Hibernation and Host-Plant Studies of the Mexican Bean Beetle in California

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The Mexican bean beetle, *Epilachna varivestis* Muls., was found on lima beans at Montalvo, Ventura County, California, in July 1946. This was the first known infestation of this pest on the Pacific coast. Armitage (1947) gives an account of its occurrence and details of the suppressive measures undertaken by the California Department of Agriculture and by Ventura County. At the request of the California Department of Agriculture the writer was assigned, on December 1, 1946, to undertake studies on the hibernation of the Mexican bean beetle and the wild host plants of the insect in Ventura County. The studies were made in cooperation with the California Department of Agriculture and the Ventura County Agricultural Commission and were continued until August 1, 1947. The study of the wild host plants, particularly of the pea family, indigenous to Ventura County was included in order to determine their importance in the eradication campaign waged against this grave pest. By the time the writer arrived, the bean beetle population had been greatly reduced by an insecticidal control program. All the beans had been harvested and the bean beetles remaining in the field were in hibernation.

HIBERNATION.—Most of the Mexican bean beetles apparently had sought shelter near the margins of bean fields in which they had been feeding about harvest time. Their numbers in these marginal areas decreased rapidly as the distance from bean fields increased. None were found hibernating more than half a mile from the bean fields. The beetles were found beneath leaves and debris at the base of eucalyptus, English walnut, cypress, and lemon trees, and also at the base of grapevines, pole beans, and around irrigation standpipes. The beetles found beneath English walnut trees were commonly associated with wild morning-

Table 1.—Emergence of Mexican bean beetles from hibernation, as indicated by their activity in lima bean fields and in a hibernation cage, in relation to temperature and precipitation and to the development of lima bean crop. Ventura, California, 1947.

Date	Temperature °F.			Precipitation	Bean Fields Planted	Fields in Which Beans Were Up	Beetles Found in Field	Beetle Emergence in a Hibernation Cage	
	Min.	Max.	Mean						
				Inches	*Number*	*Cumulative number*	*Number*	*Number*	*Cumulative percentage*
March 26–31	49	78	60.4	0.69	0	—	—	5	2.0
April 1– 5	40	68	55.3	0	0	—	—	1	2.4
6–10	44	81	57.7	0	0	—	—	5	4.5
11–15	52	96	71.7	0	0	—	—	2	5.3
16–20	48	73	60.8	0	1	0	—	2	6.1
21–25	46	69	58.5	Trace (fog)[1]	2	0	—	2	6.9
26–30	47	74	59.9	0	3	1	0	1	7.3
May 1– 5	50	82	64.1	0	9	3	0	4	9.0
6–10	46	79	61.6	0 (fog)[2]	8	6	0	0	9.0
11–15	47	71	59.5	0 (fog)[2]	7	15	1	0	9.0
16–20	47	69	59.6	Trace (fog)[1]	4	23	1	11	13.5
21–25	52	74	61.9	Trace (fog)[1]	5	30	6	9	17.1
26–31	49	75	61.1	0.11	1	34	1	18	24.5
June 1– 5	50	74	62.5	Trace (fog)[1]	0	39	5	10	28.6
6–10	55	76	64.2	0 (fog)[2]	0	40	20	18	35.9
11–15	54	81	67.1	0	0	40	6	3	37.1
16–22	52	77	64.6	0.03	0	40	23	7	40.0
23–28	52	75	62.8	0	0	40	28	0	40.0
29 to July 5	47	77	62.1	0	0	40	1	0	40.0

[1] Fog heavy enough to produce a trace of precipitation in the rain gage.
[2] Heavy fog producing surface moisture, but not sufficient to accumulate in the rain gage.

glory plants, which remained green throughout the winter. The beetles apparently sought these plants for protection, as it was subsequently determined that this species of morning-glory was not fed upon by the bean beetle.

The beetles in their winter habitat sought moist conditions. For example, during wet periods they were to be found among leaves and debris, but during dry weather they were usually found next to the moist soil beneath the debris, and occasionally in soil crevices.

A wire-screen cage, 3 by 3 by 3 feet, containing leaves of eucalyptus, cypress, walnut, and mesembryanthemum, was placed in partial shade to simulate hibernation conditions in the field. A total of 245 Mexican bean beetles were put in this cage—150 on September 27 and 95 on October 11, 1946. In order to prevent the beetles from escaping, the cage was protected by a heavy wire-screen cover and was provided with a safety entrance.

Beetle activity in the cage and air temperatures in a standard shelter a few feet away were observed daily. Lima bean fields in the area that had been infested in 1946 were examined each week for beetle infestation. Planting dates in relation to beetle emergence were observed in 40 of these fields (Table 1). On February 14, 1947, following a light rain, two beetles in the cage were active but were not removed. Except for one active beetle on February 21 no more activity was noted during the month. Although February was unusually warm, this activity did not appear to be associated with temperature, as the first and fourth days of the month were the warmest. On March 28 four beetles were active, but during the first 27 days active beetles were noted on only 14 days and never more than two at a time. Beginning on March 28 all active beetles were removed at each daily observation, and were considered to have emerged from hibernation. At this time lima beans were up in many gardens, but it was not until the latter part of April that lima beans in commercial fields came up. As shown in table 1 only 40 per cent (98) of the beetles in the hibernation cage survived the winter. The last beetle became active on June 22, 68 days after emergence was considered to have begun, and 4 months after the first activity had been noted. The first beetle in the fields was observed on May 13, at which time 9 per cent of those in the cage had become active. A total of 92 beetles was collected in the 40 fields under routine observation. Most of these were found during the last 3 weeks of June, whereas, emergence in the cage was most rapid from the middle of May to the middle of June.

The light field infestation, consisting of only 92 beetles, 100 larvae, and 49 egg clusters from May 13 to July 5, was due to suppressive measures by the California Department of Agriculture, rather than to mortality from exposure to adverse weather conditions during hibernation. The beetle population in natural hibernation quarters was materially reduced during February by raking the litter from all known hibernation places, burning it, and spraying the soil with pyrethrum, as described by Armitage (1947). The field infestations were controlled by applying rotenone dust to each field as soon as the first beetle on beans was found.

The relation of bean beetle emergence to temperature and precipitation agreed closely with observations made by Howard & English (1924) in Alabama, and Douglass (1928, 1933) in New Mexico. High temperatures of 84° to 96° F., April 11–14, accompanied by low humidity did not bring a corresponding increase in beetle emergence. Beetles emerged in numbers only during or following precipitation or during heavy fogs that left everything damp. However, the rainfall in 1947 for the coastal area of southern California was the lowest on record. The collection of adults in the lima bean fields demonstrated that in California the Mexican bean beetle is able to survive severe drought conditions and to infest the spring crop.

Host-Plant Tests.—Various wild plants were tested as possible hosts of the Mexican bean beetle by transplanting them to flower pots in the greenhouse and infesting them with adults and larvae of the beetles. The number of plants of each species which could be tested was limited by the number of beetles available. Therefore, some of the plants were tested only once, whereas those indicating possibilities of being hosts were tested a maximum of 7 times. Screen-wire cages 6 by 12 inches were used for testing beetles, and lantern-globe cages 5 by 9 inches for testing small larvae.

Beetles which had been held in outdoor cages until the greenhouse was available, and those emerging from the hibernation cage were used in these tests as long as the supply lasted, and then greenhouse-reared beetles were used. A few preliminary tests were made with larvae 8 to 14 days old, but when probable survivalwas indicated, further tests were made with newly hatched larvae. Five beetles and the larvae from a single egg cluster of about 35 eggs were used as a unit number of insects for plant tests, except in a few preliminary tests where as few as 8 partly grown larvae were used. All tests with both larvae and adults were continued until all of the insects had died, or in the case of plants on which the beetles would not remain, there was evidence that the plants were unfavorable to the beetles.

Plants were classed according to the results of these tests as follows:
Plants on which beetles would not remain:

Loco weed, *Astragalus antisellii* Jepson, 1 test
Burro fat, *Isomeris arborea* Nutt., 1 test
Malva, *Malva borealis* Wallm., 1 test

Plants on which the beetles would remain but would not feed:

Wild pea, *Lathyrus strictus* Nutt., 1 test
Morning-glory, *Convolvulus arvensis* L., 2 tests
Vetch, alsike clover, sweet clover, horse bean, 1 test each
Deer weed, *Lotus salsuginosus* Greene, 3 tests; and *L. scoparius* (Nutt.) Ottley, 2 tests
Lupine, *Lupinus bicolor* Lindl., 1 test; and *L. truncatus* Nutt., 1 test

Plants on which larvae and adults fed, but on which no reproduction occurred:

Lupine, *Lupinus hirsutissimus* Benth., 2 tests; *L. excubitus* Jones, 4 tests; and *L. succulentus* Dougl., 7 tests.

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Some Overlooked Relationships of Southern Pine Beetle

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Perhaps no forest insect has had more publicity in the southeastern United States than the southern pine beetle, *Dendroctonus frontalis* Zimm. The name of the insect is well-known to foresters and entomologists yet few are able to distinguish bark engravings of southern pine beetle from those of other bark beetles attacking pine. The sporadic appearance of southern pine beetle in great numbers and its devastating effect on stands of pine timber are not quickly forgotten by those who have witnessed outbreaks of the insect. Much stumpage value has been lost due to the depredations of this insect. The purpose of this paper is to record certain misunderstood relationships between southern pine beetle and the trees. A previously unreported possibility for control is presented.

RAINFALL.—Deficiencies in rainfall, dry weather, and drought have long been associated with outbreaks of southern pine beetle. Craighead (1925) correlated rainfall deficiencies with several outbreaks of southern pine beetle, and St. George & Beal (1929) and St. George (1930) have offered further substantiating proof that increases in the populations of southern pine beetle follow deficiencies in rainfall. Even prior to this, Felt (1914) and Blackman (1924) had pointed out that populations of the tree-killing hickory bark beetle, *Scolytus quadrispinosus* Say, built up enormous populations and killed many trees in seasons of scanty rainfall. Foresters and entomologists have accepted this explanation, and drought and dry weather are always the first thought whenever an outbreak of southern pine beetle is encountered.

Undoubtedly the lack of sufficient