crimson, or Persian clovers, and weeds are available. Thus, there is an almost constant movement from host to host and it is difficult to say when a population has reached a peak or low ebb.

Likewise, one never knows the age of the specimens he sees and cannot tell whether they are destined to die the next day or if they have recently emerged and are destined to live on for 30, 60, or 90 days. Then, too, in the winter-survival area and in the border areas to the north, while an exclusively or even predominantly female population constitutes strong evidence the specimens are migrants, one can rarely say with certainty whence or how far away they have migrated.

On the basis of all that has been said so far, one would anticipate that potato leafhoppers would breed continuously in southern Florida and southern Texas. The fact is, despite rather voluminous early literature to the contrary, not a single specimen of the potato leafhopper has been identified from a point south of Orlando, Florida, even though preferred hosts have been swept extensively at all seasons in at least 9 of the past 12 years. Also, almost every species known to occur in southern Florida and some that were new records were identified from light-trap collections, but not a single specimen of potato leafhopper was found.

A similar situation exists in Texas. The species is present in the eastern one-third of the State but the population density diminishes rapidly southward from Houston to Brownsville. Many collections made in the Brownsville area on favored hosts indicate that the species comprises less than 1% of the *Empoasca* fauna of the area, and numerous collections from Mexico and Central America demonstrate that the potato leafhopper does not occur there or in the Caribbean Islands or South America (Ross 1959, Ross et al. 1965).

The reason the potato leafhopper is not found in southern Florida and Texas is not clear, but it should be noted that the optimum temperature for oviposition is about 75°F (Kieckhefer and Medler 1964) and that populations in the Midwest seem to be depressed during the hot months of July and August; thus high summer temperatures may be an important factor. One should note also that potato leafhoppers drop out of the picture west of the 100th meridian where the rainfall for the 3 summer months is 6–8 in., the same as that recorded in southern Florida and southern Texas during the 3 winter months (Kincer 1941).

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# Development of the Salt-Marsh Caterpillar Parasite, *Exorista mella*[1] at Controlled Constant and Variable Temperatures in the Laboratory[2]

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## ABSTRACT

The rate of development of *Exorista mella* (Walker) was determined in larvae of the salt-marsh caterpillar, *Estigmene acrea* (Drury), reared on a semisynthetic diet. The egg stage required 100 hr at 68°F to 52 hr at 86°F. The egg and larval stages together required 28.1 days at 59°F to 7.9 days at 86°F. The pupal stage was approximately of the same duration as that of the egg and larval periods and required 27.4 days at 59°F to 7.8 days at 86°F. Thirty-nine percent of the parasite larvae emerged from host larvae, 20% from prepupae, 26% from pupae, and 15% remained within the host larvae. Fifty-nine percent of the parasitized host larvae had 1 larva, 23% had 2, 10% had 3, 6% had 4, and 2% had 5–7.

*Exorista mella* (Walker) is widely distributed throughout the United States and Canada. It has been collected across the southern half of Arizona in agricultural as well as mountain areas from April to November. *E. mella* parasitizes principally caterpillars of the families Arctiidae, Noctuidae, Notodontidae, Lymantriidae, and Lasiocampidae. Simpson[5] (1957) listed 41 species of hosts. Taylor (1954) observed flies parasitizing salt-marsh caterpillars, *Estigmene acrea* (Drury), and described the egg laying. He found that some individual host larvae received as

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[5] R. W. Simpson. 1957. The distribution and biology of Arizona tachinid flies. University of Arizona M.S. thesis.

**Table 1.—Duration of the egg stage of *E. mella* at different constant temperatures.**

| Temp. °F | No. individuals | Duration in hours: Mean ± SD | Duration in hours: Range |
|---|---|---|---|
| 68 | 71 | 100.4 ± 7.0 | 88 - 116 |
| 77 | 37 | 62.5 ± 2.9 | 48 - 72 |
| 81 | 34 | 53.2 ± 2.7 | 48 - 72 |
| 86 | 42 | 52.1 ± 3.2 | 48 - 64 |

many as 20–25 eggs. In the field, the female preferred to attack the larger larvae. Females were noted ovipositing on larvae migrating across plowed ground and trapped along barriers, as well as on those feeding upon plants. The present paper discusses the development of this parasite in the salt-marsh caterpillar at constant and variable temperatures in the laboratory.

METHODS.—Flies were collected October 9, 1965, from a cottonfield in Coolidge, Ariz., with a flight trap modified for use in crop areas by Butler (1966). Four traps collected 51 flies between 10 and 11 AM. These and other adults collected in the field were placed in 1-ft$^3$ screen cages and brought to the laboratory. Late-instar salt-marsh caterpillars were introduced into the cages and the flies readily oviposited on the larvae. Larvae bearing eggs were placed in individual plastic cups with a lima bean-agar medium (Shorey 1963) and held in temperature cabinets. The larvae were observed daily and the dates recorded when the prepupa or pupa formed, when parasite larvae emerged, and when adult flies appeared. To determine the duration of the egg stage, caterpillars were held in a cage with the flies for 4 hr. The *E. mella* eggs were then removed from the larvae and placed in depressions in a layer of beeswax in the bottom of small petri dishes. The dishes were held in constant-temperature cabinets and the eggs were observed for hatching at 4-hr intervals.

Temperature-controlled cabinets were used and the lights were on for a 15-hr period each day starting at 6 AM. Five cabinets were held at constant temperatures and 3 were programmed to maintain temperatures of 50, 59, and 68 ± 2.5°F from 6 PM to 6 AM and then each temperature was raised 27°F for the next 12-hr period to simulate a diurnal temperature fluctuation. Relative humidity was maintained at approximately 50%.

RESULTS.—The duration of the egg stage was determined for 184 eggs held at 4 constant temperatures (Table 1). The mean duration varied from 100 hr at 68° to 52 hr at 86°F, or slightly more than from 4 to 2 days at these temperatures. The regression equation for the duration of the egg stage at temperatures between 68 and 86°F is $\hat{y} = -0.0263 + 0.00054\ X$, where $\hat{y}$ is the reciprocal of the duration of the stage in hours and X is the temperature.

The duration of the combined egg and larval stages for 816 larvae at 8 different temperatures is given in Table 2. The average time required at 59°F was 28.1 days and at 86°F it was 7.9 days. The regression equation for the egg and larval stage is $\hat{y} = -0.1372 + 0.0030\ X$, where $\hat{y}$ is the reciprocal of the time in days and X is the temperature.

The duration of the pupal stage for 685 pupae at 8 different temperatures is given in Table 2. At 59° this stage required 27.4 days and at 86°F it required 7.8 days, which is approximately equal in duration to that of the larval stage. The regression equation for the pupal stage is $\hat{y} = -0.1406 + 0.0031\ X$, where $\hat{y}$ is the reciprocal of the time in days and X is the temperature.

Approximately 15% of the larvae remained within the body of the caterpillars and duration of the individual stages could not be determined. The time from the egg to the adult stage for 782 emerged specimens varied from 55.5 days at 59°F to 16.1 days at 86°F. The regression equation for this period, which may be useful in mass-rearing programs, is $\hat{y} = -0.0688 + 0.0015\ X$, where $\hat{y}$ is the reciprocal of the time in days from the egg stage to the adult fly and X is the temperature.

Of the fly larvae, 39% emerged from host caterpillars, 20% from prepupae, 26% from pupae, and 15% remained within the host larvae. One larva emerged from 59% of 567 parasitized caterpillars, 2 from 23%, 3 from 10%, 4 from 6%, and 5–7 from 2%.

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**Table 2.—Duration in days of the combined egg and larval stages and the pupal stage of *E. mella* in salt-marsh caterpillar larvae at different temperatures.**

| Temp (°F) | Egg and larval stage: No. individ. | Egg and larval stage: Mean ± SD | Egg and larval stage: Range | Pupal stage: No. individ. | Pupal stage: Mean ± SD | Pupal stage: Range |
|---|---|---|---|---|---|---|
| 59.0 constant | 42 | 28.1±3.6 | 24–38 | 32 | 27.4±2.3 | 23–31 |
| 63.5 (50–77) | 121 | 17.9±3.2 | 12–28 | 99 | 15.3±1.2 | 10–18 |
| 68.0 constant | 133 | 16.5±6.0 | 10–29 | 122 | 15.0±1.3 | 10–22 |
| 72.5 (59–86) | 125 | 12.6±3.1 | 8–23 | 96 | 10.5±1.2 | 8–13 |
| 77.0 constant | 131 | 10.2±1.9 | 7–16 | 117 | 10.2±0.8 | 7–12 |
| 81.0 constant | 67 | 9.7±2.6 | 5–18 | 59 | 9.3±1.2 | 6–13 |
| 81.5 (68–95) | 91 | 11.0±3.8 | 7–25 | 61 | 8.8±0.7 | 8–10 |
| 86.0 constant | 106 | 7.9±1.8 | 5–14 | 89 | 7.8±0.8 | 6–10 |