The Mexican Bean Beetle in California

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Late in July 1946, the Mexican bean beetle, *Epilachna varivestis* Muls., was found infesting lima beans at Montalvo in Ventura County. This represented not only the first established infestation in California but also the first infestation on the Pacific Coast. Though the species has been known to entomologists for over 75 years and is indigenous to Mexico and the Southwest, east of the desert area, and has spread throughout the eastern United States, even up into Canada, no spread to the westward has previously been recorded.

Immediate and intensive survey showed approximately 2000 acres of nearly contiguous plantings to be infested, in part or in whole, lying in the center of 40,000 acres of the most productive bean land in the state. Some of this land has been continuously planted to beans for over 50 years. As beans, both fresh and dry, represent one of the major agricultural crops of the state, having a value in excess of $60,000,000 annually, there was no question in the minds of either state or county agricultural officials but that immediate suppressive measures should be attempted. In this thought they were fully supported by the growers.

Early survey results indicated that the infestation centered in a 25 acre field which showed considerable plant injury and a relatively heavy population of adult beetles. Through funds made immediately available by the local bean-grower associations and by the county board of supervisors, this planting was purchased by the County Agricultural Commissioner and the plants first oil-sprayed to knock down the beetles, then burned with a tractor-drawn power burner, and the area repeatedly disked to a depth of several inches. Undoubtedly this prompt action prevented a widespread dispersal of adult beetles to adjoining or even more distant properties.

The completed survey showed other infestations to be limited to a 6-mile radius from this field with the spread more evident to the north and east in the direction of the prevailing wind. The degree of infestation decreased rapidly in direct ratio to the distance from this center. In the more distant fields infestations were restricted to a single spot of less than a dozen plants or occasionally even a single plant, indicating very recent establishment.

Just how this infestation originated, or when, will probably never be known. While host carriers from other infested states have always been kept under close surveillance, particularly fresh *green* beans, it was felt that there were so many possible avenues of entry that would *not* be subject to control that quarantine action would not justify the penalties that would be imposed. For that reason no quarantine had ever been established.

The beetle population at the time the infestation was found and the pattern of recorded spread indicated that its presence was of more than 1 year's standing but hardly of more than 3 or 4. Investigation of the ground litter under a eucalyptus windbreak along the western edge of the original field uncovered dead adults which had failed to survive winter hibernation in sufficient numbers to indicate the presence of an appreciable population during the preceding year. It is significant that along the southern edge of this same field there was a spur track serving a citrus packing house on which reefer cars, which had previously been used in the transportation of perishables on the eastern seaboard, often stood for several days in some numbers with their doors open awaiting use in transporting citrus fruits to the East. These cars represent a very probable source of introduction as was established by federal survey with respect to initial infestations of Oriental fruit moth in the western states. There is, of course, the possibility that the beetle may have come in with the personal effects of Mexican Nationals who have been employed during peak harvest periods in considerable numbers throughout the state including Ventura County for the past several years.

The method of approach to be followed in attempting eradication of this advanced incipient infestation was given careful consideration by federal, state and county

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agricultural authorities. A request to the federal Bureau of Entomology and Plant Quarantine brought Dr. Neale F. Howard to the Pacific Coast from the Columbus, Ohio, laboratory, and his long experience in the control of this insect in the east was made available to the group.

The possibility of establishing a host-free area to include all the land lying within the mountain-surrounded basin in which the infestation lay, to be continued for two or more years, was given serious consideration. Aside from the fact that if such action were taken it would have involved in excess of 40,000 acres usually planted to beans and would have represented an annual loss to the growers of more than $4,000,000 during the period it was maintained, there were two factors that definitely mitigated against such action. First, it was not known what native plants present in the area, not found in other infested areas, might be acceptable to the beetle, the presence of which would nullify such a program. Secondly, the beetle is such a strong flyer and can survive such appreciable periods without food, it was reasonably feared that the absence of host beans would force widespread dispersal with many beetles finding their way through the mountain passes or along the coast to equally heavily bean-planted areas in adjacent counties to the north and south. Also a heavily traveled four-lane arterial highway traversing the more heavily infested fields, offered an excellent opportunity for "hitchhiking" beetles to be carried into those same areas, suggesting the possibility of an infestation more widespread than so far recorded. For these reasons this approach was abandoned.

It was decided that the only practical approach was to keep all infested and contiguous or intervening fields within the area, together with a reasonable buffer acreage, continuously dusted throughout the balance of the growing season with the most effective poison available. Unfortunately this insect had been of such long standing in the east that all investigations had been conducted with the idea of developing those materials which would give the most effective control with no thought of eradication. The use of rotenone .5 per cent or .75 per cent, with a maximum recorded efficiency of 95 per cent under the most optimum conditions, was the only available recommendation of the authorities. Inasmuch as the biotic potential of this insect is such that survival is permitted at 99.6 per cent mortality, this material did not offer too much promise. In addition rotenone loses its toxicity rapidly under direct sunlight which under California conditions meant practically no residual value.

However, following the recommendation of the federal Bureau, the first dusting of the 2000 acres involved was accomplished using 0.75 per cent rotenone applied at the rate of 50 pounds per acre. Due to the advanced maturity of the vines at the time the initial infestations were first found, with the runners meeting in the rows, much of the application was necessarily by plane. Coverage of the underside of the foliage, however, was not as complete as desired. Where power ground machines were used, the results were little better. To assure effective coverage approximately 300 acres of the more heavily infested fields were actually dusted by hand using rotary hand dusters operated by a large crew of Mexican Nationals available during the slack citrus packing period.

As rotenone supplies were particularly tight at the time and the delivered price considerably above that of cryolite-50 (45 per cent sodium fluoaluminate), the second dusting, following the first by 2 weeks, was accomplished using the latter material, applied at the same rate per acre as the rotenone. Cryolite was not only more readily available and less costly but was near-equal to rotenone in efficiency and offered a greater residual action. The results obtained seemed comparable with those obtained with rotenone but neither was as effective as required.

During field screening tests by Mr. John Steinweden, departmental entomologist in supervisory charge of operations, which tests included many other available promising materials, he found that the addition of 2–3 per cent *Lethane 60* or *A-70* (two aliphatic thiocyanates) to the .75 per cent rotenone gave higher mortality of all stages of the beetle than did rotenone alone, though this action was not confirmed by tests made in the laboratory at Columbus by Dr. Howard using the same California prepared material.

However, the third and final dusting, which followed the second dusting by 2 weeks, was completed with this material. Harvesting operations precluded any further treatments during the 1946 season.

While it was true that adult beetles could be observed in infested fields throughout the period of these dusting operations there appeared to be little noticeable reproduction after the first applications. It was later evident that winter was entered with a greatly reduced population of beetles with the possibility of even these being weakened by the treatments.

It is interesting to record that as compared with figures quoted by investigators as late as 1926 covering control costs, the most common type of labor has jumped from 25 cents per hour then, to $1.00 an hour now with materials showing a comparable increase in cost. The total cost of each application in these operations averaged $9.00 per acre when using 50 pounds of dust per acre. If this insect were to be accepted as an established pest and control followed the three to five applications of dust as now recommended in the eastern states, the cost would be $36 to $45 per acre per year which is nearly prohibitive even in the exceptionally productive areas in California.

With completion of the 1946 control measures, thought was given to the program to be continued through the winter and the following season which would further the complete suppression sought, before such action was made impractical by widespread dispersal. The following program was worked out and put into practice:

1. Determination of the conditions or cover acceptable to the beetles for winter hibernation under California conditions.
2. Physical elimination of all such cover in so far as possible.
3. Maintenance of beetles, under controlled hibernation conditions and adequate safeguards, as an index to the time of spring emergence and percentage of winter survivals under California conditions.
4. Testing of any native plants not common to other infested areas suspected as being acceptable to the beetle as supplemental hosts.
5. Planting of trap crops, tentatively March 1st, along the margins of infested fields of record, in advance of commercial spring planting, normally occurring around May 1st, to trap early emerging beetles and discourage dispersal.
6. Intensive survey to determine any spread to points outside of the recorded infested area.
7. Dusting of all infested acreage of record including intervening acreage, and any found during current survey together with a buffer area when deemed desirable, using 1 per cent rotenone at the rate of 50 pounds per acre, applied every 2 weeks beginning with the formation of runners, with a minimum of three and a maximum of five applications. Reservation made to switch to any more effective material later found available.
8. Continuation of safeguard measures, restricting movement from infested fields, or from the quarantined area, of host carriers such as fresh and dry beans, bean straw and equipment used in the culture or harvesting of beans, to prevent further spread by controllable means.

During the winter it was found that the loose ground litter under eucalyptus windbreaks common to the area or under walnut or lemon trees in orchards adjacent to infested fields, was acceptable to the beetles as winter hibernation quarters. Ground litter under cypress windbreaks also common to the area was, however, found to be unacceptable. It seemed to allow the soil to dry out, a condition which apparently discouraged its use by the beetles. The beetles seemed to prefer to hide *under* rather than *in* the litter, in close contact with moist earth. Due to the readily available situations of this kind around or adjacent to nearly all bean plantings, there was apparently no inclination on the part of the beetles to leave the area, that is, so far as could be determined.

Beginning February 1st the ground litter was raked from under all such acceptable windbreaks and burned and the exposed ground sprayed with pyrethrum 1 to 400 to kill any escaped beetles, which material Steinweden had found by labora-

tory test to be toxic to the adult beetles. Roughly 5 miles of such windbreaks were cleaned up in this manner. At the same time, through grower cooperation, approximately 800 acres of walnut and lemon orchards adjacent to infested fields of record were double disked and any remaining ground litter close to the trees cleared in the same manner as under windbreaks. All weeds between infested fields and paralleling highways were oil sprayed.

Due to unseasonable dry conditions, it was not possible to plant the trap crops as planned on March 1st, and it was late in April before this was completed. Resultant plant growth paralleled that in some of the earlier commercial plantings which started under irrigation about the same time.

By June 1st it was determined that 37 per cent of the beetles placed in the controlled hibernation cage had emerged and 15 scattered adults had been picked up in the field about equally divided between the trap crops and earlier commercial plantings. So far, the latter have been restricted to those fields which were most heavily infested last season. Three masses of eggs had also been found, together with a few plants showing fairly heavy adult feeding. No larvae have so far been observed this season. As these early incipient infestations were found, all insects and eggs which could be located by intensive visual inspection were hand collected and destroyed, the infested plants pulled and burned and all plants within a 50 foot radius hand dusted with 1 per cent rotenone.

Field dusting started at about this same time, using 1 per cent rotenone applied by power ground machines. The first dusting of all infested fields of record was completed by June 15 and the second dusting well underway. By mid-June plant runners were beginning to meet in the centers of the rows. So far there has not been a sufficient field population of beetles in any stage to determine accurately the effectiveness of the increased strength rotenone as used this season. No more effective material, however, has yet been discovered.

Through the cooperation of the Division of Truck Crop and Garden Insect Control of the Federal Bureau of Entomology and Plant Quarantine, investigations were conducted during the winter and spring in the ecology of the insect under California conditions. and in a study of potential native host plants. These studies were conducted by J. C. Elmore of the federal Bureau who, fortunately, was very familiar with the area and the host crop, using federal laboratory facilities available in the area. The findings have been a definite aid in timing this season's operations and in eliminating the possibility of any new native hosts, so far, as being acceptable to the beetle, encouraging from the eradication standpoint. His observations in home gardens in which beans were present throughout the winter, failed to show any activity on the part of the beetle during that period.

With the finding of the first beetles in 1946, quarantine safeguards against controllable spread were imposed. An area encompassing all infested plantings with a generous buffer area was placed under quarantine. No potential carriers were permitted to move from an infested property excepting under supervised fumigation nor from the quarantined area to points outside excepting under similar restrictions. Investigation of harvesting operations showed that numerous live beetles survived the field process in the trash which was gathered and burned. Some live beetles were found in the harvested beans as sacked in the field and all such beans were required to be fumigated before moving to a warehouse. No beetles were found to survive the final recleaning process, and such beans were permitted to be moved without further treatment. Harvesters and field wagons used in harvesting were fumigated before moving from an infested property. Green beans moving to quick freeze plants outside the area were fumigated in the field before movement. In all of these operations the growers were fully cooperative. Ventura County Agricultural Commissioner C. J. Barrett has been in field charge of operations and has taken an aggressively active part in seeing that all quarantine requirements were fully carried out.

Investigations by Steinweden showed that both fresh and dry beans were tolerant and all stages of the beetle completely susceptible to methyl bromide when exposed to 3 pounds for 2 hours under a gas-tight tent at 80° F. or 3.5 pounds at 70° F. or 4 pounds at 60° F. Where time was not important, 2 pounds for 12 hours

or 1 pound for 24 hours was found effective and approved for dry beans or bean straw. In the case of harvesting equipment the use of cyanide under ordinary canvas was found effective and approved when used at the rate of 1.5 ounces of sodium cyanide or its equivalent for 1 hour at temperatures above 50° F. In such cases liquid HCN was used.

In addition fo $3000 appropriated by the Independent Bean Growers Association, $5000 by the Ventura County Bean Growers Association and $5000 by the Ventura County Board of Supervisors, $102,000 has been budgeted by the state Department of Agriculture to cover operations up to June 30, 1947, with approximately $120,000 budgeted for each of the next two succeeding years.

Whether eradication of this infestation can be accomplished only time can tell. Most eastern entomologists familiar with this insect were rather cold to such a suggestion when their advice was solicited. However, not being inhibited by experience, the value of the crop, the recognized seriousness of the insect as a pest of beans, and the potential high cost of control over an extensive acreage if accepted as an established pest, have left no other course open but to try.—7-27-47.

Influence of Various Exposure-Concentration Combinations on Mortality of the California Red Scale in HCN Fumigation

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The influence of the length of the exposure period to hydrocyanic acid on the kill of California red scales, *Aonidiella aurantii* (Mask.), is of practical importance in field fumigations. In field fumigation each tree is usually given an exposure of 45 to 50 minutes. Woglum (1923) states that, with untreated cloth covers on the trees, an exposure of 45 minutes gives nearly as good results as one of an hour because most of the gas escapes before the expiration of an hour. With covers that are more nearly gas tight appreciable concentrations exist at the end of 45 minutes, as shown by Lindgren & Dickson (1943) and Fulton & Nelson (1946).

If the present untreated, porous-cloth coverings are replaced by more nearly gas tight coverings, different results may be expected. Laboratory and field studies were therefore made of the influence of the duration of the exposure, in combination with other factors, on the kill of scales in fumigations with hydrocyanic acid. The treatments included exposures to both constant and decreasing concentrations without and with preliminary exposure to low concentrations of gas to produce stupefaction of the scales.

EXPERIMENTAL PROCEDURE.—Resistant scale insects reared on lemon fruits were fumigated in the laboratory under controlled conditions. Unless otherwise stated, the insects were obtained in the field and each mortality figure was based on 1200 scales. Fifty live insects in the same developmental stage were marked on each fruit prior to treatment. Those reared in the laboratory were subjected to fluctuating temperatures during development, with two exceptions. The scales were preconditioned and postconditioned for 4 hours at 59° F. and fumigated at the same temperature. After the postconditioning period the scales were held at daily fluctuating temperatures until the mortalities were determined.

In the laboratory the fumigations were made in a chamber designed by Howard (Yust & Howard 1943) and modified by Fulton (Fulton & Busbey 1943). The insects were subjected to constant or decreasing concentrations for 15 to 90 minutes in fumigations in which the products of the average concentration and exposure time were equal. This was accomplished by treatment with a high concentration for a short time and decreasing the concentration for successive increases in the exposure interval. In tests in which