

April 1944

E-616

UNITED STATES DEPARTMENT OF AGRICULTURE
Agricultural Research Administration
Bureau of Entomology and Plant Quarantine

NOTES ON THE LIFE HISTORY AND OTHER FACTORS AFFECTING
CONTROL OF THE GRAPE LEAF FOLDER

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1/ Acknowledgement is made to the following associates for assistance in making and recording observations: Charles K. Fisher of the Dried Fruit Insect Laboratory; George H. Kaloostian, Oscar G. Bacon, Dennis F. Hallowell Jr., and Charles H. Quibell, formerly connected with the Laboratory; and Eugene M. Stafford of the University of California.

INTRODUCTION

The grape leaf folder (Desmia funeralis (Hbn.)), one of the secondary grape pests of the country, frequently causes damage in the California grape-growing areas, particularly in the San Joaquin Valley. An infested area in Fresno County, varying in size from year to year, has persisted for more than 10 years. A survey made in the fall of 1943 showed that there was an area of about 150 square miles in which spots of heavy damage might be expected in 1944.

Severe infestation causes defoliation which exposes the fruit to the direct heat of the sun and reduces vine efficiency. Break-down of the fruit follows entrance of mold and souring organisms through feeding wounds made by the larvae on the ripening fruit.

The accepted methods of control are spraying with lead arsenate and dusting with arsenical or cryolite dusts, but knowledge of the best time to make applications is indefinite. Treatments applied too late in the development of a brood to be fully effective have been common, and instances are known where, in a mistaken effort to save late-maturing fruit, applications of insecticides were made after the feeding for the season had been completed. Life-history studies at the laboratory and field biology studies have been carried on at the Dried Fruit Insect Laboratory, Fresno, Calif., to improve the basis for determining the correct time for treatment.

LIFE HISTORY AND HABITS

The life history of the moth consists of four stages—egg, larva, pupa, and adult. Information on the habits of the larval, or feeding, stage and the adult, or egg-laying, stage is the basis for understanding when treatments can be applied to the best advantage.

The moths begin to fly at the end of evening twilight each day, and, on warm nights at least, flight continues all night. During the day the moths rest in protected places in and around the vineyards. A few, which have been disturbed while resting, may be seen in flight during daylight.

There are normally three clear-cut broods of the grape leaf folder each season in the San Joaquin Valley, shown in the accompanying graphic records (fig. 1) for 4 years of trapping with malt-sirup traps. A very small partial fourth brood occurs, but it develops so late that food is not available for the offspring. Two instances of hibernation of second-brood pupae have been observed. Winter is

passed in leaf envelopes in leaf debris on the ground in the vineyards. In the spring, emergence of first-brood adults begins after vine growth starts and continues until blossoming is well advanced. Trapping with malt-sirup traps has shown that the average first-brood flight period is 53 days, from about April 2 to May 24.

The females of the first brood lay their small, flat, iridescent eggs on the more mature leaves and on the surface of water sprouts, or "suckers", on parts of the vines protected from cool winds. On varieties trained on wires, as the Zante (Corinthe Noir) or Ribier (Alphonse Lavallee), most of the first-brood eggs are found in the heaviest foliage and usually on the south side. On varieties not trained on wires, as the Muscat (Muscat of Alexandria), most of the eggs are found low on the southeast side, where the females have been sheltered from the prevailing winds. Pubescent (downy or hairy) surfaces are avoided by the females when depositing their eggs, and the eggs are found on the upper surface when the lower one is pubescent, or on either surface when pubescence is sparse. Although they may be scattered anywhere on a leaf surface, a high percentage are placed in the angles between the veins and the surface. Eggs are also concentrated on the water sprouts, or "suckers", which start from the vine trunks. A heavy egg deposit has never been observed on young vines or vines without dense foliage to give protection from the wind.

During April and May eggs hatch in from 10 to 17 days, the time decreasing as the season advances. The larval stage occupies 3 to 4 weeks and the pupal stage 10 days to 2 weeks. The entire development, from egg to adult, requires from 6 1/2 to 7 1/2 weeks.

The young larvae feed in groups, eating the surface of leaves which they have webbed together. Easily recognized areas where the leaf surface has been removed between the webbed-together leaves are found following this type of feeding. After about 2 weeks of group feeding, the larvae separate and feed by eating the free edges of leaves inside of pencil-sized rolls which they make at the leaf margins. At least two rolls are made and occupied before the larvae are full-grown. Full-grown larvae usually leave the rolls and make leaf envelopes in which to pupate and transform to adults. The envelopes are small sections of leaves partially cut away, folded, and tightly webbed together from within. Some of the larvae neglect to make envelopes but pupate within the feeding rolls.

Adults of the second brood emerge from mid-June to mid-July. The average flight period is 29 days, from about June 17 to July 15. The eggs laid by this brood are deposited almost exclusively on leaves rolled by the first brood of larvae. Hatching occurs after 4 or 5 days, larvae are full-grown in 2 to 3 weeks, and the pupal period lasts 7 to 11 days. The entire development, from laying of the eggs to emergence

of the adults, requires 4 to 5 weeks. The young larvae of the second brood, as do those of the first brood, feed in groups, but many enter old rolls instead of feeding between webbed leaves. Utilization of the rolled leaves for egg laying and of old rolls for feeding brings about a concentration of the second brood of larvae in the part of the vine occupied by the first brood. Dispersion upward and outward on the vine occurs when new rolls are made. By the time the brood is complete the rolls may be scattered over the foliage of the vine.

Third-brood adults emerge from early in August to early in September. The average flight period is 34 days, from about August 3 to September 5. This brood also utilizes the leaves rolled by previous broods for egg laying and feeding. Dispersion and foliage damage by this brood spread over the vine from the points reached by the second brood.

Eggs laid by the third brood of moths hatch in 4 or 5 days, and larvae are full-grown in 3 to 5 weeks after hatching. Only a few adults emerge in the fall, consequently most of the brood spends between 6 and 8 months as overwintering pupae. Although the partially-cut-away pupal leaf envelopes made by larvae of the first two broods remain attached to the leaves on the vines, those of the third brood break from the dried leaves and are found with their enclosed pupae scattered among the leaf debris on the ground. Not all third-brood larvae pupate on the foliage, for in heavy infestations some larvae leave the foliage or fruit on which they have developed and overwintering pupae may be found under the loose bark of the vine trunks.

The behavior of the females in seeking protection in the spring influences not only the location of the infestation on individual vines but to some extent in the vineyard. It is noticeable that, early in the season at least, infestation is heavy near weedy ditch banks, shrubbery, citrus trees, and other protected sites which the adults occupy while resting during the daylight hours.

The larvae pass through 5 instars, or stadia, before pupation, molting or shedding their skin at the end of each stadium. No characteristic marks for field identification appear on the first two instars. On the third a small black spot appears on each side of the body above the second pair of legs, on the middle segment of the thorax, which is the division of the body just behind the head. On the fourth instar there are two spots, the second being indistinct early in the stadium. In addition to three distinct markings on the thorax of the fifth instar, a distinct spot appears near the anal end. As soon as feeding begins, the ingested food showing through the translucent body walls gives the larva a bright-green color. At the end of each stadium feeding stops, food material is evacuated, and the color is lost by the time the larva is ready to molt. Color reappears when the larva resumes feeding after the molt.

Making the leaf roll is an engineering feat of interest. The larva, spinning a filament of silk, establishes an anchorage near the margin of a leaf and then reaches a short distance toward the middle of the leaf to establish a second anchorage. It completes the strand by moving the head back and forth 200 to 300 times, spinning and anchoring a thread at each movement. Several strands made along the margin start the leaf edge rolling as the strands dry and contract. Additional strands, which slacken the previous ones, are required to complete a tight tube, open at each end. Several rolls frequently are made on a single leaf.

Observations on the areas of leaf surface eaten during the development of 69 larvae fed on Emperor grape foliage showed that the average was 3.34 square inches. The areas eaten by each larva ranged from 2.21 to 4.68 square inches. Less than 15 percent of the total was eaten during the first three stadia, the period when the small larvae feed in groups. The average areas eaten by each instar are assembled below.

AREAS OF FOLIAGE EATEN DURING LARVAL DEVELOPMENT

	Average area eaten by each instar					Total
	1st	2nd	3rd	4th	5th	
Square inches	0.02	0.06	0.39	0.73	2.14	3.34
Percent of total	0.6	1.6	11.7	21.8	64.1	100.

TIMING OF INSECTICIDE APPLICATIONS

The insecticides commonly used in the San Joaquin Valley for the control of the grape leaf folder are lead arsenate sprays, usually with wettable sulfur, or lead arsenate and cryolite dusts. Four to 6 pounds of lead arsenate and 5 or 6 pounds of wettable sulfur per 100 gallons are used in the sprays, while the dusts contain 40 to 50 percent of the active ingredient, with hydrated lime or dusting sulfur as a diluent, usually dusting sulfur.

The best period for making insecticide applications varies with the different broods. In the first brood it lasts about 3 weeks, beginning when 60 to 80 percent of the eggs observed on any day have hatched and ending before 20 percent of the larvae seen on any day have begun making their own rolls. This is the period between the start of bloom in the

early varieties of grapes and the end of bloom in the late varieties; for example, from the start of blossoming of the Zante to its end in the Muscat vineyards. The delay of a month between the start of flight activity and treatment is caused by the long period during which egg-laying females are present, the long incubation of the eggs during the cool weather of early summer, and the slow development of foliage. If the treatment is made too early, the steady increase in the area of new foliage will leave much of the vine unprotected by poison and the larvae may roll and eat unpoisoned leaves.

The periods of insecticide application for the second and third broods last about 2 weeks. They begin with the peaks of adult activity, at which time more than 20 percent of the eggs observed on any day have hatched, and end before more than 20 percent of the larvae seen on any day have made their own rolls. In the case of the second brood the period falls in July, between the harvest of Early Elberta and Hale peaches; while for the third brood it occurs after mid-August, between the start and height of picking of Thompson Seedless (Sultanina) grapes for raisins.

Since in the San Joaquin Valley grape-growing areas most ranch homes are surrounded by vineyards, a simple method for securing information about moth activity is to make nightly observations on the number of moths collecting on the screens of lighted porches, recording the numbers appearing on the same area at the same time after sunset each night. Malt-sirup traps give information on activity during flight but are impractical as indicators of the time for insecticide applications, except where a group of grape growers might be willing to cooperate in securing information for a district.

After flight activity starts, weekly or semiweekly counts of eggs and larvae on infested leaves will serve as guides for determining when to put on dusts or sprays. The number of eggs and the number of larvae in each stage should be recorded. When the examinations of first-brood eggs show hatching of about 80 percent of the eggs observed on any day, the time to begin treatment is indicated. For the later broods the figure is about 20 percent. When more than 20 percent of the larvae seen on any day bear more than one spot (fourth instar) the end of the period is indicated, for all broods.

CULTURAL PRACTICES

Removal of water sprouts, or "suckers," on which many first-brood eggs are concentrated, may reduce the egg infestation by a third. It is common practice to remove the suckers whenever spring work permits.

The most effective time is a week or 10 days before blossoming, when the egg deposit is nearly complete but before extensive hatching has caused crowding of larvae and their migration from the limited sucker foliage.

Shoot thinning of wine and table-grape varieties removes shoots where the foliage is dense, and consequently a large percentage of the first-brood larvae are removed at the same time. As a result, second-brood eggs are concentrated on a reduced number of leaves rolled by the remaining first brood. Leaf thinning, which is practiced with these varieties to increase the amount of light reaching the developing fruit, begins when the second brood of adults are active. If the first leaf thinning is delayed until egg deposition by the second brood is complete, the small number of egg-infested rolled leaves can be removed with a slight additional cost for labor, and a reduction of infestation by the second brood can be accomplished. Observations on the effects of thinning of shoots and leaves have been made by the writer on the Ribier variety only.

DISCUSSION

Although the larvae feed in protected locations during most of their development, the protection is interrupted when they leave the webbed-together leaves or old rolls to make new rolls at the end of the group-feeding period, early in the fourth stadium of their growth. Applying insecticides before rolling occurs forces larvae to feed upon poisoned foliage within new rolls, and they die before they have eaten more than 15 or 20 percent of the foliage necessary for their development. If the larvae are not killed in their first roll they may be reached by poison later, since more than one roll is made during their development, but foliage injury which might have been avoided occurs in the meantime.

As a rule there is little foliage or fruit damage if control is applied during the development of the first brood of larvae. When the control is delayed until the second brood of larvae appear, loss of foliage will be increased but only minor fruit damage will occur, except in very heavy infestations. The only advantage in delaying is that, by observing the first brood, it will be easier to estimate the probable infestation that will occur later. Applications of control measures during the third brood will be of value only for late-maturing grapes, such as the Emperor variety. Since there has been no study of insecticide-residue problems in connection with control measures for the grape leaf folder, recommendation cannot be made for control of the third brood.

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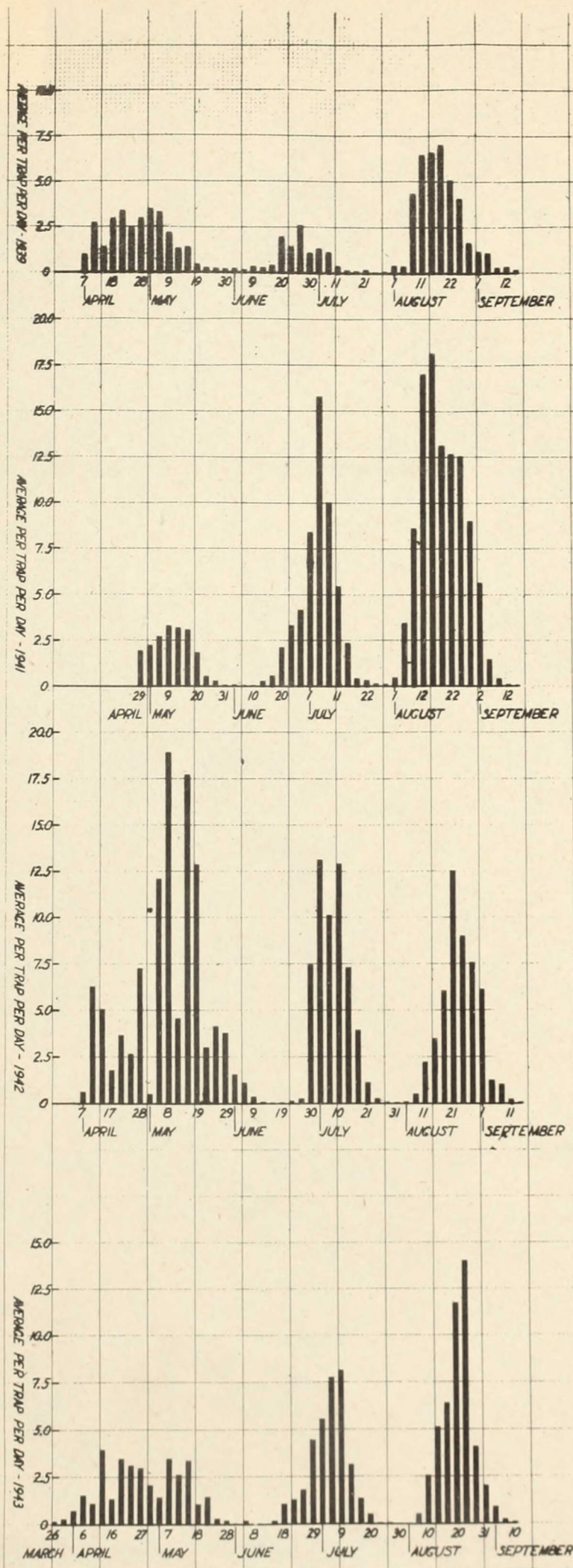


Figure 1.—Average number of grape leaf folder moths taken per trap per day during 4 years of trapping with malt-sirup bait traps.

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