Derris and the Control of the Mexican Bean Beetle[1]

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Rotenone-containing dusts and sprays are commonly regarded as highly satisfactory materials for control of the Mexican bean beetle.[2] Their effectiveness has been attributed to the toxic action of the active principles of the insecticide when brought in contact with or when ingested by the insect whilst feeding. It has also been claimed that they possess marked deterrent or repellent properties when sprayed on the foliage (Turner 1932) (Hamilton 1937) (Fulton & Mason 1937) (Gimingham & Tattersfield 1928). Owing to the combination of ways by which such mixtures may serve to protect bean plants it was deemed desirable that more detailed observations be made than had hitherto been recorded in order to understand properly some of the relationships existing in the field between the application of derris sprays and the resultant control. In this study chief attention has been given to observing the ways by which derris sprays may be said to function when applied for the purpose of checking immediate larval injury to the plant. Advantage was also taken of the occasion to include tests with bordeaux mixture, since no plausible reason had yet been suggested to account for satisfactory results obtained with such sprays, especially when containing derris powder.

In preliminary trials it was evident that larvae and adults, but particularly larvae, were susceptible to the ill-effects of adverse environmental conditions such as when deprived of normal moisture requirements or if exposed temporarily to unduly warm temperatures, or to the interplay of two such forces. On the other hand the insect was capable of surviving extended periods under artificial conditions provided moisture was present. It therefore seemed desirable in studies concerning the reaction of the insect to the presence of derris spray residues that special precautions be taken to satisfy the physical needs of the insect with regard to moisture and temperature conditions within the cages. This care seemed all the more important in view of the fact that in tests on the effect of rotenone-containing residues on larval activity mortality during the limited period of exposure was commonly attributed to starvation rather than desiccation. It was also evident from preliminary trials that to maintain sprayed foliage in a fresh condition for a week or so required the use of growing plants placed under well lighted conditions, such as in an open greenhouse. To help offset some of the more obvious defects in such an arrangement whitewash was sprayed over the glass of the house; blinds and tobacco cloth were used to screen the bench on which the cages were set.

The usual procedure in such tests was as follows: Larvae or adults of the first and second generations were collected in unsprayed fields during August, September and October. Insects were collected in the morning in paper cups containing foliage in quotas of 20 to 40 specimens per cup. So far as possible only medium sized larvae were selected for test purposes. Treatment followed during the afternoon. Larvae were confined for experimental purposes by means of lantern chimneys covered with cheesecloth, adults by cylindrical wire screen cages. Each cage except those without food contained two bean seedlings. Watering of plants was accomplished by means of shallow troughs. In cases where foliage was sprayed, leaves were allowed to dry before insects were introduced. So-called contact sprays were applied to larvae placed on sheets of absorbent paper, and to adults confined in wire screen tubes. The following sprays were applied: (1) calcium caseinate spreader 1.25 gm., water or bordeaux mixture (4:4:50) 500 cc., (2) standard derris powder (5 per cent rotenone) 2.5 gm., calcium caseinate 1.25 gm., water or bordeaux mixture 500 cc., (3) stabilized derris powder (4.75 per cent rotenone) 2.5 gm., calcium caseinate 1.25 gm., water or bordeaux mixture 500 cc. In addition there were two controls in each series of tests—one in which insects were provided with food and the other where food was omitted. Each test was performed intriplicate whenever treatments were applied.

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[2] *Epilachna varivestis* Muls.

During the course of these experiments it was commonly observed that in cases where untreated larvae were confined with foliage sprayed with a derris mixture very few of them remained on the plants or were seen to search the foliage for food. For the greater part of the time larvae remained on the soil. On examining cages containing derris sprayed foliage it was observed that the leaves showed signs of very little feeding and that in some such instances the leaf surface was marked with a brownish exudate apparently as a result of regurgitation. A large proportion of the larvae had been able to survive such conditions after five days' confinement. It was also noted in cages where little or no feeding had been attempted or where larvae had been left without some source of food that cannibalism had accounted for the death of some of the larvae. This phenomenon was probably due to enforced hunger under cage conditions. In the case of treatments containing bordeaux mixture it was generally observed that larvae were deterred from feeding owing to the presence of bordeaux mixture itself, but that the amount of food consumed was much less when derris powder was included in the treatment. Adults appeared to react under such conditions in much the same manner as larvae, except that they were generally found on the upper parts of wire cages and in no instance was cannibalism observed.

In each series of tests results were recorded five days after the commencement of treatment and were expressed in terms of the average percentage mortality and according to extent of foliage injury for each treatment. Doubtful cases of mortality were retained in cages furnished with fresh food for a further period of three days, after which specimens were considered dead if no movement was shown when exposed to direct sun or electric light. Larvae destroyed by cannibalism were counted as not having been killed by the effects of treatment.

In tests with larvae there was a considerable degree of difference in the average percentage mortality from treatment between the various series as carried out on several separate occasions, evidently due to various factors that were beyond the control of experimental procedure. Results in this respect tended to show that the mortality level was generally lower when the experiment was carried out under cool temperature conditions, such as commonly occur during the latter part of the season on Long Island, and generally higher when the experiment was carried out under warmer spells during the summer. However comparisons drawn between treatments in each of the several series indicated invariably a common trend in the results similar to that expressed by the average percentage mortality for each treatment in all series. When results were expressed according to degree of foliage injury by feeding the comparisons between treatments were uniformly consistent whether recorded per series or on the basis of averages for all series.

EFFECTIVENESS WHEN LARVAE OR FOLIAGE ARE SPRAYED.—In an attempt to measure the comparative effectiveness of rotenone- and copper-containing sprays when applied for contact and noncontact purposes two comparative series of treatments were made, one in which the foliage was sprayed and larvae were not sprayed, the other in which larvae were sprayed and foliage left unsprayed. These tests were made on five occasions, data from which are summarized in table 1.

The data pertaining to percentage mortality clearly indicated that larvae, as sampled, were much more susceptible to the toxic effect of rotenone sprays when the latter were applied as contact sprays than when applied to the foliage for purposes of ingestion. It was also evident from the data obtained in the control cages under starvation conditions that the majority of larvae had not died of starvation under existing conditions, and that there were small grounds for assuming that the effectiveness of rotenone-containing sprays was due to their toxic properties as stomach poisons with such larvae. That they were otherwise highly effective when applied in this manner may be concluded from the fact that foliage of plants thus treated was, if anything, more effectively protected than in the case of contact sprays.

In tests with bordeaux mixture and derris powder it was evident that in general the results compared favorably with those obtained with calcium caseinate and derris powder. Bordeaux mixture itself when sprayed on foliage seemed to give

considerable protection from excessive larval feeding. In these tests the data from treatment with a so-called stabilized form of derris powder were slightly superior to those from treatment with a standard grade of derris, but it is doubtful whether such differences were sufficiently large to be significant.

It may be concluded from these results that derris sprays were lethal when they came into contact with larvae. When derris sprays did not come into direct contact with the insects a large proportion of the larvae was capable of surviving the treatment, despite the fact that they were deterred from feeding owing to the presence of derris on the foliage.

EXTENT OF REPELLENCY.—Although it had become apparent that the effectiveness of derris sprays might be attributed largely to their so-called repellent properties, it seemed desirable that further information be gathered relative to the degree or extent of repellency in view of the large proportion of larvae that survived such treatment and owing to the fact that under field conditions fresh food would quickly be forthcoming as a result of new growth.[3] In order to ascertain whether or not the protective influence of derris spray residues on the foliage might be extended in some degree to include unsprayed plants placed immediately adjacent sprayed plants, or whether or not the larvae might be capable of detecting a difference between sprayed and unsprayed plants for feeding purposes, an experiment was planned in which much of the procedure outlined for previous tests was repeated, except that in place of contact sprays there was substituted a treatment in which one of the two plants in each pot was sprayed and the other left unsprayed. The plants were not permitted to touch each other until after the spray had dried on treated plant. These tests were made on three occasions. The data are summarized in table 2.

Table 1.—Comparative effectiveness of derris sprays when applied to larvae of *varivestis* for contact purposes or to the foliage of beans as a stomach poison as expressed in larval mortality and extent of feeding injury.

Spray Treatment and Method of Application	Total Larvae	Average Per Cent Mortality	Number of Plants — Degrees of Foliage Injury			
			Trace	Slight	Moderate	Severe
Water and calcium caseinate						
foliage	469	6.2			4	26
contact	446	9.7			2	28
Water, calcium caseinate and standard derris powder						
foliage	443	32.8	28	2		
contact	483	70.6	26	4		
Water, calcium caseinate and stabilized derris powder						
foliage	482	37.9	30			
contact	481	78.4	24	5	1	
Bordeaux mixture and calcium caseinate						
foliage	473	11.1	6	18	6	
contact	472	8.2		6	4	20
Bordeaux mixture, calcium caseinate, standard derris powder						
foliage	418	19.7	30			
contact	485	61.1	22	6	2	
Bordeaux mixture, calcium caseinate, stabilized derris powder						
foliage	432	29.3	30			
contact	464	65.1	25	5		
Control, fed	470	7.4			2	28
Control, starved	449	29.5				

[3] During the course of these experiments Fulton & Mason (1937) have claimed that the constituents of derris powder may be translocated from treated foliage to new growth on the same plant, a phenomenon that merits more detailed observation than provided for in this study.

The results from these tests tended to emphasise the nonlethal effect of derris sprays under such circumstances as well as to clearly indicate that their protective influence was limited to plants on which they occurred. It was evident also despite the intermingling of sprayed and unsprayed leaves within the same cage that larvae were capable of detecting a difference between such leaves for feeding purposes, and further in view of the extent of injury to unsprayed foliage it seems that larvae were not seriously deterred from feeding by the proximity of derris-treated plants.

The results from treatments containing bordeaux mixture closely paralleled those of similar tests in the previous experiment. The protective influence of derris-bordeaux mixture sprays was confined to plants thus treated. Even after a period of five days sprayed leaves showed little injury from larval feeding. No corroborative evidence was forthcoming that might provide grounds for the disuse of sprays containing derris powder and bordeaux mixture on the score of insufficient protection. However other phases of the problem require elucidation before the full meaning of such results can be explained (Roark 1937) (Allen & Brooks 1940).

INFLUENCE OF DRY AND MOIST SOIL CONDITIONS ON LARVAL MORTALITY.—It may be deduced from the results of the foregoing experiments that derris sprays as applied were reasonably efficient in protecting bean foliage, their greatest weakness from practical considerations being apparently that they failed to kill a large percentage of larvae unless applied directly as contact sprays. It was also evident that a large proportion of larvae was able to survive without food for several days under what might be considered favorable humidity and temperature conditions. It was felt in the light of these results that it would not be superfluous to a better understanding of the relation of derris sprays to control if an attempt was made to render some accounting for the

Table 2.—Comparative effectiveness of derris spray residues when applied and when not applied to foliage immediately adjacent sprayed plants as expressed by larval mortality and extent of feeding injury.

Spray Treatment	Plant Treatment	Total Number of Larvae	Per Cent Average Mortality	Total Number of Plants	Number of Plants: Degrees of Foliage Injury			
					Trace	Slight	Moderate	Severe
Water and calcium caseinate	both sprayed	280	7.2	18				18
	one sprayed	243	4.1	9				9
	one unsprayed			9				9
Water, calcium caseinate, standard derris powder	both sprayed	268	19.9	18	18			
	one sprayed	234	11.8	9	9			
	one unsprayed			9				9
Water, calcium caseinate, stabilized derris powder	both sprayed	251	23.5	18	18			
	one sprayed	251	17.3	9	9			
	one unsprayed			9				9
Bordeaux mixture, calcium caseinate	both sprayed	249	5.1	18		15	3	
	one sprayed	248	4.6	9	3	5	1	
	one unsprayed			9				9
Bordeaux mixture, calcium caseinate, standard derris powder	both sprayed	243	12.7	18	18			
	one sprayed	247	11.3	9	9			
	one unsprayed			9			1	8
Bordeaux mixture, calcium caseinate, stabilized derris powder	both sprayed	246	13.3	18	18			
	one sprayed	264	14.1	9	8	1		
	one unsprayed			9			1	8
Control, fed		255	6.3	18			1	17
Control, starved		239	10.4					

probable fate of larvae in such circumstances under field conditions.

According to the literature (Marcovitch & Stanley 1930), (Sweetman & Fernald 1930), (Sweetman 1931) the activities of the insect are closely correlated with the existence of certain climatic and soil conditions. In periods of more or less drought a large number of the population may die from starvation, desiccation, or from both causes. It is conceivable therefore that larvae that are deterred from feeding or are repelled from staying on the foliage due to the presence of derris are likely to spend a greater proportion of their time on the ground searching for suitable living conditions. In such an environment during the summer season the chances of survival are seriously diminished owing to unfavorable influences inherent in such a situation. With a view to obtaining some conception concerning the possible effect of any one of such factors on conditions as they existed in these experiments it was planned to carry out tests in which the contrasting influences of moist and dry soil might be compared as reflected in larval mortality. Thus one half of each treatment was furnished with pots in which the surface soil was dry, and in the other half the soil was kept moist. Three treatments were incorporated with each set of soil conditions, namely, (1) foliage present and not sprayed, (2) no food provided, (3) foliage present and sprayed with a derris mixture. Where no food was provided a small piece of wire gauze was inserted in the cage to provide larvae an additional means of leaving the soil. To help maintain a dry condition on the soil surface and yet provide the necessary moisture for plant growth, all in the same pot, a layer of paraffin was implanted below the surface soil to interrupt capillarity. These tests were made on five occasions. The data are summarized in table 3.

From the data presented in table 3 it will be seen that a higher percentage mortality was obtained in cages provided with a dry surface soil, other things being equal. The degree of mortality was raised considerably where larvae were deprived of food, either by the presence of derris spray on the foliage or by the omission of food in the cage. Where such a condition occurred in combination with dry soil the percentage mortality again rose perceptibly. That the mortality in cages containing sprayed foliage and a dry soil was not as high as in cages containing no food and a dry soil may be mainly attributed to the alleviating influence of plant transpiration within glass cages. From these data it seems evident that dry conditions on the soil surface may have a marked bearing on the degree of larval mortality secured from treatments containing rotenone. Such hostile influences, which are commonly to be met with during the season, may in part serve to explain why rotenone-bearing insecticides are apparently so successful in protecting bean foliage from feeding injury by larvae of the Mexican bean beetle.

Table 3.—Comparative influence of moist and dry soil conditions as expressed in larval mortality.

Treatment	Soil Condition	Total Larvae	Mortality	Plants Injured	
				Slightly	Severely
Control, foliage unsprayed	moist	665	7.5		30
	dry	623	13.7		30
Control, no foliage	moist	659	32.2		
	dry	637	87.0		
Treated, foliage sprayed	moist	663	36.3	30	
	dry	677	54.8	30	

Tests with Adults.—A similar series of tests though not as extensive was made with adults of the Mexican bean beetle, the results of which were essentially similar to those obtained with larvae. Adults were readily killed when directly sprayed with derris mixture, and were successfully repelled by derris residues on bean foliage. In the latter case few of the beetles were killed, but the foliage was as free from feeding injury as in the case of contact sprays, where a large proportion of the

beetles had been killed by the treatments.

Adults, like larvae, were capable of detecting a difference between derris sprayed foliage and unsprayed foliage within the same cage for feeding purposes, with the result that leaves were practically uninjured by feeding in the former case and were severely injured in the latter.

The percentage mortality among adults was increased considerably when the surface soil was kept dry as compared to a moist condition, provided beetles were deprived of food or prevented from feeding.

SUMMARY.—Experiments were conducted under greenhouse conditions with larvae and adults of the Mexican bean beetle for the purpose of observing more closely the relation of derris sprays to Mexican bean beetle control.

Tests carried out under conditions of moisture and temperature considered favorable for the insect indicated that a large percentage of larvae and adults were capable of surviving 5 days' exposure to the presence of foliage sprayed with derris powder and that little if any feeding had taken place. Further tests indicated that the insect was capable of distinguishing sprayed and unsprayed foliage in the same cage for purposes of feeding, and that the proximity of derris on the foliage had little if any effect in retarding the insect from feeding on unsprayed foliage.

Supplementary tests confirmed the fact that derris sprays are lethal when larvae and adults are directly hit in spraying. Otherwise their effectiveness when applied as for purposes of ingestion was dependent on their repellent properties and, in the case of larvae, on desiccation as a result of unfavorable living conditions on the soil surface.

Tests with bordeaux mixture indicated that the spray residue on foliage served to reduce the amount of feeding by both larvae and adults, and when containing derris powder exerted a marked effect in protecting the foliage.—4-14-41.

LITERATURE CITED

Allen, T. C., and J. W. Brooks. 1940. The effect of alkaline dust diluents on toxicity of rotenone-bearing roots as determined by tests with houseflies. Jour. Agr. Res. 60(12): 839–45.

Fulton, Robert A., and Horatio C. Mason. 1937. The translocation of derris constituents in bean plants. Jour. Agr. Res. 55(12): 903–7.

Gimingham, C. T., and F. Tattersfield, 1928. Laboratory experiments with non-arsenical insecticides for biting insects. Ann. Appl. Biol. 15(4): 649–58.

Hamilton, C. C. 1937. Tests with derris powder or cubé powder in rosin residue emulsion sprays for the control of shade tree insects. Proc. 13th Nat. Shade Tree Conference. 140–50.

Marcovitch, S., and W. W. Stanley. 1930. The climatic limitations of the Mexican bean beetle. Ann. Ent. Soc. Amer. 23(4): 666–86.

Roark, R. C. 1937. An insect that breathes through its nose. JOUR. ECON. ENT. 30(3): 526.

Sweetman, Harvey L. 1931. The Mexican bean beetle. Wyoming Agr. Expt. Sta. Bul. 176: 1–23.

Sweetman, Harvey L., and H. T. Fernald. 1930. Ecological studies of the Mexican bean beetle. Mass. Agr. Expt. Sta. Bul. 26: 1–32.

Turner, Neely. 1932. Notes on rotenone as an insecticide. JOUR. ECON. ENT. 25(6): 1228–37.

A HOST PLANT RECORD FOR THE WEEVIL, *Peritelopsis globiventris* (LEC.)

In 1936 the author reported[1] the rather uncommon broad-nosed weevil, *Peritelopsis globiventris* (Lec.) as causing some minor injury to the globe artichoke (*Cynara scolymus*) in Santa Cruz County, California. Since this record it has been found commonly overwintering among and feeding on the nterfolded young leaves of this plant in the same locality. Ting[2] reported a collection of this weevil from the sea side daisy, *crigeron glaucus*, in San Mateo County, California. On June 10, 1940, the author collected several plants (no underground portions) of lizard tail, *Eriophyllum staechadifolium*, from near Sharp Park, San Mateo County, California, to record the emergence of certain Lepidoptera, from which three specimens of this weevil emerged and were removed dead on November 16, 1940. Inasmuch as *Eriophyllum* is a very common perennial composite of the sand dune areas of the coast, and occurs in close proximity to artichoke plantings where damage has been observed, it seems apparent that it is a host of *Peritelopsis*. Numerous collections of *Erigeron glaucus* from the same locality have failed to show the presence of this weevil.—6-18-41.

[1] Pan. Pac. Ent. 12(4): 195.
[2] Pan. Pac. Ent. 13(1–2): 24, 1937.

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