ent. Mo. Mag. 20: 258-259.

(3) AUSTRALIAN COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH.
1937 Austral. Council Sci. and Indus. Res. Rpt. 11 (1936-37): 15-21.

(4) Barnes, D. F., Fisher, C. K., and Kaloostian, G. H.
1939. flight habits of the raisin moth and other insects as indicated by the use of a rotary net. Jour. Econ. Ent. 32: 859-863, illus.

(5) ——— and Kaloostian, G. H.
1940. flight habits and seasonal abundance of dried-fruit insects. Jour. Econ. Ent. 33: 115-119, illus.

(6) Barrett, C. G.
1875. on the species of ephestia occurring in britain. Ent. Mo. Mag. 11: 269-273.

(7) ———
1905. lepidoptera of the british islands. v. 10, Pyralidina, Tortricina, 381 pp., illus. London.

(8) Chittenden, F. H.
1897. some little-known insects affecting stored vegetable products. U. S. Dept. Agr. Bul. 8 (n. s.) 45 pp., illus.

(9) Curran, C. H.
1926. the identification and control of adult lepidopterous insects attacking stored products. [Canada] Sci. Agr. 6: 383-388, illus.

(10) Donohoe, H. C.
1934. a treadle sifter for examination of soil in studies of insects. U. S. Bur. Ent. and Plant Quar. ET-1, 3 pp., illus. [Processed.]

(11) ———
1934. a laboratory device for supplying liquids to adult insects. U. S. Bur. Ent. and Plant Quar. ET-34, 1 p. [Processed.]

(12) ———
1935. a covered sifter for separating insects from host material. U. S. Bur. Ent. and Plant Quar. ET-53, 1 p. [Processed.]

(13) ———
1937. notes on the black widow spider in the san joaquin valley. Jour. Parasitol. 23: 424.

(14) ———
1939. notes on coleoptera found in raisin storages. Ent. Soc. Wash. Proc. 41: 154-162.

(15) ——— and Barnes, D. F.
1934. notes on field trapping of lepidoptera attacking dried fruits. Jour. Econ. Ent. 27: 1067-1072.

(16) ——— and Barnes, D. F.
1934. notes on host materials of ephestia figulilella gregson. Jour. Econ. Ent. 27: 1075-1077.

(17) ——— Simmons, Perez, Barnes, D. F., and Fisher, C. K.
1937. the importance of mulberries in raisin moth control. Calif. Dept. Agr. Bul. 26: 339-340.

(18) Forbes, W. T. M.
1923. the lepidoptera of new york and neighboring states. N. Y. (Cornell) Agr. Expt. Sta. Mem. 68, 729 pp., illus.

(19) Gregory, F. W., and Featherstone, R. V.
1945. hot water treatment, under field conditions, of peach pits infested with raisin moth. Ent. Soc. Ontario, Ann. Rpt. 75: 31-35. [From Rev. Appl. Ent., Ser. A, 35: 13.]

(20) Gregson, C. S.
1871. description of an ephestia new to science. Entomologist 5: 385.

(21) Kaloostian, G. H., Barnes, D. F., Fisher, C. K., and Simmons, Perez.
1941. the raisin moth on grapes. U. S. Bur. Ent. and Plant Quar. E-527, 4 pp. [Processed.]

(22) Knapp, A. W.
1921. insect pests in the cacao store. [Gt. Brit.] Imp. Inst. Bul. 19: 189-200, illus.

(23) Mackie, D. B.
1932 ephestia figulilella greg. a storage pest taken feeding upon fresh grapes. Calif. Dept. Agr. Monthly Bul. 21: 314-315, illus.

(24) Meyrick, E.
1887. On Pyralidina from Australia and the South Pacific. Ent. Soc. London, Trans. 1887: 185-268.
(25) ———
1888. On the Pyralidina of the Hawaiian Islands. Ent. Soc. London, Trans. 1888: 209-246.
(26) Morrill, A. W., Jr.
1942. Notes on the biology of Microbracon hebetor. (Sci. Note) Jour. Econ. Ent. 35: 593, 594.
(27) Ragonot, E. L., and Hampson, G. F.
1901. Monographie des Phycitinae et des Galleriinae. II. Mém. sur Lépidoptères, t. 8, 602 pp., illus.
(28) Richards, O. W., and Thomson, W. S.
1932. A contribution to the study of the genera Ephestia, Gn. (including Strymax, Dyar), and Plodia, Gn. (Lepidoptera, Phycitidae), with notes on parasites of the larvae. Ent. Soc. London, Trans. 80: 169-250, illus.
(29) Riley, C. V.
1893. Insect life. (U. S. Dept. Agr. Div. Ent.) v. 5, p. 350.
(30) Schaffnit, E.
1907. Das Auftreten der Ephestia figulilella im Reisfuttermehl. Landw. Vers. Stat. 65: 457-462.
(31) Shafik, M.
1938. Constant temperature hot air sterilizer for the control of Ephestia and Myelois on dates. Bul. Soc. Fouad 1er d'Ent. Année 31, v. 22: 233-264. Cairo.
(32) Simmons, Perez, and Donohoe, Heber C.
1938. Changes in the insect population of stored raisins. U. S. Bur. Ent. and Plant Quar. E-437, 3 pp., illus. [Processed.]
(33) ——— and Reed, W. D.
1929. An outbreak of the fig moth in California. Jour. Econ. Ent. 22: 595-596.
(34) ——— Reed, W. D., and McGregor, E. A.
1931. Fig insects in California. U. S. Dept. Agr. Cir. 157, 71 pp., illus.
(35) Turati, E.
1926. Novità di lepidotterologia in Cirenaica. Soc. Ital. di Sci. Nat. Atti. 65: 25-83, illus.
(36) ———
1927. Novità di lepidotterologia in Cirenaica. Soc. Ital. di Sci. Nat. Atti. 66: 313-344, illus.
(37) Zacher, F.
1931. Interessante Fälle aus der Praxis der Vorratsschutzes. Gesell. f. Vorratsschutz E. V. Mitt. 7: 5-8.
(38) Zeller, P. C.
1876. Beiträge zur Kenntnis der nordamerikanischen Nachtfalter, besonders der Mikrolepidopteren. Zool.-Bot. Gesell. Wien. Verhandl. 25: 206-360, illus.

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