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A REVIEW OF THE INSECTICIDAL USES OF ROTENONE AND ROTENOIDS FROM DERRIS, LONCHOCARPUS (CUBE AND TIMBO), TEPHROSIA, AND RELATED PLANTS

PART VII: LEPIDOPTERA

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INTRODUCTION

This is the seventh in a series of papers designed to review all available information on the insecticidal uses of rotenone and the rotenoids. Part I reviewed tests with derris, cube, timbo, Tephrosia, Mundulea, and their constituents on members of the Collembola, Orthoptera, Dermaptera, Odonata, Isoptera, Corrodentia, and Mallophaga. Apparently no tests with the rotenone plants on Thysanura, Ephemeroptera, or Plecoptera have been recorded. Part II reviewed the tests that have been made on Thysanoptera; Part III, the tests on Homoptera; Part IV, the tests on Hemiptera; Part V, the tests on Anoplura; Part VI, the tests on Coleoptera, and Part VII, the present paper, reviews the tests and recommendations for use on Lepidoptera.

LEPIDOPTERA

Aegeriidae

Cephonodes hylas (L.)

Corbett and Yusope (82) in 1932 stated that the extract from 20 pounds of tuba root diluted to 100 imperial gallons with water, although not so satisfactory as lead arsenate in solutions of 4 pounds to 100 gallons of water, is effective against the coffee clear-wing moth on coffee bushes.

Melittia satyriniformis Hon., the squash borer

At the 1934 meeting of the American Association of Economic Entomologists, as reported by the United States Department of Agriculture Bureau of Entomology and Plant Quarantine (437), Cory led a discussion of field results with arsenical substitutes for the control of vegetable insects. Headlee, of New Jersey, stated that the squash borer is among the insects that may be controlled with derris dust.

Burdette (55) in 1935 recorded results of tests with three derris dusts and one derris spray, all materials being applied three times to the stems and basal portions of the plants only, care being taken to cover all parts thoroughly, beginning July 10, when eggs were first found. The dusts were applied with a Vermorel puff duster and the spray with a Vermorel hand sprayer. The total amount of dust applied per acre ranged from 55 to 65 pounds.

Material	Increase in borer-free vines over check.	Increase in weight of squash over check.
	Percent	Percent
Derris 25 + talc 75 (rotenone = 1 percent)	83.5	33.5
Derris 20 + sulfur 25 + clay 55 (rotenone = 1 percent)	71.3	74.5
Pyrethrum extract in a carrier + derris	37.4	39.3
Lead arsenate 3 pounds/100 gallons + 1 percent oil	51.7	29.5

Headlee (136) in 1935 reported tests made in New Jersey with derris as a substitute for arsenicals on vegetables. The squash borer is among the insects that may be controlled by derris dust.

The New Jersey Agricultural Experiment Station (292) in 1935 reported that a mixture of 20 parts of finely ground derris root (5 percent rotenone and 18 to 20 percent total acetone extractives), 25 parts of finely ground sulfur (300-mesh), and 55 parts of finely ground clay controls this insect.

The most effective insecticidal treatment, according to the Massachusetts Agricultural Experiment Station (270) in 1937, was a spray prepared from cube powder at the rate of 5 pounds in 100 gallons of water, and made wettable with fish-oil soap at the rate of 1 quart in 100 gallons of spray. This reduced the injury 74 percent. Spraying with nicotine sulfate 1:500 plus 1 percent of summer oil was more effective

than nicotine sulfate 1:250. Dusts were not so effective as in 1935, although they protected the vines from serious injury and were applied much more quickly and easily than the sprays. Pyrethrum-clay dust 30:70 gave slightly better control than derris or cube dusts.

The same station (271) in 1938 reported that the liquid sprays were consistently superior to the dusts, although the cube-clay dust containing 0.6 percent of rotenone was nearly as effective. As in other years, the spray consisting of nicotine sulfate 1:500 plus summer-oil emulsion 1:100 was the most effective treatment and reduced the borer injury 88.59 percent. The wettable cube spray using 4 pounds in 100 gallons of water showed a reduction of 81.53 percent and, being less expensive, would seem more practical. Contrary to the results in 1936, the pyrethrum-clay dust containing 30 percent of pyrethrum powder was ineffective.

Treatment	Plants	Average borer tunnels per vine	Reduction in injury over check
	Number	Number	Percent
Check	25	3.68	-----
Nicotine sulfate 1:500 + oil emulsion 1:100	19	.42	88.59
Wettable cube spray, 4 lbs. in 100 gallons	28	.68	81.53
Nicotine sulfate 1:250	22	.77	79.08
Cube-clay dust, 0.6 percent of rotenone	25	.84	77.81
Derris-clay dust[2/], 0.6 percent of rotenone	27	1.48	59.79
Pyrethrum-clay dust, 30 percent of pyrethrum	29	2.06	44.03

The average field infestation in hubbard squash at Waltham in 1937 was 3.68 borers per vine, which is three times as heavy as last year.

2/ Derris powder, 1936; other powders, 1937.

The borer moths were late in appearing and the first treatment was not applied until July 9, followed by three additional applications at weekly intervals. This station (272) in 1939 reported that insecticides were applied on July 6, 13, 22 and 29, and 40 percent of nicotine sulfate 1:250 permitted an average of 3.06 borer tunnels per vine, a reduction of 54.12 percent over the infestation in the untreated plants. Cube-clay dust (0.6 percent rotenone), wettable cube spray (4 pounds in 100 gallons), and a neutral copper-rotenone dust (0.8 percent rotenone) all reduced the infestation approximately 45 percent. Nicotine sulfate 1:500 plus oil emulsion 1 percent and cube-clay dust (0.75 percent rotenone) were less effective in the record but obviously were affected by the unfavorable weather conditions.

The New York County Agents' Training School (299) in 1938 discussed the control of insects attacking vegetables, including the squash borer. Derris dust with 1 percent of rotenone gave 79 percent control; derris spray (4 pounds to 100 gallons), 73 percent control.

The Wisconsin Agricultural Experiment Station (488) in 1938 reported that the effectiveness of derris insecticide against this insect was improved by including 2 percent of oil emulsion to the spray.

Crosby, Chupp, and Leiby (87), of the Cornell University Agricultural Extension Service, in 1939 reported that recent insecticide-control tests indicated that dusting the plants with a 1 percent rotenone dust will give good commercial control of the insect. Spraying with derris or cube at the rate of 4 pounds to 100 gallons of spray also gave fair control, but not quite so good as the dust. The treatments should be started about July 1 and repeated at weekly intervals until 4 or 5 applications have been made. The spray or dust should be applied over the entire plant. The rotenone in the insecticide kills the newly hatched larvae and also seems to have a repellent effect on the moth at the time of egg laying.

Mr. W. J. Haude in 1939 stated, in advertising literature published by John Powell and Co., New York, New York, that a wettable cube or derris spray (4 pounds to 100 gallons) will give better than 80-percent reduction of infestation.

Amathusiidae

Amathusia phidippus (L.)

Flippance (137) in 1920 suggested tuba-root (derris) powder for use against the larvae of the large coconut butterfly.

Arctiidae

Arctia caia (L.)

Van der Laan (244) in 1936 reported that this species was not affected by derris.

Diacrisia lubricipeda (L.)

Van der Laan (244) in 1936 reported that this species was not affected by derris.

Diacrisia subcarnea (Walk.)

The Institute of Physical and Chemical Research (214), Tokyo, Japan, in 1927 reported that Neoton at 300 gm. plus 750 gm. of soap per 40 imperial gallons of water gave 100-percent mortality of the larvae of this species.

Estigmene acraea (Drury), the salt-marsh caterpillar

Finch et al. (133) in 1939 recommended derris preparations for control on grapes in Arizona.

Tyria jacobacae (L.)

Craufurd-Benson (85) in 1938 reported that for testing derris insecticides by his dipping method (Bul. Ent. Res. 29:41) many insects are unsuitable. Cinnabar moth larvae, Tyria (Hipocrita) jacobacae (L.), have been tried with unreliable results. This was probably due to the variable weather conditions at the time of collection, the variety of food material, the lack of uniformity in the size of the larvae, and the impossibility of knowing their age.

Hyphantria cunea (Drury) the fall webworm

McIndoo, Sievers, and Abbott (264) in 1919 reported that caterpillars about one-third grown were killed within a week by a ... spray containing 1 pound of derris powder to 5 gallons of water. Mixtures ranging from 1 pound per 50 gallons to 1 pound per 200 gallons were not satisfactory because nearly all the sprayed foliage was eaten and not all the caterpillars were killed.

Brittain (50) in 1924 reported derris to be of no value against the larvae. In these tests the larvae were dipped in a suspension of derris in water and then allowed to feed on unsprayed leaves; also, larvae were allowed to feed on dipped leaves.

Kopp (242) in 1924 reviewed the use of derris as an insecticide. Derris powder has given excellent results against larvae of this species.

Kelsall et al. (233) in 1926 reported that the larvae were strongly resistant to derris dust and derris spray. Not even at 10 pounds per 100 imperial gallons of water did the derris have the slightest effect.

Kelsall and Stultz (234) in 1937 reported laboratory tests of derris (5.95 percent rotenone) and pyrethrum (0.94 percent pyrethrins) as dusts, with gypsum as the diluent. Derris 25 percent and 100 percent each produced 20 percent mortality in 5 days. Feeding on foliage was somewhat reduced. Phrethrum at 50 percent gave 100 percent mortality in five days.

Hamilton (180) in 1938 reported that on walnut trees the larvae were satisfactorily controlled by derris or cube powder spray (0.02 percent rotenone) plus rosin-residue emulsion (4 pounds per hundred gallons) as a sticker. The spray acts as a contact poison, the effective period being 6 days. There was 100 percent kill of larvae in sprayed webs.

According to the New Jersey Agricultural Experiment Station (294) in 1938, derris or cube powder in water to which rosin-residue emulsion had been added was effective.

W. J. Haude in March 1939, in advertising literature published by John Powell and Co. New York, N. Y., recommended a cube or derris spray (4 pounds of powder containing 4 percent rotenone per 100 gallons plus 4 pounds rosin residue emulsion) against this insect on walnut.

In cage tests Bonrote (a rotenone spray made by the Bonide Chemical Company) at 10 pounds per 100 gallons gave 67.7 percent kill of two-thirds-grown exposed caterpillars at the end of 13 days.--Felt and Bromley (128) in 1940.

Isia spp.

Agicide DC-4 (rotenone 0.6 percent at the rate of 4 pounds per 100 gallons of water (0.003 percent rotenone in spray) killed from 50 to 100 percent of brown woolly-bear caterpillars within 96 hours.--Agicide Laboratories (8) in 1939.

Utetheisa lotrix (Cramer)

U. pulchella (L.)

Dusting with derris mixtures containing 0.5 to 1.0 percent of rotenone failed to give more than 30 to 50 percent control of the larvae in the laboratory. About 50 percent of the caterpillars of U. lotrix survived after being dusted in the field with derris dust containing 2 percent of rotenone.--Van der Vecht (454) in 1936.

Blastobasidae

Holcocera iceryaeella (Riley)

See Basinger and Boyce (24) under Argyrotaenia citrana (Fern.), on page 154.

Bombycidae

Bombyx mori (L.) the silkworm

Silkworms were used as test insects by Fryer et al. (149) in 1923 in evaluting derris extracts.

The cold alcoholic extract of cube used without soap was effective. A water extract of a species of Lonchocarpus had no effect. A commercial derris powder was effective. Used as a fumigant (burned it was also effective.--McIndoo and Sievers (263) in 1924.

Gross and Fahey (170) in 1930 referred to tests made by F. L. Campbell, which indicated that rotenone as a stomach poison is 30 times as toxic to silkworms as is lead arsenate.

F. L. Campbell (60, 61) in 1932 reported results by Davidson. Rotenone suspended in water 1:1,000 sprayed on leaves and fed to the third instars as a sandwich killed all; at 1:5,000, 40 percent were killed. More precise results were obtained by Campbell with fourth instars. Using the sandwich method as described by Campbell and Filmer, Campbell found the median lethal dose of rotenone to be about 0.003mg. per gm. Since the m.l.d. of acid lead arsenate for the fourth instar is about 0.09mg. per gm, rotenone is about 30 times as toxic as acid lead arsenate for this insect. In two of his tests Davidson did not kill all the silkworms. In his quantitative tests of various stomach poisons Campbell found that the most obvious effect of nearly lethal doses is to prevent the larvae from feeding on untreated leaves for a period that depends on the quantity of the sublethal dose. When lethal doses of rotenone are taken, the silkworm does not eat again, but may remain alive for several days. The toxic action of rotenone is slow as compared with that of established insecticides, and the silkworm is so slowly affected by rotenone that it may take a dose many times as large as the median lethal dose. The quantity of rotenone that an insect may eat in excess of the median lethal dose depends on the concentration of rotenone on the foliage, the feeding habits of the insect, and its specific reaction to rotenone. Dr. Campbell also reported in 1932 that the m.l.d. of malachite green for fourth instars is about 0.025mg. per gm.

Ginsburg(163) in 1932 reported experiments with waxes as possible carriers of insecticides. An emulsion containing 1 percent of spermaceti, derris-root extract 1:400, and 0.2 percent of triethanolamine oleate caused a mortality of 96 percent after 72 hours. Similar tests with paraffin (42° m.p.) and with paraffin (55° m.p.) instead of the spermaceti gave mortalities of 95 and 100 percent, respectively. Derris and triethanolamine oleate at the same strength without wax gave a mortality of 90 percent. These tests were made as follows: Mulberry twigs were sprayed with the desired solutions and placed in vials of water under cages. As soon as the leaves were dry, 20 third or fourth instars were transferred to the foliage in the cages, 3 or more cages being used for each test. After 72 hours, the number of dead and living caterpillars was counted. The derris was used in the form of an extract equivalent to 1 pound of derris root (4 percent rotenone) to a gallon of stock emulsion. Similar tests with a pyrethrum extract equivalent to 1 pound of flowers (0.9 percent pyrethrins) to a gallon of stock emulsion killed less than half as many caterpillars.

Shepard and Campbell (368) in 1932 tested compounds isolated from derris and derivatives of rotenone, by the leaf-sandwich method of Campbell and Filmer, as modified by Campbell, in fourth instars with the following results:

Material	m.l.d. (mg./gm.)	
Rotenone	approximately	0.003
Dihydrorotenone	not more than	.010
Deguelin	between 0.01 and	.012
Tephrosin	between 0.03 and	.060
Acid lead arsenate	approximately	.090
Toxicarol	more than	1.540
Derritol	more than	.870
Rotenol	more than	.510
Dehydrorotenone	more than	.400
Tubaic acid	more than	.540

Voelkel (460) in 1933 gave an account of the after effect of a derris preparation on some silkworms that were not killed by it, but there was an apparent decrease in the number of individuals produced. The insects were carried through two generations.

Ginsburg and Granett (164, 165) in 1934 reported on the insecticidal properties of completely extracted derris-root residue, applied in the form of coarsely and finely ground dusts, against chewing and sucking insects. Silk moth larvae, cabbage worms, and apple aphids were used. The results suggest the following conclusions: Derris-root dust is very toxic to sucking and chewing insects. Against aphids the toxicity was greater when the dust was applied on wet than on dry foliage. Residues from derris root completely extracted with acetone possess practically no toxicity to aphids, but are both toxic and repellent to caterpillars. Residues from derris root extracted first with acetone and then with water do not seem to possess direct toxicity to caterpillars but act as a deterrent, preventing them from feeding on the dusted foliage. [Note: It is doubtful whether the extractions were complete.---R.C.R.]

Ginsburg, Schmitt, and Granett (167, 168) in 1934 reported the toxicity of various extracts of derris root to sucking and chewing insects. Derris root was extracted with acetone, alcohol, and water, two different processes being used, one consisting of continuous distillation in a Soxhlet apparatus for 10 hours, the other, of making a suspension of the ground root in cheesecloth and washing several times with fresh solvent. Secondary extracts were obtained by re-extracting the root residues from one solvent with another solvent. The primary and secondary extracts were tested on apple aphids, silk moth caterpillars, and mosquito larvae. The results suggest the following conclusions: Water-soluble organic solvents, such as acetone and alcohol, are able to extract practically all the water-soluble and water-insoluble ingredients of derris root toxic to sucking insects. Either continuous distillation or soaking with subsequent filtration and washing will extract practically all the active principles of derris root. At low dilutions the water extracts compared well in toxicity with acetone and alcohol extracts but proved inferior to them in high dilutions. Water extracts rapidly deteriorate on standing, with resultant loss of toxicity.

Garnett (169) in 1935 described further studies on the insecticidal properties of derris-root residues extracted with different solvents. Extractions were made by continuous distillation in Soxhlet apparatus for about 10 hours. These solvents can be divided into two groups: (a) Water-soluble: Ethyl alcohol, acetone, and acetic acid; (b) water-insoluble: Ethyl acetate, carbon tetrachloride, benzene, chloroform, and ether. Successive or secondary extractions were obtained by re-extracting the marc with the same or a different solvent. In some cases, the residue left on re-extraction was still further extracted with another solvent. The extracts were used to determine the percentage of total extractives present. The residues left after extraction and certain of the extracts were tested on silk moth larvae. The following conclusions were drawn from the results:

Ethyl alcohol was the only solvent which removed practically all the insecticidal substances from the root, leaving a residue which produced slight, if any, effect on silkworms or aphids. All the marcs tested, exerted a deterrent effect on silkworms.

The percentage of total extractives obtained from derris root varies with the type of organic solvent used. Water-soluble solvents tend to extract more total solids from the root than do water-insoluble solvents. However, the removal of a large percentage of total extractives by a solvent does not always indicate more efficient insecticidal extractive properties.

Tests on insects with the marcs and with certain of the extracts indicate that the water-soluble solvents also extract more of the active insecticidal ingredients.

Re-extraction with the same solvent after 10 hours' continuous Soxhlet extraction removes very little, if any, additional solids or insecticidal material from the root.

Successive extraction with a water-soluble solvent (acetone or alcohol) of a residue previously extracted with a water-insoluble solvent (ether or carbon tetrachloride) removes additional insecticidal constituents.

These results are also referred to in the annual report of the New Jersey Agricultural Experiment Station (292) for 1935.

Fischer and Nitsche (134) in 1935 reported tests on fifth instars with rotenone and various derris preparations. Pure rotenone 0.15 gm. in 98 cc. of neutral Turkey-red oil plus 2 cc. of acetone diluted with water 6:94 killed 97.5 percent of the silkworms within 2 days.

Tischler (413) in 1935 studied the mechanism of how derris kills insects. Studies on the heart rates of various insects (including silkworms) showed that the rate of pulsation was markedly decreased before the insects exhibited incoordinated movements. Other tests made with silkworms led to the conclusion that derris inhibits oxygen utilization by the tissues and that its detrimental effects are general rather than specific to any organ.

Trappmann and Nitsche (417) in 1935 reported that rotenone sprays gave 98-percent and rotenone dusts 100-percent mortality of fourth instars of the silkworm after 8 days. Dosage was regulated to give a deposit of 0.18 mg. of rotenone per 500 $cm.^2$.

Klinger (237) in 1936 reported the results of toxicity tests carried out with pyrethrum extract and with rotenone and derris root on fourth instars of a number of Lepidoptera. Fifteen-percent petroleum extracts of pyrethrum and of rotenone were diluted to 0.15 percent, with Turkey-red oil for spray tests and with talc for dusts. These talc and Turkery-red oil preparations served as standard solutions, being diluted further for the tests. The spray balance described by Trappmann and Nitsche and the dusting bell used by Lang and Welte were employed for measuring the dosages. The concentrations used in the actual tests were 0.00015 gm. of pyrethrin or rotenone in 100 gm. of dust (on 415 $cm.^2$) and 0.00018 gm. in 100 gm. of spray (on 500 $cm.^2$). In some instances it was necessary to double or treble this concentration. The standard agents were kept in well-closed containers in the dark and no loss in toxicity was apparent after 4 to 5 months. The tests were carried out at room temperature (19° to 25° C.). The spray gave 100-percent and the dust 95-percent mortality of 20 fourth instar silkworms after 8 days. Derris dust caused 100-percent mortality in 6 days. Rotenone was less effective than pyrethrum against most of the insects. Derris root was markedly more toxic than rotenone, showing that the other active constituents of the root--tephrosin, deguelin, and toxicarol--are of importance. The toxicity of the insect poisons in derris root, expecially rotenone, was shown to be due to a hindering of cell respiration and not to any action on the nervous system such as that caused by the pyrethrins.

Citheroniidae

Anisota senatoria (A. & S.), the orange-striped oak worm

Two small oak trees, on which about 300 caterpillars of this species were feeding, were sprayed thoroughly with derris at the rate

of 1 pound of powder to 25 gallons of water; soap was added at the rate of 1 pound to 50 gallons, and a knapsack sprayer was used. Within 24 hours the larvae became inactive and ceased to feed, and at the end of 6 days no living ones could be found. As a check on this test, powdered lead arsenate was applied at the rate of 1 pound to 50 gallons of water, and almost identical results were obtained. In a second test a small tree was sprayed and 24 hours later about 50 larvae were placed on it. The caterpillars ate very little and gradually disappeared, evidently leaving the tree, and at the end of 5 days they were nearly all gone.--McIndoo, Sievers, and Abbott (264) in 1919.

Kopp (242) in 1924 in a review of the use of derris as an insecticide stated that derris powder has given excellent results against this species when used as a spray (500 gm. to 100 liters containing 250 gm. of soap.)

Potts and Whitten (337) in 1940 described tests with concentrated mixtures for aerial spraying. In order to determine whether certain concentrated spray mixtures could be successfully applied from the air, and to study the comparative merits of various spreading agents, adhesives, arsenicals, and substitutes for arsenicals in concentrates, 22 mixtures were sprayed on woodland plots from an autogiro. Fresh foliage from most of the plots was fed to fourth and fifth instars. The degree of control was determined by comparing the amounts of frass passed by larvae feeding on sprayed and on unsprayed foliage. These foliage samples were taken 1 to 56 days after treatment and in all cases the spray residue was sufficient to kill some of the larvae. The arsenical sprays were more toxic than the organic sprays after the longer periods of exposure. The toxic principles of derris, derris extract, nicotine sulfate, free nicotine, and quebracho-fixed nicotine remained on the foliage in effective quantities after 2 to 3 weeks' exposure. With the exception of lime-sulfur none of the mixtures caused any injury to foliage of wild black cherry. The following derris mixtures were tested: (1) Derris 1, fish oil 0.4, water 5.6; (2) derris 1, fish oil 0.2, spreader B (water-soluble sulfonic acid of petroleum) 0.07, paraffin oil 0.2, water 5; and (3) derris extract 1, acetone 1, fish oil 4, spreader A (alkylphenylbenzene sulfonic acid) 0.5, water 37. The derris powder contained 4 percent of rotenone and the derris extract 25 percent.

Coleophoridae

Coleophora laricella (Hbn.), the larch casebearer

Kelsall et al. (233) in 1926 reported that derris, both dust and spray, gave a measure of control.

Hamilton (180) in 1938 reported that on larch trees 75 percent were controlled by a spray of derris or cube powder (4 percent rotenone) at 4 pounds per 100 gallons of water plus 4 pounds of rosin-residue emulsion. The spray acts as a stomach poison. The effective period is 3 to 4 days. Results are slow. These results are referred to in the 1938 annual report of the New Jersey Agricultural Experiment Station (294).

W. J. Haude in 1939, in advertising literature published by John Powell and Company, New York, N. Y., recommended a cube or derris spray (4 pounds of powder containing 4 percent rotenone per 100 gallons plus 4 pounds rosin-residue emulsion) against this insect on larch.

Coleophora malivorella Riley, the pistol casebearer

Pearis and Gould (325) in 1930 tested Derrisol, alone and also with Penetrol as an activator, against the newly hatched larvae. Varying results were obtained.

Coleophora pruniella Clem., the cherry casebearer

Hutson (205) in 1932 reported that a summer application of Derrisol 1:800 plus lime-sulfur solution 1:40 as a contact spray killed 84 percent of the larvae on cherry trees. Nicotine sulfate 1;800 plus lime-sulfar 1:40 gave a control of 88 percent.

Cosmopterygidae

Batrachedra amydraula Meyr.

Derris and derris plus sulfur were ineffective against the lesser date moth.--Dowson (100) in 1935.

Cossidae

Cossus cossus (L.)

Debussy et al. (57) reported in 1936 that this species is sensitive to derris dust but difficult to reach.

Crambidae

Chilo simplex (Butl.), the Asiatic rice borer

The Institute of Physical and Chemical Research (214), Tokyo, Japan, in 1927 reported that Neoton at the rate of 1 pound in 40 imperial gallons of water, sprayed on the eggs soon after oviposition and kept from rain, gave a mortality of 60 percent.

Chilo suppressalis (Walk.) (syn., Diatraea auricilia Dudgeon)

Jack (216) in 1923 wrote that the juice extracted from Derris elliptica was most effective in combating this stem-boring insect attacking rice.

Crambus bonifatellus (Hulst),

C. sperryellus Klots

Bohart (39) in 1940 reported that derris extract containing 2 percent of rotenone, diluted 1:400 with water and applied at the rate of 1 gallon per square yard, gave temporary control of these two sod webworms known to damage lawns in California. This treatment

did not prevent reinfestation within from 3 weeks to 1 month; therefore, it was necessary to repeat the treatment from one to three times during the summer. Lead arsenate used at the rate of 5 pounds to 1,000 square feet in 50 gallons of water, with 2 pounds of white flour added as an adhesive, gave excellent temporary control and retained its effectiveness throughout the season under most conditions. Where watering is done every day, it may be necessary in some cases to make two applications a month apart, using 10 pounds of lead arsenate and 4 pounds of flour to 1,000 square feet.

Crambus teterellus (Zinck.)

North and Thompson (308) in 1933 reported that damage to velvet bentgrass by the bluegrass webworm was reduced from an average of 2.25 percent to an average of 0.25 percent by the application of 1.5 pints of a proprietary rotenone extract per 111 gallons of water per 1,000 square feet. Lead arsenate 2 pounds in 20 gallons of water per 1,000 square feet reduced the damage to zero.

Crambus spp., sod webworms

Apply a dust (1.0 percent rotenone) at the rate of 1 pound per 100 square feet of wetted sod, or spray with cube or derris powder (4 percent rotenone) at the rate of 4 pounds per 100 gallons of water.--Haude in 1939, in advertising literature, published by John Powell and Co., New York, N. Y.

Crambidae sp. (unidentified), crambids on tobacco

L. B. Scott, at the second annual meeting of the Tobacco Insect Council in 1938 (414), discussing the use of dips prior to setting tobacco plants, stated that cube dust may be used with safety but its effectiveness against crambids is not known.

Galleriidae

Arenipses sabella Hampson

Derris and derris plus sulfur were ineffective against the greater date moth.--Dowson (100) in 1935.

Tirathaba sp.

Gater (154) in 1925 reported dipping tests with larvae to determine the relative values of extracts of different species of Derris.

Achroia grisella (F.)

Dusting with derris powder was unsuccessful.--Anonymous (5) in 1937.

Gelechiidae

Dichomeris marginellus (F.), the juniper webworm

A series of sprays and dusts was applied on May 8, 1936, to trees

in a heavily infested nursery block and therefore adjacent to infested unsprayed trees. On October 14, results were as follows: After rotenone sprays (several dilutions of rotenone-bearing proprietary sprays and 2 pounds of 3 percent rotenone dust in 50 gallons of water with and without spreader), the trees were heavily infested. Results obtained with rotenone dusts have been variable. The best kill, 73.3 percent, was obtained with a 0.75 percent rotenone dust applied late in the summer.--Langford (247) in 1937.

Keiferia lycopersicella (Busck.) the tomato pinworm

Barfoot. (23) in 1935 wrote as follows:

> Due to the rather outstanding results being obtained in the control of the pea leafminer by the use of standardized rotenone liquid sprays, it is this writer's opinion that if the same procedure were adopted on the tomatoes, this material would go far in the way of controlling the 'pinworm;' however, I strongly recommend spraying early and as often as every 10 days from blossom time until maturity.

C. A. Thomas (407, 408) in 1936 reporting on tests made in Pennsylvania, said that the larvae were easily affected by derris, pyrethrum, cube, and nicotine dusts and sprays, and proprietary insecticides containing these materials or extracts of them in combination with various carriers. Ground derris and cube root (2 to 4 percent rotenone) and mixtures of these with carriers such as dusting sulfur, bentonite and inert C, also are toxic, although the larvae die quietly without the violent reaction and strong regurgitation characteristic of pyrethrum effects. Tomato leaves dusted with a derris powder containing 4 percent of rotenone were still toxic to these larvae at the end of 4 weeks, although the plants were exposed in a window during that time. After the tomatoes have begun to form. such contact materials as derris, rotenone, pyrethrum, or nicotine dusts and sprays should be used. These materials, especially derris, containing several percent of rotenone, are very toxic to the larvae, and will kill them on brief contact. Many proprietary dusts contain too low a percentage of rotenone to be very toxic. Treatments with any of these materials should begin with the small seedlings and be repeated at intervals of a week or 10 days.

The Pennsylvania Agricultural Experiment Station (327) in 1937 stated that dusting with sulfur-clay-derris-lead arsenate gave good control.

Elmore (110) in 1938 reported tests of insecticides at Alhambra, Calif. Cube extract was ineffective. Cryolite and cuprous cyanide, in either sprays or dusts, were the most effective.

Haude in 1939, in advertising literature, published by John Powell and Co., New York, N. Y., cited Thomas of Pennsylvania, who found derris dust very toxic to young larvae.

Pectinophora gossypiella (Saund.) the pink bollworm

Fenton and Chapman (130) in 1933, reporting results of laboratory

and small field-plot tests at El Paso, Tex., stated that derris was by far the most effective insecticide used. In addition to preventing the young larvae from entering the bolls, derris was a repellent and decreased oviposition on the dusted bolls.

Chapman and Cavitt, in a typewritten report to the Division of Cotton Insect Investigations, Bureau of Entomology and Plant Quarantine, gave the following results of laboratory tests with cube and other insecticides in Presidio, Tex., in May 1934. Petri dishes with a small coin placed in the center were given a light covering of dust applied with a small hand gun in a dusting chamber. Approximately 25 newly hatched first instars were placed in the undusted circle, which had been covered by the coin, and were allowed to crawl into the dust. Examinations for mortality were made at intervals ranging from 1/2 hour to 2-1/2 hours. Four dusted dishes and a check were used for each test. In series I, 13 insecticides, including several samples of derris from different sources, cube, and pyrethrum, were used. The derris samples contained from 1 to 8 percent of rotenone and the cube contained 6 percent of rotenone. All the samples were mixed with flour in equal proportions. Pyrethrum showed no kill, "while many of the derris samples and the cube root showed as much as 100 percent kill at the 2-1/2 hour examinations. The checks showed no mortality."

In series II, the above-mentioned samples were all diluted with flour 1:3. "At the end of 2 hours there were few larvae alive in any of the tests and in one sample there was 100 percent mortality." In series III, the two samples of derris that gave the best results in Series I and II and the cube were selected. Dust No. 1: Derris, claimed to contain between 5 and 7 percent of rotenone, was mixed with flour 1:7. Diluted dust therefore contained approximately 0.75 percent of rotenone. In 2-1/2 hours 86.5 percent of the larvae were dead. Dust No. 7: Derris containing 5-1/8 percent of rotenone was mixed with flour 1:7. Diluted dust therefore contained approximately 5/8 percent of rotenone. Eighty percent of the larvae were killed in 2-1/2 hours. There was no mortality in the checks during the same period. Dust No. 12: Cube containing 6 percent of rotenone was mixed with flour 1:7. Diluted dust contained 0.75 percent of rotenone. All the larvae were dead in 2-1/2 hours.

Fenton, Chapman, Owen, and Fife (131) in 1934 reported the results of laboratory and field tests with insecticides at Presidio, Tex. In the laboratory tests for larval mortality, green bolls grown under cages and worm-free were used. They were cut from the plants with attached stems, which were inserted through carboard covers over jars of water. The bracts were removed and 10 eggs about ready to hatch were inserted beneath the involucre. The bolls were then thoroughly dusted and were examined 4 to 5 days later. Powdered derris (rotenone, 4.8 percent) was the most effective material in laboratory tests. It reduced the number of worms per boll over that of the checks 89 percent.

The field tests were confined to small groups of plants. All the bolls of suitable size were tagged and the infestations "stepped up"

in half of them by placing 10 eggs under the involucre, and leaving the other half with the natural infestation. The bolls were collected after 10 days and examined for worms that had entered. In the field tests derris reduced the number of worms 23 percent on the stepped-up infestation and 49 percent on the nautral infestation. Of the 12 insecticides tried, only sodium fluosilicate (26 percent reduction on the stepped-up infestation) was better than derris.

The effect of dusting bolls on oviposition was tried by placing 5 pairs of moths in breeding cages with dusted and undusted bolls and determining the total number of eggs laid and the percentage laid on the bolls. Moths in the derris cages became inactive and the average longevity was somewhat reduced.

Chapman, Hollingsworth and Robertson, in a typewritten report to the Chief of the Division of Cotton Insect Investigations, stated that only slight reduction in the pink bollworm infestation was effected in plants heavily dusted with a mixture of cube and sulfur (1 percent rotenone) at Presidio, Tex., in 1935. Cube (5 percent rotenone) used as a spray, 10 pounds to 50 gallons of water and 2 pounds of flour, reduced the worm population 71.9 percent, as compared with 46.8 percent from the use of barium fluosilicate spray. Chapman and Williams, in a typewritten report in 1936 stated that a dust of 10 percent cube, 10 percent pyrethrum, and 80 percent sulfur (0.49 percent rotenone), used in cage tests in 1936, was not so effective as barium fluosilicate or calcium arsenate. The weighted average percentage reduction in entries was 94.22 for barium fluosilicate dust, 81 for calcium arsenate dust, and 76.21 for the cube-mixture dust.

The Texas Agricultural Experiment Station (404) in 1936 and 1937 reported the results of tests by Chapman and others. Field tests were conducted during 1934 using derris, one of the three insecticides that showed most promise in 1933. Sulfur seemed slightly superior to either flour, kaolin, or tobacco dust as a diluent for derris. In 1937 the Texas Agricultural Experiment Station (405) reported on remedial measures conducted by Chapman as follows: Seasonal infestation counts indicated that barium fluosilicate and cube-sulfur used separately as dusts or sprays reduced the worm population. This was more apparent on the plants dusted with barium fluosilicate. Further investigations are necessary to determine the merits of insecticides for the control of this insect.

The United States Department of Agriculture, Bureau of Entomology and Plant Quarantine (442) in 1936 reported that barium flusoilicate cube, and cube-sulfur mixtures were selected for additional field-plot tests. All gave some control, as indicated by a reduction of the the number of worms per boll, but none were very effective or satisfactory.

Roark (357) in 1938 reviewed the comparative action of derris and cube of equal rotenone content on many insects. He referred to a typewritten report by Chapman and Cavitt, of the Division of Cotton Insect Investigations, who, in 1934, made laboratory tests on first in-

star pink bollworms at Presidio, Tex. Derris dust diluted with flour to 0.75 percent of rotenone killed 86.5 percent in 2-1/2 hours; cube dust of equal strength killed 100 percent in 2-1/2 hours.

Sitotroga cerealella (Oliv.) the Angoumois grain moth

Breakey and Miller (48) in 1935 reported the results of tests with rotenone as follows:

> Rotenone sprays were prepared from an extract of derris in pine oil, assaying 5 gm. of rotenone for each 100 cc. Emulsions were made fr m this stock containing 1 part of rotenone, 19 parts of pine oil, 5 parts of saponin, and 75 parts of water. Dilutions made from these emulsions gave the desired concentrations of rotenone. An attempt was also made to use rotenone as a colloidal suspension, preparing the suspensions from an extract of derris in acetone with the aid of a protective colloid, tannic acid. The results obtained from the use of these suspensions confirmed, in general, those obtained from the use of the emulsions. However, since there appeared to be impurities present in the suspensions which might affect the behavior of the toxin, these results have not been used in preparing this paper. A concentration of 1 part of rotenone in 50,000 parts of the spray killed more than 95 percent of the eggs.

Smerinthus ocellatus (L.)

Trappmann and Nitsche (417) in 1935 reported that rotenone sprays and dusts were not effective against fourth and last instars, respectively, of this species. Dosage was regulated to give a deposit of 0.18 mg. of rotenone per 500 $cm.^2$.

Klinger (237) in 1936 reported that rotenone spray (0.18 mg. per 500 $cm.^2$) killed 5 percent in 6 days and rotenone dust (0.15 mg. per 415 $cm.^2$) killed none in 8 days. Derris dust killed 60 percent in 4 days. These tests were made in the laboratory on fourth instars. Rotenone and ground derris root produced no symptoms of poisoning when applied to the body segments of larvae of this species.

Geometridae

Abraxas grossulariata (L.)

DeBussy et al. (57) in 1936 reported that the magpie moth is sensitive to derris dust.

Van der Laan (244) in 1936 reported that a plague of the currant cankerworm on gooseberry in the Netherlands was effectively controlled with derris.

Alsophila pometaria (Harr.), the fall cankerworm

Felt and Bromley (126) in 1937 reported the results of tests

made in 1936 and . 1937 several brands of pyrethrum powder and cube powders applied in a mixture of summer oil, 1:200, as contact insecticides. In general, results on exposed tent caterpillars were better than on this species. In 1938 these authors (127) reported on a comparative test conducted in May 1937, of lead arsenate, cryolite, and derris-resin-residue emulsion. A woodland border comprising deciduous trees up to 80 or 90 feet maximum height which were lightly infested with the young caterpillars, was sprayed with power sprayers. The derris powder (4 percent rotenone and 15 to 16 percent total ether extractives) was applied at the rate of 4 pounds to 100 gallons plus rosin-residue emulsion at 2 quarts to 100 gallons; Kryocide cryolite at 4 pounds to 100 gallons plus S.S.S. Spreader at 2 pounds to 100 gallons; and lead arsenate at 5 pounds to 100 gallons plus 0.5 pound of S. S. S. Spreader to 100 gallons. On the young larvae a good initial kill was obtained with all three materials, the most lasting protection being obtained with lead arsenate.

McDaniel (260) in 1938 reported on control on elms in Michigan. All sprays were applied under 600 to 800 pounds pressure at the nozzle. None of the sprays caused injury to the foliage. Results were good with cube and derris applied in June 1937 at the rate of 3 and 4 pounds, respectively, plus 3 pounds of rosin residue per 100 gallons of water. No live larvae were found on sprayed elms at the end of 72 hours, but they were numerous on the checks.

Bupalus piniarius (L.)

See Trägårdh (416) under Panolis griseovariegata, page 92.

Weis (477) in 1931 reported that fifth instars were very resistant to Polvo but the effect of the poison was noted in a decrease in the amount of excrement.

Schwerdtfeger and Stahl (367) in 1937 reported tests made in 1936 with 12 proprietary contact dust insecticides against larvae of the pine geometrid in Prussia. In the laboratory, batches of 50 larvae were dusted in the Lang-Welte apparatus [Rev. Appl. Ent. (A) 18:701] with quantities corresponding to about 45 pounds per acre, fed on untreated material, and examined for mortality after 2 days. Seven insecticides based on derris, pyrethrum, or veratrine caused average mortalities ranging from 44 to 100 percent, while 5 based on dinitrocresol gave 100-percent mortality. The effect of the latter was confirmed in further tests, in which almost complete mortality was obtained in 2 hours. In field work between July 20 and August 20, the insecticides were applied by power dusters at the rate of 45 pounds per acre in unmixed pine stands, each test area covering nearly 2-1/2 acres. The first group of 7 insecticides gave average mortalities of 30-79 percent, while the 5 dinitrocresol poisons gave mortalities of from 90 to 99 percent. The latter caused slight scorching of the pines, but only when the amount applied was excessive.

Cheimatobia brumata (L.)

Gimingham and Tattersfield (161) in 1928 found that extracts of

Tephrosia vogelii leaves and the stems and roots of black and white haiari were extremely repellent to larvae of the winter moth. Extracts of T. toxicaria roots and of T. macropoda stems and roots were also repellent to the larvae on hawthorn. Even at high dilutions (1 part of plant material to 400 parts of water) the sprayed foliage remained uneaten, and the larvae died of starvation. Soap 0.25 percent, was added to all these extracts.

Kearns, Marsh, and Pearce (231) in 1933 reported that derris spray gave good control of small winter moth larvae. Commercial experience with derris as a means of controlling apple pests in England is limited and the results have been variable. The indifferent results are probably due to the use of too low a concentration of the toxic principle (rotenone). Derris is used mainly in two forms for the preparation of sprays: (a) Finely ground derris root added to a weak soap solution, and (b) an oil emulsion consisting of a derris extract in a mineral or vegetable oil. The duration of effective toxicity after application of some preparations may be several days, but critical data on this point are not available for apple pests. Derris dusts have not been used to any extent on apples.

Kearns, Marsh, and Martin (230) in 1934 tried mixtures of rotenone and lime sulfur for the control of the winter moth on apples in Worcestershire, England. The composition of the rotenone spray was as follows: 1.2 ounces of rotenone, 1.18 pints of acetone, 1.5 gallons of lime-sulfur, and 1 pound of sulfonated Lorol to 100 imperial gallons of water. This was prepared by the addition of an acetone solution (5.13 percent) of rotenone to the dilute lime-sulfur plus sulfonated Lorol solution. The sprays were applied in drenching amounts on May 17, 1934, each to 4 trees selected at random, 4 other trees being left unsprayed as controls. Immediately after spraying small numbers of half-grown larvae were collected from the sprayed trees and kept under observation. Many of the insects collected from the rotenone-sprayed trees remained active for an hour, then paralysis set in; 15 hours later all the larvae were moribund.

Moore (105) in 1934 reported field tests of combined derris-fungicide sprays. Lead arsenate was not included in the program and control of caterpillars of the winter moth group by the contact insecticides was indifferent, although infestation of fruits on unsprayed control trees reached only about percent. Derris with sulfite lye failed to wet and spread well on the foliage but the addition of lime-sulfur improved the mixture in this respect. Neither nicotine nor derris greatly reduced the proportion of fruits bitten by winter moth caterpillars.

Craufurd-Benson (85) in 1938 reported that for testing derris insecticides by his dipping method (Bul. Ent. Res. 29:41) many insects are unsuitable. Winter moth larvae were tried, with unreliable results, probably because of the variable weather conditions at the time of collection, the variety of food material, the lack of uniformity in the size of the larvae, and the impossibility of knowing their age. The following tabulation shows a typical result of a trial with a derris insecticide on larvae of this species collected in the field.

Concentration (mg./l: mg. of derris)	Trial No. 1	2	3	4	Average
250.0	100	70	100	70	85.0
125.0	100	60	80	50	72.5
62.5	90	40	60	40	57.25

This pest on cherry, pear, and plum was killed by a product containing 12 percent of powdered Lonchocarpus nicou root (6 percent rotenone content) and 88 percent of talcum, according to a letter from Etablissements Rotenia to R. C. Roark in 1938.

Cingilia catenaria (Drury), the chain-spotted geometer

Derris, both dust and spray, was ineffective. -- Kelsall et al. (233) in 1926.

Paleacrita vernata (Peck), the spring cankerworm

McDaniel (260) in 1938 reported on control on elms in Michigan. All sprays were applied under 600 to 800 pounds pressure at the nozzle and none injured the foliage. No live larvae were found at the end of 72 hours after the application of cube or derris powder (3 and 4 pounds, respectively, plus 3 pounds of rosin residue per 100 gallons of spray). Larvae were numerous on the unsprayed trees.

Selenia tetralunaria (Hufn.)

Gimingham and Tattersfield (161) in 1928 found that extracts of Tephrosia vogelii leaves and the stems and roots of black and white haiari were extremely repellent to larvae. Even at high dilutions (1 part of plant material to 400 parts of water) the sprayed foliage remained uneaten, and the larvae died of starvation. Soap, 0.25 percent, was added to all these extracts.

Tattersfield and Gimingham (401) in 1932 reported that an alcoholic extract of the root of Tephrosia macropoda when sprayed on the larvae had considerable value as a contact insecticide. The stems were less effective and the leaves were of little value. Alcoholic extracts of black haiari (Lonchocarpus sp.) were toxic to the young larvae and to those three-quarters grown.

Tephroclystia absinthiacta (Cl.)

Schotte and Görnitz (364) in United States patent 2,024,392 claim an insecticidal preparation consisting of a mixture containing rotenone and veratrine. They also claim an insecticidal preparation consisting of a mixture containing 2.5 parts of Derris elliptica root and 7.5 parts of sabadilla seed. By combining one of these drugs containing rotenone with a drug containing veratrine, $C_{37}H_{53}O_{11}N$ sabadilla seed or an extract or alkaloids recovered from

such products--an insecticidal effect was obtained which was far greater than the effects exerted by the two drugs used singly. This is shown by the following comparative tests made by using strewable preparations consisting of intimate ground mixtures of sabadilla seed with talc, Derris elliptica root with talc, and with a mixture of sabadilla seed and D. elliptica root. In each test 30 caterpillars of Tephroclystia absinthiaeta (Cl.), placed on blotting paper, were dusted with a quantity of one of the mixtures corresponding to 0.16 mg. per square centimeter, the powder being evenly distributed.

Preparation	Caterpillars	
	Killed	Not Killed
	Number	Number
Talc + 2.5 percent derris root	1	29
Talc + 5 percent derris root	10	20
Talc + 7.5 percent derris root	18	12
Talc + 7.5 percent sabadilla seed	17	13
Talc + 10 percent sabadilla seed	19	11
Talc + 15 percent sabadilla seed	26	4
Talc + 2.5 percent derris root + 7.5 percent sabadilla seed	30	0
Control test	0	30

Geometridae (unidentified sp.)

Geometrid larvae on a cut-leaf birch were killed and dropped in a few hours when sprayed with derris 1.5 pounds per 100 imperial gallons of water, plus soap.--Kelsall et al. (233) in 1926.

The Institute of Physical and Chemical Research (214) Tokyo, Japan, in 1927 reported that the external or contact action of Neoton is effective against geometers (larvae).

Turner (418) in 1932 reported that in a field test some small apple trees received 2 sprays containing cube extract at the rate of 1:25,000 and 1:12,500, to kill a heavy infestation of cankerworms. The sprays did not kill the worms, but no further feeding occurred on the sprayed trees. The larvae remained on the sprayed leaves for several days and were apparently normal in reaction to prodding.

Hamilton (179) in 1935 stated that powdered derris is more stable and cheaper than derris extract. One pound of derris dust (rotenone 1 percent) to 15 gallons of water was effective against half-grown cankerworms.

Van Gundia (452) in 1936 reported control of cankerworm on many varieties of shade trees with a rotenone dust containing approximately

30 percent of sulfur in the form of fused bentonite sulfur, which aids as a sticker for the rotenone and also acts as an activator.

Hamilton (180) in 1938 reported that cankerworms on various shade trees were satisfactorily controlled by a spray of cube or derris powder (4 percent rotenone) at the rate of 4 pounds per 100 gallons of water plus 4 pounds of rosin-residue emulsion. The spray acts as a contact poison and as a repellent. The effective period is 3 days to 2 weeks, and one spraying before larvae were more than two-thirds grown gave good kill. These results are referred to by the New Jersey Agricultural Experiment Station (294) in 1938.

W. J. Baude in 1939 in advertising literature published by John Powell and Co., New York, N. Y., recommended cube or derris spray, 4 pounds of powder of 4 percent rotenone content plus 4 pounds of rosin-residue emulsion per 100 gallons, for the control of cankerworms.

Gracilariidae

Phyllonorycter, n. sp.

The United States Department of Agriculture, Puerto Rico Experiment Station (451), in 1940 reported that early in January 1939 the leaflets of a number of potted insecticidal plants of Tephrosia toxicaria and T. vogelii were attacked by the larvae of a small moth, which caused them to drop prematurely.

Hesperiidae

Erionota thrax (L.)

Flippance (137) in 1920 suggested derris powder for use against the larvae.

Urbanus proteus (L.) the bean leaf roller

Wisecup (489) in 1933 reported tests in which leaves were treated in the laboratory and larvae introduced. Rotenone dust was effective against small larvae but against large larvae cryolite and lead arsenate dusts were more effective. Rotenone-containing sprays, 1 part in 200 parts of water, appeared to be rather effective repellents, as only a small portion of the treated food was eaten. However, when untreated food was added the larvae fed readily and developed normally, indicating that the contact with the rotenone-treated food had not been fatal.

Hyponomeutidae

Argyresthia conjugella Zell., the apple fruit moth

Stapley (392) in 1934 described laboratory tests with derris against the apple fruit miner in England. Two batches of eggs were lightly dusted over with a derris dust 10 days after they were laid. The young larvae could be seen inside the eggs, which were due to hatch in 3 or 4 days. About half the eggs hatched but the young

larvae were killed on leaving the eggs or immediately afterwards, as soon as they touched the dust. The dust may have inhibited the hatching of some of the eggs but it must be remembered that mortality of ova was often observed to be high when large numbers were present on a single fruit.

Argyresthia ephipella (F.)

Jancke (217) in 1931 reported that in investigations in Germany on the control of the cherry blossom moth, a bait spray of 2 parts per 1,000 of Polvosol (a proprietary insecticide containing derris) and 4 percent of molasses (50 percent sugar) gave excellent results against the adults. In the laboratory a mortality of 80 percent on the third day after spraying was obtained with this concentration of insecticide, higher or lower concentrations being less successful. Probably a second or third application would increase the effect. Only about a pint of spray was required for each tree, so the cost was low.

Hyponomeuta cognatella (Hbn.)

Spoon and Van der Laan (385) in 1935 described tests with various samples of powdered derris root to determine whether rotenone content or total ether extract is the better means of judging the quality. The materials were dusted and sprayed on caterpillars of several species, including this ermine moth. The rotenone content of the 10 samples of derris root ranged from 0 to 8 percent, and the total ether extract from 8 to 23 percent. When applied as a spray 0.1 percent of Agral was added as a spreader. The writers concluded that the ether extract is not a sufficient indication of the biological value of derris root. A good indication, however, was obtained from a consideration of the rotenone content as obtained by the extraction-crystallization method. The rotenone content must therefore be given first consideration in rating derris root. In derris root containing a sufficient amount of rotenone (4 percent or more) the quantity of ether extract is of no consequence in respect to biological effectiveness, but with roots having low rotenone content (under 2 percent) and high ether extract the latter factor can influence the effectiveness.

DeBussy et al. (67) in 1936 reported that the larvae were sensitive but the moths insensitive to derris dusts and sprays.

Hyponomeuta malinella Zell.

Jancke (218) in 1933 reported that in Germany certain derris preparations proved very suitable in the control of the larvae of Hyponomeuta (variabilis) malinella and H. padella. A mortality of 80 to 85 percent was obtained by the use in bait traps of derris extract and of Katakilla (a proprietary derris preparation) when used at 1:100 in 3 percent sugar solution. The cheapness of the material indicates the possibility of complete control.

Klinger (237) in 1936 reported that rotenone spray and dust gave no mortality in 8 days. These tests were made in the laboratory on fourth instars.

Böhmel (40) in 1937 reported that effective poisoned baits against this species were 0.4 percent of sodium fluoride and 1 percent of derris (as an acetone extract or as Katakilla) when mixed with sugar. Derris did not produce any scorching, but sodium fluoride did. The bait sprays contained either 0.4 percent of sodium fluoride with sugar or molasses, or 1 percent of an acetone extract of Derris elliptica with sugar. In some tests a dye was added to the spray and was traced on dissection, which confirmed direct observation of feeding. In the laboratory, all adults placed on sprayed leaves before and after the spray had dried were dead in 2 to 3 days. These results were confirmed by tests in field cages, and in a test on plum trees in the open the number of moths was greatly reduced within 2 to 5 days, in spite of rain. With molasses the toxic action was a little slower than with sugar, and derris was the more effective poison.

Hyponomeuta padella (L.), the ermine moth

See also Jancke (218) under Hyponomeuta malinella, on page 24.

The larvae were used as test insects by Fryer et al. (149) in 1923 in studying the insecticidal properties of derris.

A product containing 12 percent of powdered Lonchocarpus nicou root (6 percent rotenone) and 88 percent of talcum killed Yponomeuta padella on cherry, according to a letter from Etablissements Rotenia to R. C. Roark in 1938.

Hyponomeuta sp.

Van der Laan (244) in 1936 reported that "Yponomeuta" sp. was sensitive to derris.

Lasiocampidae

Dendrolimus pini (L.)

See also Trägårdh (416) under Panolis griseovariegata, on page 92.

Schwerdtfeger (366) in 1932 reported effective control of this species with the proprietary powders Derrothan I and Derrothan II and the emulsion Derrothan, containing derris.

Fischer and Nitsche (134) in 1935 reported tests on these pine moth caterpillars with rotenone and various derris preparations. Crude rotenone 0.6 gm. in 94 cc. of neutral Turkey-red oil plus 6 cc. of acetone, diluted with water 6:94, killed 55 percent after 5 days.

Trappmann and Nitsche (417) in 1935 reported that rotenone sprays gave a 4-percent and rotenone dusts an 8-percent mortality of last instars of this species after 8 days. Dosage was regulated to give a deposit of 0.18 mg. of rotenone per 500 cm.^{2}.

Klinger (237, 238) in 1936 reported that rotenone dust gave 5 percent mortality and rotenone spray 15-percent mortality of this species after 8 days. Derris dust gave 40-percent mortality in 6 days.

These tests were made in the laboratory on fourth instars. Later this author reported that of 17 fourth instars treated with derris root 5 died at the following molt and 3 more could not build complete pupal cases. Of the 9 normally pupated caterpillars, 6 developed into female moths and the other 3 died in the pupal cases.

Malacosoma americana (F.), the eastern tent caterpillar

McIndoo, Sievers, and Abbott (264) in 1919 reported the results of tests with derris against young caterpillars of this species in a series of strengths ranging from 1 pound of powder per 8 gallons of water to 1 pound per 200 gallons. All the mixtures were effective. Apple-tree branches were thoroughly sprayed and after the foliage had dried 20 to 40 newly hatched larvae were placed on each branch. The larvae began to show signs of discomfort within 48 hours and practically all were dead in from 5 to 10 days. No appreciable feeding was observed. In a second series of tests the larvae were placed on the branches and sprayed after they had begun to form their tents. Sprays containing 1 pound of powder to 50 gallons of water and 1 pound to 100 gallons killed all the larvae within 24 hours. When 1 pound to 200 gallons and 1 pound to 400 gallons were used, not all the larvae were killed within 11 days, but the few remaining alive were very small and inactive. Used as a dust, this material killed all the treated larvae within 1 week.

Kelsall et al. (233) in 1926 reported (1) that the derris applied to the caterpillars along with the foliage gave much higher control than where applied to the foliage alone; (2) that 1 pound of derris per 100 imperial gallons of water gave an equal eventual control, though much more rapidly, than 2 pounds of lead arsenate; (3) that when applied direct to the foliage but not to the caterpillars, derris was not quite equal, pound for pound, to lead arsenate; and (4)that used in practical strengths, derris was much more effective than nicotine.

Rotenone suspended in water 1:30,000 killed 100 percent of the first and second instars on plum and apple. Of the thirs instars 47 percent were killed at 1:100,000--Davidson (90) in 1930.

Little (254, 255) in 1931 reported on the insecticidal properties of roots of devil's-shoestrings (Tephrosia virginiana) dug from several localities at various times of the year and dried by different methods, then finely ground in an herb mill. Field experiments showed that the plant has considerable promise as a contact spray against this species. He also determined the comparative death rates caused by Tephrosia virginiana root and by derris in experiments with this insect. Caterpillars ranging from one-third to two-thirds grown were dipped in dilutions of 1:400 for 20 seconds and then placed in cages on dipped foliage. Fifty caterpillars were used in each experiment, and with each insecticide 4 experiments were run. All the larvae were affected, but some recovered and resumed feeding. Two experiments with each insecticide were carried through until the caterpillars had either died or transformed to moths. From 100 caterpillars dipped in the derris spray, 14 pupated and 11 moths emerged, with 38 pupating and 34 moths emerging from the experiments with devil's-shoestrings. Field

tests with the powdered devil's-shoestrings root gave excellent control. It was indicated that the plant is a repellent rather than a stomach poison.

F. L. Campbell (60) in 1932 critically reviewed the results of Davidson, who found that rotenone suspended in water 1:400, sprayed on leaves and fed to the fourth instars as a sandwich, killed all; at 1:1,000, feeding was curtailed. Ten larvae at the beginning of the fourth stadium were used, 1 larva to a Petri dish. Each larva was given an apple-leaf sandwich (5/8 inch in diameter) containing about 0.002 cc. of a 1:1,000 suspension of rotenone, and probably containing about 0.002 mg. of rotenone. The larvae ate from one-eighth to one-third of the sandwiches and therefore probably did not consume more than 0.001 mg. of rotenone. All but one of these larvae finally died. If they weighed about 0.1 gm., they were killed by doses of about 0.005 mg. of rotenone per gram of body weight. This calculation is very uncertain, but shows that rotenone is much more toxic to tent caterpillars than is acid lead arsenate. Preliminary results obtained by Bulger indicate that a dose of at least 0.15 mg. of acid lead arsenate per gram of body weight of tent caterpillar in the last instar is required to kill 50 percent of a population or, in other words, that the median lethal dose is greater than 0.15 mg. per gram.

Turner (418) in 1932 reported that cube extract in oil emulsified in water with a sulfonated mineral oil (cube extract 1:50,000, oil 0.5 percent) killed 62 percent of the half-grown larvae. The check oil killed 12 percent. In tests made by Turner in 1929 to determine the repellent effect of cube extract, rose plants in the greenhouse were sprayed with emulsified mineral oil containing cube extract 1:25,000. Several larvae were placed on each sprayed plant and on suitable check plants. In four tests there was much less feeding on the sprayed than on the unsprayed leaves. The larvae failed to grow on sprayed plants One sprayed plant was washed twice in 4 days before larvae were placed on it. These larvae grew normally.

Badertscher and Wotherspoon (19) in 1935 compared the stability of treated derris and pyrethrum powders with that of untreated powders. Tests were made on the eastern tent caterpillar. Exposure to a light from a Uviarc mercury vapor lamp operating on 118 volts with a current of 4.8 amperes and 450 watts for 24 hours destroyed about half the toxicity of a derris powder containing 6 percent of rotenone and 18 percent of acetone extractives. Treated powders (treatment not described) prolonged the life of these powders when exposed to light. The authors concluded:

> That derris powder requires at least twice as long as pyrethrum to lose most of its toxicity when exposed to the action of air and sunlight in the summertime.
>
> That the rapidity of loss of toxicity in pyrethrum and derris powders is largely directly dependent on the intensity and duration of the light.
>
> That derris powder loses its toxicity relatively much slower than pyrethrum powder when exposed to air in the absence of direct light.

That treated derris powder after exposure to light and air shows an efficiency from 34 to 93 percent greater than untreated derris powder similarly exposed.

Felt and Bromley (126) in 1937 reported the results of tests made in 1936 with several brands of pyrethrum powder and cube powder applied in a mixture of summer oil 1:200 as contact insecticides. In general, results on exposed tent caterpillars were better than on cankerworms. One or two commercial brands of derris powder gave excellent kills of exposed tent caterpillars at the rate of 3 pounds of 4-percent powder to 100 g llons of spray. The cube powder appeared slightly less toxic, requiring larger amounts of material. The pyrethrum powder in the oil emulsions was invariably less toxic than the pyrethrum-extract soap sprays and less toxic to the older tent cater illars than was the derris.

Derris-gypsum dusts containing 5, 12.5, and 25 percent of derris (4 percent rotenone) in laboratory tests caused mortalities of 0, 28, and 92 percent, respectively.--Kelsall and Stultz (234) in 1937.

Hamilton (180) in 1938 reported that the larvae on wild cherry, apple, and hawthorn trees were satisfactorily controlled by a spray of cube or derris powder (4 percent rotenone) at the rate of 4 pounds per 100 gallons of spray plus 4 pounds of rosin-residue emulsion. The spray acts as a contact poison and as a repellent. The effective period is 6 to 8 days. Caterpillars would not feed on sprayed foliage. These results were referred to by the New Jersey State Agricultural Experiment Station (294) in 1938.

Felt and Bromley (128) in 1940 reported that cube dust was effective against very young eastern tent caterpillars in southwestern Connecticut in the spring of 1939.

Malacosoma disstria Hbn., the forest tent caterpillar

A 5 or 6-year old sample of derris was ineffective when dusted or sprayed on chokecherry foliage fed on by the caterpillars.--Kelsall et al. (233) in 1926.

Malacosoma neustria (L.)

The larvae were used as a test insect by Fryer et al. (149) in 1923 in evaluating derris preparations.

Spoon and Van der Laan (385) in 1935 described tests with various samples of powdered derris root to determine whether the rotenone content or the total ether extract is the better means of judging the quality. The materials were dusted and sprayed on the caterpillars of several species, including the lackey moth. The rotenone content of the 10 samples of derris root ranged from 0 to 8 percent; and the total ether extract from 8 to 23 percent. When applied as a spray 0.1 percent of Agral was added as a spreader. It was concluded that the ether extract is not a sufficient indication of the biological value of derris roots. A good indication, however, is obtained from a consideration of the rotenone content as obtained by the extraction-crys-

tallization method. The rotenone content must therefore be given first consideration in rating derris root. In derris root containing a sufficient amount of rotenone (4 percent or more) the quantity of ether extract is of no consequence in respect to biological effectiveness, but with roots with low rotenone content (under 2 percent) and high ether extract, the latter is a factor in the effectiveness.

De Bussy et al. (57) and also Van der Laan (244) in 1936 reported that this species is sensitive to derris dust.

Klinger (237) in 1936 reported that larvae of this species had been used to test the effect of rotenone dusts and sprays but no results were recorded.

A product containing 12 percent of powdered Lenchocarpus nicou root (6 percent rotenone) and 88 percent of talcum killed this species on pear, according to Etablissements Rotenia in 1938, in a letter to R. C. Roark.

The Koloniaal Instituut of Amsterdam (241) in 1938 proposed specifications for derris root, derris powder for spraying purposes, and powdered-derris mixtures. The moisture content of the root and of powdered root for spraying purposes must not be over 10 percent. The fineness of the latter material must be such that 90 percent will pass a 75-mesh sieve. The powdered mixtures must be made with a neutral filler, the maximum moisture content should be 2 percent, at least 90 percent must pass a 125-mesh sieve, and the density must be between 0.6 and 1.2. The following materials were suggested as carriers: Diatomaceous earth (density 0.65), Kaolin (density 0.83), talc (density 1.12), and gypsum (density 1.33). Derris powder of a fineness such that 90 percent passes a 125-mesh screen has a density of 0.56. During 1937 derris preparations containing 1 percent of rotenone were used in the Netherlands in combating this species.

At a meeting of the Netherlands Entomological Society in 1938, Polak (329) criticized the use of a derris dust against larvae of this species attacking trees in Amsterdam. He argued that the larvae would be shielded by their webs against the dust, that many harmless species would be destroyed, and that control would best be obtained by means of hymenopterous parasites. Diakonoff replied that derris greatly reduced the ultimate number of pupae and adults.

Fransen (141) in 1939 reported the results of investigations in the Netherlands on the most economical employment of contact dust insecticides. The apparatus used for ascertaining the minimum lethal dosages is described. Tests were made on larvae in different stages of development. Fifty times as much rotenone was necessary to kill the largest larvae as to kill the smallest used (3.0 and 0.4 cm. in length, respectively). The author concluded that for a given insecticide there is no fixed relation between the quantities necessary to control the larvae of this in different stages of development, and still less between the necessary quantities of the active components of the various insecticides and a given developmental stage of any group of insects. The susceptibility of the larvae may vary, owing to internal causes and weather conditions. Temperature did not greatly

affect mortality, but dew and light rain before or after the dusting increased the mortality.

Malacosoma pluvialis (Dyar), the western tent caterpillar

Campbell (60) in 1932 reviewed unpublished work by Robinson of Oregon, who reported a few tests with rotenone in an insectary. Most of the caterpillars that ate any of the foliage treated with rotenone at 1:1,890 and 1:1,260 died. Robinson noted that the toxic action was slow and that many of the caterpillars placed on the sprayed apple foliage fell to the table below. He therefore concluded that rotenone is repellent to the larvae. However, Campbell surmised that the caterpillars that fell from the foliage might have been irritated by handling.

Lasiocampidae (unidentified sp.)

Kopp (242) in 1924, in a review of the use of derris as an insecticide, stated that derris powder has given excellent results against Malacosoma (500 gm. to 32-800 liters of water).

McIndoo and Sievers (263) in 1924 reported that a hot-water extract of the stems of a fish poison, Cracca villosa purpurea (Tephrosia purpurea), had no effect on tent caterpillars, and that derris powder used as a fumigant was ineffective against small tent caterpillars.

The Institute of Physical and Chemical Research (214), Tokyo, Japan, in 1927 reported that Neoton at 150, 225, and 300 gm. plus 450 gm. of soap per 40 imperial gallons of water gave mortalities of 56, 60, and 72 percent, respectively, after 24 hours; and of 82, 78, and 96 percent, respectively, after 30 hours. Neoton at 225 gm. plus 675 gm. of soap per 40 imperial gallons of water gave 100-percent mortality of the Japanese tent caterpillar.

According to the Harder Extermination Service, Inc., in an advertising leaflet in 1934, its Harder Rotenone Plant Spray is used at 1:40 for killing tent caterpillars.

Tischler (413) in 1935 studied the mechanism of how derris kills insects. Tests made with insects such as tent caterpillars lead to the conclusion that derris inhibits the utilization of oxygen by the tissues and that its detrimental effects are general rather than specific to any organ.

Haude in 1939, in advertising literature published by John Powell & Co., New York, N. Y., recommended a cube or derris spray (4 lb. of powder containing 4 percent rotenone per 100 gal. plus 4 lb. rosin-residue emulsion) against the tent caterpillar on wild cherry, apple, and hawthorn.

Limacodidae

Parasa consocia Walk.

Yago (502) in 1933 wrote that this species, formerly abundant in

pear orchards in Shizuoka, Japan, had become scarce, probably owing to the use of insecticides, including derris.

Parasa herbifera (Walk.)

Gater (154) in 1925 reported dipping tests with mature larvae of this species to determine the relative values of extracts of different species of derris.

Setora nitens Walk.

Van der Scheer (360) in 1935 ascribed the unsatisfactory results reported for the use of rotenone suspensions to a lack of stability of the suspensions used, and suggested first dissolving the rotenone in a liquid insoluble in water, then preparing a rotenone emulsion from this solution, because emulsions are regarded as being more stable than suspensions. Benzene is well suited as a solvent for rotenone for the preparation of rotenone emulsions. Soap is not suitable, because of its alkaline reaction. Igepon T may be used, as follows: One gm. of rotenone is dissolved in 20 cc. of benzene. This is added to 30 cc. of Igepon T solution (0.3 to 0.5 percent Igepon T) and the mixture agitated until a homogeneous liquid is obtained. This concentrated emulsion is then diluted with water to the desired concentration, which should first be determined on a small scale. The spray material must be kept in a closed container, or evaporation of the benzene will cause the rotenone to separate from the emulsion. This disadvantage may be avoided by the use of some inexpensive essential oil, such as "katjang" oil, which also has some insecticidal activity, and which protects rotenone from oxidation. Stable emulsions were prepared by the addition of pine oil to the katjang oil. Oil citronella may also be added. The rotenone-benzol emulsions at a concentration of 1:5,000 gave good control of "Setora nitensis." The fruit of the lerak (Sapindus rarak) contains a saponin that is an excellent emulsifying agent and may be used to replace the Igepon T. By heating 8 of the fruits with 1 liter of water, sufficient emulsifying agent to prepare 250 liters of emulsion is obtained.

Limacodidae (unidentified sp.)

The Ceylon Tea Research Institute (66) in 1930 described tests of insecticides against nettle grubs on tea in Ceylon. Nicotine oleate at the dilution tested gave very disappointing results. A spray solution made from the foliage of Tephrosia vogelii waseffective.

Lymantriidae

Arctornis alba (Bremer)

Sonan (378) in 1927 reported that spraying with derris and soap proved very effective against this species infesting tea plants in Formosa.

Dasychira mendosa (Hbn.)

Sonan (378) in 1927 reported that spraying with derris and soap

proved very effective against (Olene) Dasychira mendosa (Hbn.) infesting tea plants in Formosa.

Euproctis conspersa (Felder)

The Institute of Physical and Chemical Research (214), Tokyo, Japan, in 1927 reported that Neoton at 300 gm. plus 750 gm. of soap per 40 imperial gallons of water gave 100-percent mortality of the larvae.

Euproctis fraterna (Moore)

Bhatta and Narayanan (35) in 1938 reported that in small-scale field trials extracts of seeds of Tephrosia candida and stem bark of Mundulea sericea were effective at 2-and 3-percent concentrations, respectively, against larvae of this species on apple.

Water suspensions and alcoholic extracts of the roots of Derris elliptica grown at Bangalore, India (rotenone 7 percent, ether extractives 22 percent) were effective.--Mysore, India, Department of Agriculture (287) in 1938.

Euproctis pseudoconspersa (Strand)

Sonan (378) in 1927 reported that spraying with derris and soap proved very effective against this species infesting tea plants in Formosa.

Hemerocampa leucostigma (A. & S.) the white-marked tussock moth

McIndoo, Sievers, and Abbott (264) in 1919 reported the results of tests in which fine derris powder was extracted successively with five solvents, namely, petroleum ether, ether, chloroform, alcohol, and water, in five different sequences. Water used as the primary solvent extracted 10.80 percent of the material. The extracts and the marcs were added to honey and fed to honeybees (Apis mellifera L.). The extracts were dissolved in alcohol (0.4 gm. in 10 cc. of 95 percent alcohol), and 1/4 cc. of this solution was mixed with 5 cc. of honey. The water extract had no effect on the bees tested and the powder exhausted with water killed 94 percent of the bees within 48 hours. All the other extracts, whether obtained with the use of heat or without it, were almost equally toxic to honeybees. Using the same extracts against tussock moth caterpillars gave similar results.

Hamilton (180) in 1938 reported that larvae on various shade trees were not satisfactorily controlled by cube or derris-powder spray (4 lb. of powder containing 4 percent rotenone per 100 gal. of water, plus 4 lb. rosin-residue emulsion). The spray acts as a contact poison and as a repellent. Control was 10 percent in one test and from 50 to 75 percent in other tests.

Laelia suffosa (Walk.)

Gater and Yusope (155) in 1925 stated that the usual aqueous derris extract, as made in British Malaya, would form an effective spray

against young caterpillars of this species damaging padi.

Lymantria monacha (L.)

See Tragardh (416) under Panolis griseovariegata, on page 92.

Schwerdfeger (366) in 1932 reported experiments on the control of the nun moth with several proprietary insecticides, including an emulsion (Derrothan) and two powders (Derrothan I and Derrothan II) containing derris or extracts thereof. The powders, tested at 50 kg. per hectare, caused 100-percent mortality in 24 hours, and the emulsion also was very effective.

Trappmann and Nitsche (417) in 1935 reported that rotenone sprays were not effective against last instars of this species. Dosage was regulated to give a deposit of 0.18 mg. of rotenone per 500 $cm.^2$.

Klinger (237) in 1936 reported that rotenone spray and dust gave no mortality in 8 days. These tests were made in the laboratory on fourth instars.

Schotte and Gornitz (365) in United States patent 2,136,868, issued November 15, 1938, claim as an insecticide a finely divided mixture, solidified from the molten state, of an insecticidal vegetable material and a carrier substance, the said carrier substance being solid at ordinary temperatures, but melting below carbonization temperatures of said vegetable material and in its molten state being capable of extracting the active insecticide from said insecticidal vegetable material. For example, derris root is mixed with molten naphthol in the proportion of 3:5 and the solid mixture is ground with a suitable diluting agent, such as talc. The product is highly efficient against caterpillars and also possesses fungicidal properties. Comparative tests each made with 50 5th instars, 44 pounds being distributed on 2.5 acres, gave the following results:

Test No.	Killed after -- 7 days	Killed after -- 8 days	Feeding Conditions
	Number	Number	
A. Mixture of inert powder 80 percent and derris root 20 percent.			
1	20	30	Strong
2	22	33	Strong
3	15	30	Strong
B. Mixture of inert powder, 80 percent and derris root-naphthol mixture, 20 percent.			
4	32	39	Weak
5	33	41	Not feeding
6	29	35	Weak

In another example equal parts of pyrethrum blossoms and derris root were mixed with molten naphthalene in the proportion of 3:5 and the mixture ground with alumina. Sodium acetate, borax, carbazole, thymol, isothymol, or crude anthracene may be used in place of naphthalene or naphthol. The insecticides obtained according to the present invention may also be combined with other insecticidal substances, such as arsenic compounds; or with fungicides, such as copper compounds; and with adhesives, such as lime-soaps; or with fillers, such as talc, alumina, china clay, bole, and the like. It has been found useful to add Turkey-red oil or other salts of sulfonic acids for spraying purposes.

Notolophus posticus (Walk.)

Sonan (378) in 1927 reported that spraying with derris and soap proved very effective against this species infesting tea plants in Formosa.

Nygmia phaeorrhoea (Donov.) (syn., Euproctis chrysorrhoea L.), the brown-tail moth

Weis (477) in 1931 reported that larvae were killed more quickly when dusted with Polvo on the ventral side than when dusted on the dorsal side. Polvo repelled third instars.

Van der Laan (243) in 1935 reported that at 1:5,000, dihydrorotenone was less than half as toxic to the larvae as rotenone, and equally as toxic at 1:10,000. A solution of rotenone in water (1:1,500) lost half its toxicity on 5 hours' exposure to direct sunlight. Dry rotenone lost none of its toxicity on 42 days' exposure to direct sunlight, as determined by the relative toxicity of sprays prepared from irradiated and nonirradiated rotenone. The same procedure showed that dry derris powder lost half its activity when exposed to sunlight for 3 days, but retained it much longer after standing 5 days in shadow.

Aqueous suspensions of derris powder, stored in bottles, lose no toxicity in 4 to 11 days, but the toxicity is appreciably lower 25 days after preparation. An aqueous suspension of derris powder was mixed with a concentrated soap solution, allowed to stand 2 days, then diluted and sprayed. The toxicity was 20 percent less than that of a similar suspension used immediately after preparation or a similar suspension that had been allowed to stand 2 days but to which the soap was added immediately before spraying.

Trappmann and Nitsche (417) in 1935 reported that rotenone sprays gave 15-percent mortality of last instars after 8 days, whereas rotenone dusts had no effect. Dosage was regulated to give a deposit of 0.18 mg. of rotenone per 500 $cm.^2$.

DeBussy et al. (57) in 1936 reported that young larvae can be controlled by derris dust (rotenone 1 percent) but a dust containing 2 percent of rotenone and 5 percent of ether extract killed only half of the older larvae tested.

Klinger (237) in 1936 reported that rotenone dust was not effective against fourth instars in the laboratory and that rotenone spray (0.18 mg. per 500 $cm.^2$ gave only 10-percent mortality after 8 days. Derris dust caused 25-percent mortality in 4 days.

Van der Laan (244) in 1936 reported that this species is sensitive to derris.

An anonymous author (5) in 1937 wrote that for the control of this species with derris in the Netherlands a concentration of not less than 1 percent of rotenone was necessary, which must be applied on a dry day at the end of April or the beginning of May.

Fransen (139) in 1937 reported the results of various observations on the overwintered larvae in Holland in the spring of 1937. At the end of April he carried out experiments on active larvae with several poison dusts, mainly derris and pyrethrum, using a special dusting box. Dusts of derris and Lonchocarpus containing 0.5, 0.75, and 1 percent of rotenone proved inadequate. Fransen (140) later described a series of field tests in which rows of infested oaks were power-dusted with insecticides at an approximate rate of 45 pounds per acre on the 7th or 10th of May. The treatments were largely ineffective, as all the trees were heavily infested on May 26 but, so far as could be ascertained, they contradicted the laboratory tests, as derris dust (0.75 percent rotenone) appeared to have been more effective than pyrethrum containing 0.45, 0.15, or 0.3 percent of pyrethrins, which seemed to be effectiv in that order.

During 1937 in the Netherlands derris dust containing from 0.5 to 0.75 percent of rot none was used successfully for the control of this species.--Koloniaal Instituut of Amsterdam (241) in 1938.

Spoon et al. (386) of the Koloniaal Instituut of Amsterdam in 1937 compared the relative insecticidal value of dusts made from derris and cube. Eight sets of powders were prepared, each set consisting of one powder prepared with derris, the other with Lonchocarpus, both powders containing equally high amounts of rotenone and ether extract. These powders were mixed with diatomaceous earth in order to obtain dusts with definite amounts of rotenone (0.5, 0.75, and 1.0 percent), according to the sensitivity of the various insects. The dusts containing 0.75 percent of rotenone were tested on caterpillars of this species. The results are based on the observation of 120 specimens at least. In 7 of the 8 sets the effect of derris was stronger than that of Lonchocarpus. The effect of derris dust on caterpillars of this species is about one and one-half times as strong as that of Lonchocarpus dust.

A product containing 12 percent of powdered Lonchocarpus nicou root (6 percent rotenone) and 88 percent of talcum mitigated "chrysorrhea" on plum trees, as reported by Etablissements Rot nia in a letter to R. C. Roark in 1938.

This species was used by Spoon and Van der Laan (385) in 1935 as a test insect in correlating rotenone content of derris with its insecticidal value. (See also under Malacosoma neustria (L.), p. 43).

Fransen (141) in 1939 reported the results of investigations in Holland on the most economical employment of contact dust insecticides. The apparatus used for ascertaining the minimum lethal dosages is described. Tests were made on larvae in different stages of development. Ten times as much rotenone was necessary to kill overwintered larvae 1.2 cm. long as to kill first instars 0.35 cm. long. In 1940 Fransen (142) reported that the best results were obtained by dusting with pyrethrum against larvae in the earlier instars and with derris against the older ones, but crushing the nests is still considered the most effective control measure.

Notolophus antiqua (L.), the rusty tussock moth

Gimingham and Tattersfield (161) in 1928 reported that in laboratory tests extracts of the stems and roots of black and white haiari and of the leaves of Tephrosia vogelii were extremely repellent to larvae of this species. Soap, 0.25 percent, was added to these extracts. Even at high dilution (1 part plant material to 400 parts water), the sprayed foliage remained uneaten and the larvae died of starvation.

An alcoholic extract of the root of Tephrosia macropoda was sprayed on the larvae and had considerable contact insecticidal value. Alcoholic extracts of black haiari (Lonchocarpus sp.) were toxic to the 1 month-old larvae.--Tattersfield and Gimingham (401) in 1932.

A product containing 12 percent of powdered Lonchocarpus nicou root (6 percent rotenone) and 88 percent of talcum mitigated (Orgya) Notolophus antiqua (L.) on apple and plum, according to Etablissements Rotenia in a letter to R. C. Roark in 1938.

Porthesia scintillans (Walk.)

P. sericea (Wileman)

P. taiwana Shir.

Sonan (378) in 1927 reported that spraying with derris and soap proved very effective against these species infesting tea plants in Formosa.

Porthetria dispar (L.), the gypsy moth

See also Trägårdh (416) under Panolis griseovariegata, on page 92.

Weis (477) in 1931 reported that the larvae were killed more quickly when dusted with Polvo on the ventral side than when dusted on the dorsal side. Polvo repelled fourth and fifth instars.

Potts (330) in 1935 reported that promising results were obtained with derris as a stomach poison against a number of insect species (including the gypsy moth) when an oil adhesive such as 0.5 to 1.5 percent of castor oil, fish-oil, or linseed oil was added to the spray mixture.

Trappmann and Nitsche (417) in 1935 reported that rotenone dusts were not effective against last instars after 8 days. Dosage was

regulated to give a deposit of 0.18 mg. of rotenone per 500 cm.^{2}.

DeBussy et al. (57) and also Van der Laan (244) in 1936 reported that this species is sensitive to derris dust.

Klinger (237) in 1936 reported that rotenone spray or dust gave no mortality of fourth instars in 8 days. Derris dust killed 10 percent in 6 days.

Potts (331) in 1936 reported that nine 10 acre plots were sprayed in two series by an autogiro at Assonet, Mass. The lead arsenate and calcium arsenate spray contained, by weight, 1 part of arsenical, 0.4 part of fish oil, and 2.1 parts of water. In the derris spray the ratio of derris to water by weight was 1:6. Excellent adherence, fairly good distribution, and fairly good control was indicated. Effective control was obtained in both the early and later series of half-acre plots with a spray containing 3 pounds of derris per 100 gallons of water and 0.5 percent of fish oil.

Van Gundia (452) in 1936 reported control of the gypsy moth, and many other leaf-eating insects, with rotenone dust. The formula used carried approximately 30 percent of sulfur in the form of fused bentonite sulfur, which aids as a sticker for the rotenone, and also acts as an activator.

The Massachusetts Agricultural Experiment Station (270) in 1937 reported that the nearly full-grown caterpillars of this species were treated with derris sprays with results as follows: 4 pounds of derris powder (4 percent rotenone) and 4 pounds of fish-oil soap in 100 gallons of water to an acre killed only 40 percent; 6 pounds of derris powder (4 percent rotenone) and 4 pounds of fish-oil soap in 100 gallons of water, 400 gallons to the acre, killed only 75 percent.

Potts (333) in 1937, reporting on tests at New Haven, Conn., stated that this insect can be controlled by a spray containing from 5 to 8 pounds of derris (4 percent rotenone) per 100 gallons of water. When from 0.5 to 1.0 gallon of fish oil or linseed oil per 100 gallons of spray mixture is added the period of effectiveness of the derris was greatly prolonged and its adherence increased.

Fransen (141) in 1939 reported that 32 times as much rotenone was necessary to kill larvae 2.5 cm. long as to kill larvae 0.35 cm. long, but only 8 times as much to kill still larger larvae which were ready to pupate.

Pseudodura dasychiroides Strand
Stilpnotia cygna (Moore)

Sonan (378) in 1927 reported that spraying with derris and soap proved very effective against these insects infesting tea plants in Formosa.

Stilpnotia salicis (L.) the satin moth

Trappmann and Nitsche (417) in 1935 reported that rotenone sprays

and dusts regulated to give a deposit of 0.18 mg. of rotenone per 500 $cm.^2$ were not effective against last instars.

DeBussy et al. (57) and also Van der Laan (244) in 1936 reported that this species is sensitive to derris dust.

Klinger (237) in 1936 reported that rotenone spray and dust gave no mortality in 8 days. These tests were made on fourth instars in the laboratory.

Kelsall and Stultz (234) in 1937 reported that derris-gypsum dust (1 percent rotenone) caused no mortality in 36 hours in laboratory tests.

Fransen (141) in 1939 reported that nearly full-grown larvae of this species were very resistant to derris.

Lymantriidae (unidentified sp.), tussock moths

The Institute of Physical and Chemical Research (214), Tokyo, Jap. in 1927 reported that Neoton is effective as a contact spray against the larvae.

The larvae were not controlled satisfactorily by derris or cube powder in water to which rosin-residue emulsion had been added.--New Jersey Agricultural Experiment Station (294) in 1938.

Agicide DC-4 (rotenone 0.6 percent) at the rate of 4 pounds per 100 gallons of water (0.003 percent rotenone) killed from 50 to 100 percent within 96 hours.--Agicide Laboratories (8) in 1939.

Lyonetiidae

Lyonetia clerkella (L.)

Ahlberg (9) in 1934 reported spraying experiments in the laboratory, in which the materials tested included derris preparations used in 1- and 2-percent water solutions. Only 37 percent of the pupae in the leaves were killed.

Oda(312) in 1934 reported that injury to peach trees by this species in southern Japan was minimized by spraying with Neoton and nicotine sulfate, which are effective against the moths and the larvae.

Notodontidae

Drymonia manleyi Leech

Tanaka (400) in 1927 recommended a derris-soap spray for control of the older larvae.

Phalera bucephala (L.)

The larvae were used as test insects by Fryer et al. (149) in 1923 in evaluating derris extracts.

Van der Laan (243) in 1935 reported that when used as a spray containing 0.1 to 0.5 percent of Agral, at a concentration of 1:5,000, rotenone gave a mortality of 95 percent and dihydrorotenone a mortality of 80 percent of the larvae.

DeBussy et al. (57) in 1936 reported that this species is sensitive to derris dust.

The Koloniaal Instituut (240) in 1936 reported that powdered Tephrosia root applied as an undiluted dust was inert to the larvae. Derris-kieselguhr dust (1:4) was always deadly.

Phalera flavescens (Brim. & Grey)

The Institute of Physical and Chemical Research (214), Tokyo, Japan, in 1927 reported that Neoton at a concentration of 150 to 225 gm. plus 750 gm. of soap per 40 imperial gallons of water gave 100-percent mortality.

Datana ministra (Drury), the yellow-necked caterpillar

McIndoo, Sievers, and Abbott (264) in 1919 reported that two apple trees, on which large colonies of nearly full-grown larvae were feeding, were sprayed with derris at the rate of 1 pound of powder to 50 gallons of water. Twenty-four hours later one living larva was found on one tree and two on the other. The ground under the trees was thickly sprinkled with dead larvae and many had lodged in the trees.

Kopp (242) in 1924, in a review of the use of derris as an insecticide stated that derris powder has given excellent results against this species at a concentration of 500 gm. to 200 liters of water.

Observations on this species indicate that the powdered root of Tephrosia virginiana has little or no value as a stomach poison but is repelling and has promise as a contact insecticide. Field experiments with this powder at 4 pounds per 100 gallons are described against this species feeding on post oak. Excellent control was obtained.--Little (254, 255) in 1931.

The Iowa Agricultural Experiment Station (215) in 1934 reported that C. H. Richardson found dihydrorotenone approximately one-half as toxic as lead arsenate to the larvae when tested by the leaf-sandwich method.

Hansberry and Richardson (183) in 1936 reported the median lethal dose of dihydrorotenone for Datana ministra larvae to be 0.11 mg. per gram of body weight.

Nymphalidae

Euphydryas chalcedona (Dbldy. and Hew.)

DeOng and White (96) in 1924 reported that derris powder gave 98-percent control of the larvae when dusted on the leaves upon which they were feeding.

DeOng (95) in 1930 tested the repelling action of the ether extracts of four species of Derris on larvae of varying ages. Solutions containing 2 percent by weight of the extract were sprayed on the foliage and stems of Scrofularia californica (the common host of this insect), and as soon as it was dried the larvae were placed upon the twigs. Feeding caused, in most instances, after a few attempts to consume the sprayed foliage. A small percentage of the caterpillars were killed and the more mature ones pupated. The larvae were confined with these twigs for 8 days with no appreciable increase in feeding, except that in one cage the growing tip was consumed. The repelling effect apparently lasted during the entire time the cuttings were kept alive in the laboratory.

Aglais antiopa (L.)

Hamilton (180) in 1938 reported that these caterpillars on elm trees were satisfactorily controlled by cube or derris spray (4 pounds of powder containing 4 percent of rotenone plus 4 pounds of rosin-residue emulsion per 100 gallons of water). The spray acts as a contact poison. The effective period is 3 to 4 days, and the kill was 100 percent by actual count.

W. J. Haude, in advertising literature published by John Powell & Co., New York, N. Y., in 1939 also recommended this spray.

Vanessa cardui (L.), the painted lady

Hansberry and Richardson (183) in 1936 reported the median lethal dose of rotenone in milligrams per gram of body weight for the larvae to be 0.03.

Vanessa io (L.)

Trappmann and Nitsche (417) in 1935 reported that rotenone sprays and dusts were not effective against last instars. The dosage was regulated to give a deposit of 0.18 mg. of rotenone per 500 $cm.^2$.

Klinger (237) in 1936 reported that rotenone dust (0.15 mg. per $cm.^2$) gave 15-percent mortality, and rotenone spray (0.18 mg. per 500 $cm.^2$) 45-percent mortality after 8 days. Derris dust caused 70-percent mortality in 6 days. These tests were made on fourth instars in the laboratory.

Vanessa polychloros (L.)

Trappmann and Nitsche (417) in 1935 reported that rotenone sprays gave 30-percent mortality of last instars after 8 days; but rotenone dusts gave only 10-percent mortality. Dosage was regulated to give a deposit of 0.18 mg. of rotenone per 500 $cm.^2$.

Vanessa urticae (L.)

Trappmann and Nitsche (417) in 1935 reported that rotenone sprays

were not effective against last instars. Dosage was regulated to give a deposit of 0.18 mg. of rotenone per 500 cm.^{2}.

Nymphalidae (unidentified sp.)

Sprays made by extracting Tephrosia vogelii seeds with kerosene proved about half as toxic to unidentified caterpillars of this family as similar sprays containing pyrethrum. -- Worsley (499) in 1934.

Oecophoridae

Cremona cotoneasteri Busck

Roaf, Dimick, and Mote (356) in 1937 reported tests against this webworm on Cotoneaster horizontalis near Portland, Oreg. A derris dust applied to the infested shrub with a large salt shaker gave good control. This dust was prepared by mixing 1 part of derris (rotenone 5 percent) with 9 parts of hydrate of lime. This mixture did not kill the caterpillars quickly but in a week's time most of the webworms were dead. After the caterpillars died a garden hose was used to wash the material from the plant.

Depressaria nervosa Haw.

The Wageningen (461) Station in Holland in 1934 reported that sprays containing 0.01 percent of rotenone, 0.25 percent of acetone, and 0.2 percent of Agral gave from poor to fair control.

Blijdorp (36) in 1935 reported that derris powder containing 2 percent of rotenone was the best of several materials tried for the control of the caraway moth. This was applied at a rate of 37.5 and 75 kg. per hectare (equivalent to about 33.5 to 67 pounds per acre), in two applications using one-third of the total amount in the first application. The results were obtained by measuring the yield of caraway seed obtained from each of four experimental plots 10 by 20 meters, and counting the number of cocoons. Later Blijdorp (37) reported that for control of this moth it is almost always better to apply an insecticide as a dust than as a spray, advocating derris of known rotenone content diluted with talc. Dusting is worth while if a count at the end of March over a few square yards indicates the presence of more than 6 to 8 thousand females per acre.

Spoon (384) in 1935 reported on the control with derris powder in Holland. Derris powder (8 percent rotenone, 21 percent other extract) was mixed with 3 parts of French chalk. This mixture at 33 pounds per acre gave better results than 133 pounds per acre of either 20 percent of barium fluosilicate or 30 percent of sodium fluosilicate. At 66 pounds per acre this derris mixture gave practically complete control.

DeBussy, van der Laan, and Diakonoff (57) in 1936 reported that in the Netherlands derris was the best material for the control of this species. The rotenone content should be at least 0.5 percent and, preferably, 0.75 percent. The dosage was 50 to 75 kg. per 10,000 m^2.

The Koloniaal Instituut (240) in 1936 reported that in the Netherlands an example of the practical use of derris is the control of this insect in Groningen. Eighty-six thousand kg. of derris dusting mixture was used in 1935 for control. Derris was first applied as a dust in 1934 and pure rotenone was also used in 1934.

The destruction of the caraway moth by means of derris has become a general practice in the Netherlands. -- Koloniaal Instituut of Amsterdam (239) in 1936.

In the Netherlands, one of the principal uses of derris is to control this insect. -- Van der Laan (244) in 1936.

An anonymous writer (5) wrote in 1937 that in the Netherlands the caraway moth was effectively checked with a derris dust containing 0.75 percent of rotenone.

The Koloniaal Instituut (241) in 1938 reported that in the Netherlands derris dusts containing 0.5 to 0.75 percent of rotenone were largely used for combating the caraway moth.

Hofmannophila pseudospretella (Stt.)

An anonymous author (5) in 1937 wrote that the larvae of (Borkhausenia) Hofmannophila pseudospretella were sensitive to derris dust containing 1 percent of rotenone.

Olethreutidae

Ancylis comptana fragariae (Walsh & Riley), the strawberry leaf roller

At the 1934 meeting of the American Association of Economic Entomologists, as reported by the United States Department of Agriculture, Bureau of Entomology and Plant Quarantine (437), Cory led a discussion of field results with arsenical substitutes for the control of vegetable insects. Hutson, of Michigan, reported that derris dust containing 0.5 percent of rotenone had been most satisfactory for the control of the strawberry leaf roller. Satisfactory diluents were flour, talc, bentonite, china clay, 300-mesh dusting sulfur, tobacco dust, silicated infusorial earth, and finely ground gypsum.

In 1934 the Michigan Agricultural Experiment Station (275) reported that an infestation when there were berries on the plants was best controlled by the use of pyrethrum or derris dusts or sprays.

Hutson (207) in 1935 reported that derris was tested both as a dust and as a spray. A dust made by mixing 25 pounds derris powder (2 percent rotenone) with 75 pounds talc, applied at the rate of 30 pounds per acre, left 74 live leaf rollers on a 10-rod row at the end of 10 days. A spray made by adding 5 pounds of this derris powder plus 2 pounds of soap chips to 100 gallons of water, applied at the rate of 125 gallons per acre, left 68 live leaf rollers. On the untreated check 267 live leaf rollers were found. Hutson concluded that better control was obtained by the use of derris and pyrethrum than with other materials.

The Ohio Agricultural Experiment Station (316) in 1937 reported that life-history studies conducted in the insectary at Wooster showed that 3 broods may occur annually, but during the preceding season the first brood of larvae was most abundant and did most damage. In southwestern Ohio 16 insecticidal treatments were tested against the first brood and each was replicated 5 times. Applications were made on May 11-12, May 21-22, and May 27. In the third application, however, only materials that would leave no poisonous residue on the berries were used. Differences in the extent of injury detected in the various plots on May 21 were slight, but increased as the season advanced. On June 10, 600 leaflets from each of the more outstanding plots were examined for injury. The efficiency of the various insecticides, measured by the number of injured strawberry leaflets in a 600-leaflet sample taken from each replicate of each plot, is shown in the following table.

Material	Applications	Replications 1	2	3	4	5	Total	Control
	Number						Number	Percent
Derris, 4 percent, 12-1/2 pounds Gypsum, 87-1/2 pounds	3	122	73	124	135	100	554	75.7
Cube, 4 percent, 12-1/2 pounds Gypsum, 87-1/2 pounds	3	197	276	243	246	244	1206	47.2
Black Arrow Dust	3	215	254	256	240	260	1225	46.3
Dutox, 5 pounds SS-3, 100 cc. Water, 100 gallons	2	233	310	284	286	200	1313	42.5
Kalo Spray, 5 pounds SS-3, 100 cc. Water, 100 gallons	2	74	170	111	78	118	551	75.9
Check, no treatment	0	383	503	416	502	478	2282	-----

Two spray applications of Kalo Spray proved just as effective as three dust applications of powdered derris root, each effecting a 75-percent control. Powdered cube root, although it contained the same amount of rotenone and was used in the same way, was significantly less effective than powdered derris root.

The Kansas Agricultural Experiment Station (228) in 1938 reported that pyrethrum and rotenone dusts applied three times at 5-day intervals during the period of nonrolling of the leaves by the larvae gave good control.

Neiswander (290) in 1938 reported that three applications of derris dust gave 75.7-percent control in Ohio in 1936 and three applications of cube dust gave 47.2 percent control. Each material contained 4 percent of rotenone and was diluted with gypsum in the ratio 12.5:87.5. Cryolite (either natural or artificial) is recommended as giving the best control.

The North Central States Entomologists (309) in 1938 discussed the control of certain insects by the use of cube and derris. Parker and Lamerson, of Manhattan, Kan., reported on the control of the strawberry leaf roller. Nicotine sulfate or pyrethrum extract in combination with summer-oil emulsion, sprayed three times at 5-day intervals during the period of nonrolling of the leaves by the larvae, gave the best results. This held true for the second and third broods, as well as for the first brood. Pyrethrum and rotenone dusts applied during the same period gave good control. Cubor containing 0.75 percent of rotenone, with and without sulfur, was also tested by these workers.

Roark (357) in 1938 reviewed the comparative action of derris and cube of equal rotenone content, on this species. Reference was made to the Ohio Agricultural Experiment Station (316), which in 1936 obtained 47.2-percent control with a cube-gypsum dust and 75.7-percent control with a derris-gypsum dust (each containing 0.5 percent of rotenone).

Lamerson and Parker (246) in 1939 recorded tests of insecticides against the American strawberry leaf roller at Manhattan, Kans. Against half-grown to mature larvae in rolled leaflets, pyrethrum dust containing 0.8 percent of pyrethrins gave the best control--96.8 percent killed. A dust containing 1 percent of rotenone killed 90.8 percent and one containing 0.75 percent of rotenone killed 85.8 percent.

Carpocapsa pomonella (L.), the codling moth

Quaintance (338) reported in 1928 that, according to Van Leeuwen, derris in laboratory and field tests in New Jersey had shown promise for control. In 1929 (339) he reported that derris had been tested for control in Arkansas, Colorado, Illinois, Indiana, Kansas, New Jersey, and Washington. In Illinois good results were obtained with commercial derris extract combined with white oil, 1.25 percent. An alcoholic extract of derris used against second-brood worms appeared to be of little value.

Van Leeuwen (453) in 1928 reported that at Riverton, N. J., three early applications of lead arsenate against the first brood, followed by three applications of pyrethrum, nicotine, or derris against the second brood, gave good results. Check trees showed 83 percent of all apples free from worms, whereas the lead arsenate plat showed 97 percent, the nicotine plat 95 percent, the pyrethrum plat 93 percent, and the derris plat 95 percent free from worms. In laboratory tests with newly hatched larvae, derris, pyrethrum, and nicotine gave very encouraging results.

The Bureau of Entomology (428) in 1928 mentioned that extracts of derris at 1:800 had been tested as contact sprays and as ovicides.

Farrar (117) in 1930 reported that Derrisol 1:800 in combination with Verdol 1:50, applied for the control of the second brood, kept the wormy fruit down to 1.1 percent in 1928 and 7.0 percent in 1929. The corresponding figures for Verdol were 3.6 and 6.0, respectively. Lead arsenate, 2 pounds to 100 gallons plus hydrated lime 4 pounds to 100 gallons, gave 3.6 and 2.7 percent wormy fruit for these years. Farrar concluded that in field combinations the addition of 1:800 parts of either nicotine sulfate or Derrisol was satisfactory. Whether the grower would be recompensed in full for this additional cost in the spray is questionable.

Flint (135) in 1929 reported on Derrisol for the control of second and third-brood larvae. In southern Illinois two commercial sprays using a 2-percent white-oil emulsion allowed infestations of 1.1 and 0.7 percent, respectively. The same oil at 1 percent plus nicotine sulfate 1:800 permitted 0.3-percent infestation, and a similar experiment with Derrisol at the same dilution gave 1.1-percent infestation. The commercial sprayed plot in the same orchard, where lead arsenate was used in the second-brood sprays, had 5.2-percent infestation. The check showed that 31 percent of the apples were injured by this insect. Nearly as good results were obtained in a second orchard in western Illinois.

At the codling moth conference held in 1929 by the United States Department of Agriculture, Bureau of Entomology (429), the following Federal men reported on derris: Ackerman, of Bentonville, Ark.; Gilmer, of Wichita, Kans.; Newcomer and Yothers, of Yakima, Wash.; Van Leeuwen and McAllister, of Moorestown, N. J.; and Siegler, Quaintance, and Roark of Washington, D. C. Reports were also given by the following State men: Eyer, of New Mexico, and List, Yetter, and Newton, of Colorado. In field tests both derris powder and the alcoholic extract of derris gave poor results, and in laboratory tests against larvae the extract of derris gave poor results. As pointed out by Roark, this alcoholic extract of derris was later examined and found to contain very little if any of the active principles. Eyer reported that bands treated with Derrisol at full strength were definitely repellent to the larvae in New Mexico, and List, Yetter, and Newton reported that Derrisol appeared to have some value for control in Colorado but not enough to be very encouraging. The Bureau of Entomology (430) in 1929 referred to tests with rotenone and with derris plus oil spray.

Gross and Fahey (170) in 1930 wrote that in field tests at Yakima, Wash., in 1929 rotenone in low concentration was not so toxic as had been expected.

The Kansas Agricultural Experiment Station (227) in 1930 reported that Derrisol 1:200 plus summer oil 2:100 was tested as a substitute for lead arsenate for the control of the codling moth. Fair to good control was obtained.

Quaintance (340) in 1930 reported that the addition of derris extract, 1:800, to oil did not materially improve its effectiveness. In small-scale field tests rotenone gave very poor results; in the laboratory results ranged from good to poor. Rotenone appeared to be effective immediately after application but lost its effectiveness rapidly on exposure.

Spuler et al. (388) in 1930 reported that the use of spreaders, fish oils, mineral oils, nicotine, derris, and pyrethrum compounds in combination with lead arsenate had given variable results.

The United States Department of Agriculture (425) in 1930 stated that rotenone was being tested against this insect. At the annual codling moth conference in 1930 the Bureau of Entomology (431), of the Department, included reports on derris and retenone by Newcomer, Dean, Campbell, Roark, and Runnor. Newcomer reported as follows:

> Laboratory and field results with derris were poor in 1928, and laboratory results with derris were poor in 1929, even when tested the day the spray was applied. In the 1929 tests, the commercial Derrisol was used at 1:400 and 1:800, with and without a mineral-oil emulsion. Derrisol at 1:800, plus 0.75 percent of oil, used in the orchard, burned the fruit and foliage, and the experiment was discontinued.
>
> The rotenone was first used at 1:1,500 and 1:3,000 in alcoholic solution, alone and with mineral oil, fish oil, and cascin spreader, and later at the same dilutions and the same combinations, with saponin at 1 pound to 200 gallons. The rotenone-saponin combination was better than the alcoholic solution, and this combination with mineral oil showed some indication of value.

Dean reported that Derrisol at 1:200 plus summer oil at 2:100 gave fair control and seemed worthy of further trial. Campbell stated that rotenone was the most toxic compound to the silkworm that he had tested so far under laboratory conditions and that if it failed in the field decomposition or some other fact must be responsible. Such failure cannot be due to lack of original toxicity. The Bureau of Entomology (432) in 1930 reported that derris extract combined with white-oil emulsion had been tested in the field against codling moth at Yakima, Wash.; Bentonville, Ark., and Wichita, Kans. Field and laboratory tests were made with rotenone. The Bureau (433) in 1931 reported that tests of rotenone against the codling moth in the field gave disappointing results, but because of the high initial toxicity this material possesses, efforts to develop ways of effectively utilizing it were being continued.

Headlee (185) in 1931 recorded tests with arsenical substitutes for the control of the codling moth. Four applications against first brood on early apples (Starr variety) gave the following percentages of infested fruit: Lead arsenate, 9.6; oil-pyrethrum, 11.4; light oil-rotenone, 12.0; heavy oil-rotenone, 14.9; and tank-mixed nicotine tannate, 11.0.

The Virginia Agricultural Experiment Station (458) in 1931 referred to the work of Hough to determine the difference between western and Virginia strains in resistance to arsenical sprays. The results had indicated that tolerance to spray materials is not specific for arsenic, but also holds true for such insecticides as cryolite, barium fluosilicate, and rotenone.

For control rotenone is considered as still in the experimental stage. -- Anonymous (3) in 1932.

Campbell (60) in 1932 critically reviewed all tests with rotenone. In all tests the apples were sprayed with suspensions of rotenone in water with or without the addition of other substances. Newcomer found that rotenone alone at 1:3,340 and 1:4,450 was decidedly more effective than lead arsenate at 2 pounds to 100 gallons (1:416) when the tests were made shortly after application of the spray, but the effectiveness of rotenone was markedly reduced when the tests were made 7 days after application; whereas the effectiveness of lead arsenate remained about the same. Hough noted the same phenomenon in a test of rotenone with Penetrol. Of the larvae that hatched from 6 to 48 hours after the application of the spray, 6.8 percent entered the fruit; of those that hatched from 48 to 72 hours after the application 25 percent entered. An experiment by Lathrop supports results of Newcomer and Hough. Using a 1:4,450 suspension of rotenone, Lathrop found that 97.4 percent of the number of larvae that entered the untreated apples were prevented from entering apples freshly treated with rotenone. However, the efficiency of rotenone, when the larvae were placed on the fruit several days after treatment, was found to be only 32.5 percent. Newcomer also tested rotenone at 1:1,110 and found that the effectiveness of the deposit was greatly reduced in 7 days.

In all tests by Newcomer and Hough the percentage of stings on apples treated with rotenone was lower than that on apples treated with lead arsenate. In laboratory tests against this insect the addition of starch and glue as stickers reduced immediate effectiveness. The addition of mineral-oil and fish-oil emulsions to rotenone suspensions appeared to have no significant effect in immediate tests. In Hough's experiment with rotenone and soap excellent results were obtained 3 days after application of the spray. On the basis of total injuries, rotenone-soap was distinctly superior to the lead arsenate check. Hough noted that the addition of soap materially improved the distribution of rotenone. Several field tests have been made in the Pacific Northwest by Newcomer, Robinson, and Spuler. Some results of such tests of rotenone in comparison with lead arsenate are given in the following table. The rotenone was dissolved in acetone and the solution was added to water to form a suspension.

Material	Spray schedule	Apples wormy and stung
		Percent
Rotenone 1:1,670	Calyx and first cover spray of lead arsenate followed by 6 cover sprays of rotenone	70.4
Lead arsenate 1:416	Calyx and 6 cover sprays	51.5
Rotenone 1:4,200	Calyx and 3 cover sprays Tannic acid was added to first cover spray	41.5
Lead arsenate 3 pounds per 100 gallons	Calyx and 3 cover sprays	9.3
Rotenone 1:4,450	Calyx spray of lead arsenate followed by 6 cover sprays of rotenone	17.0
Lead arsenate 3 pounds per 100 gallons	Calyx and 6 cover sprays	2.5

Those who have tested rotenone in the field do not consider it a promising substitute for lead arsenate. However, it is so effective in laboratory experiments when freshly applied that the possibility of its use in the field should not be abandoned until efforts have been made to understand and control its adherence and decomposition on fruit and foliage.

Newcomer (306) in 1932 stated that pyrethrum had been tested rather thoroughly but no way had been found that would make it as effective as nicotine for control of this insect and the same might be said of rotenone.

Newcomer and Yothers (307) in 1932 reported that a commercial extract of derris [Derrisol?] was ineffective as an ovicide (1:800) and as a larvicide (1:400). A mixture of 0.75 percent of lubricating-oil emulsion and commercial derris extract (1:400 and 1:800) was ineffective in preventing the worms from entering sprayed fruit in laboratory experiments. An alcoholic extract of derris and a kerosene extract of pyrethrum in orchard experiments were practically worthless, the fruit becoming extremely wormy. This sample of derris root was later found to be low in total extract and to contain not more than traces of rotenone, which explains the very poor results obtained with it. An orchard experiment with the commercial derris extract was discontinued because fruit and foliage injury developed and much of the fruit was becoming wormy.

Spuler, Dorman, and Gillies (387) in 1932 reported that none of the contact sprays, such as mineral oil, nicotine sulfate, pyrethrum, and rotenone, have sufficient larvicidal value as a spray when used alone. Their chief value is in combination with other materials in such a way that the resultant spray contains both ovicidal and larvicidal value.

Turner (418) in 1932 reported that tests in controlling this insect were limited, owing to low infestations, but in general they showed that rotenone is of some value.

Webster (475) in 1932 reported that on blocks of trees in the Wenatchee, Wash., experimental orchard sprayed with rotenone, oil-nicotine, or the oil-pyrethrum combination, freedom from red spider injury was conspicuous during the past season. He said: "We must still regard the use of rotenone, and the oil-pyrethrum combination as well, as in the experimental stage so far as codling moth control is concerned."

Jarvis (222) in 1933 reported on the use of Katakilla with white oil in Queensland. Five rows of 5- to 6-year-old apple trees, four trees in each row (Jonathan and Vanderpool Red) were sprayed with nonarsenicals, each row receiving a different treatment. Four treatments were given each row, the spray being applied with a knapsack spray outfit of 4 gallons' capacity. Approximately 3/4 to 1 gallon of spray fluid was used for each tree per application. For a small tree this was a generous allowance and permitted a thorough coverage. In the Katakilla and white-oil mixture, Katakilla was used at 2 pounds to 32 imperial gallons and the white oil at 1:80. White oil alone was used at 1:64. Nicotine sulfate-white oil and Katakilla-white oil gave equally good results and both were slightly more efficient than lead arsenate but were much more expensive. However, it is possible that the strength of these two sprays might be reduced, and three applications be given instead of four. The percentage of sound fruit obtained by each treatment was as follows: Barium fluosilicate 92.8, lead arsenate 97.3, nicotine sulfate-white oil 98.2, Katakilla-white oil 98.1, white oil 97.8.

List (252) in 1933 discussed the progress made in codling moth control during the preceding decade. Petroleum oils as carriers of nicotine, pyrethrum, and rotenone must be used cautiously to avoid foliage injury.

The United States Department of Agriculture, Bureau of Entomology (439) reported that Childs in 1934 tested mixtures of cube or derris and kaolin 1:3 (rotenone 1 percent) on apples at Hood River, Oreg. The results, compared with those obtained with lead arsenate, are as follows:

Material	Fruit		
	Free from worms and stings	Worm	Sting
	Percent	Percent	Percent
Lead arsenate, 3 pounds per 100 gallons, 5 applications	96.1	0.8	3.2
Cube mixture, 10 pounds per 100 gallons, 10 applications	93.5	2.5	2.0

Derris-kaolin gave results similar to those obtained with cube-kaoli Gentner in 1934 tested the same mixtures at Talent, Oreg., against codlin moth infesting 25-year-old Bartlett pear trees. Four cover sprays of the material tested were applied following a calyx and first cover of lead arsenate, and 6 cover sprays of cube-kaolin were applied also following a calyx and first cover of lead arsenate. Because of delay in receiving materials, nicotine-bentonite (3 pounds per 100 gallons) was used in the third cover spray in place of cube-kaolin. When lead arsenate only was used, 5.6 percent of the fruit was wormy; when cube-kaolin was used as described, 14.2 percent was wormy; and when derris-kaolin was used, 16.3 percent was wormy. None of the sprays injured the fruit, but the heavy residue of cube-kaolin prevented uniform coloring of pears that developed a red cheek. An acid wash containing 3 percent of acid at 100° F. failed to remove a derris-kaolin residue on pears, but Robinson removed all traces of the residue by washing in a solution of sodium silicate. Haegele in 1935 tested these mixtures at Parma, Idaho, using either 5 or 10 pounds of the mixture per 100 gallons of water, and making 8 or 12 applications to trees about 20 years old. Comparative figures for this mixture and lead arsenate, 3 pounds per 100 gallons, applied in the regular schedule (8 applications) are as follows:

Material	Fruit		Worms per 100 apples	Stings pe 100 apple
	Wormy	Free from worms and stings		
	Percent	Percent	Number	Number
Lead arsenate, 3 pounds per 100 gallons, 8 applications	68.0	2.6	266.9	317.3
Cube mixture, 10 pounds per 100 gallons, 12 applications	98.6	1.0	481.9	16.9
Lead arsenate, 3 pounds per 100 gallons, 8 applications	66.3	2.4	181.6	318.2
Cube mixture, 5 pounds per 100 gallons + 0.5 percent of white oil, 12 applications	91.3	1.6	304.9	131.8

Although a heavy residue of cube-kaolin was left on the fruits, this did not inhibit coloring. The derris and cube dusts tended to be somewhat nauseating to the operators. Derris-kaolin was not so effective as the cube-kaolin mixture.

Haegele (176) in 1935 also reported that derris, 10 pounds per 100 gallons alone and also plus 0.5 percent of oil, proved most unsatisfactory in controlling the insect at Parma, Idaho, in 1934.

Harman (184) in 1934 reported experiments in a badly infested King orchard during 1933 in New York. Kubatox (a derris extract), 1 quart to 100 gallons, permitted 3 percent of stings and 89 percent of worms; the same plus 1 quart of oil permitted 3 percent of stings and 87 percent of worms, as compared with 60 percent of stings and 13 percent of worms for lead arsenate at 3 pounds to 100 gallons. The addition of 1 quart of oil to 1 quart of Kubatox per 100 gallons of spray resulted in 3 percent of stings and 87 percent of worms.

Hough (192) in 1934 reported on the relative abilities of Colorado and Virginia strains of the larvae to enter apples sprayed with rotenone. Eggs placed on the apples sprayed with rotenone hatched 3 days after the spray was applied. Greater ability of the Colorado larvae to enter sprayed fruit was not specific for lead arsenate but was also demonstrated when such nonarsenical sprays as cryolite, barium fluosilicate, rotenone, cuprous cyanide, and nicotine were used. Comparative tests with Colorado and Virginia larvae on apples that received two applications of a nonarsenical spray (rotenone, 1 gm. in 2,000 cc.) gave results as follows:

Strain	Eggs hatched	Live larvae		Total injuries	
	Number	Number	Percent	Number	Percent
Colorado	377	57	15.1	67	17.7
Virginia	440	24	5.4	25	5.6

Kearns (229) in 1934 reported that derris did not provide a very high control in England.

Marshall (269) in 1934 stated that derivatives of derris or cube root have not been so widely applicable as nicotine sulfate.

Moto and Thompson (284) in 1934 recorded tests of substitutes for lead arsenate in Oregon. Various materials were tried as substitutes. The material was applied at a pressure of between 300 and 350 pounds, 10 trees being used in each plot. All the apples on each tree, including windfalls, were examined and the percentages of wormy apples, stings, and clean fruit were recorded. Rotenone was tried only 1 year, 3 ounces being used in each 100 gallons of spray. In the first 2 cover sprays, 6 ounces of tannin was added to each 100 gallons and this may have been responsible for considerable foliage injury, which developed on this plot.

Material	Fruit		
	Clean	Wormy	Stings
	Percent	Percent	Percent
Rotenone	72.1	23.5	4.4
Lead arsenate check	89.0	6.5	4.5
Unsprayed control	15.2	82.0	2.8

The New York State Agricultural Experiment Station (300) in 1935 stated that rotenone and derris gave unpromising results as substitutes for lead arsenate.

The United States Department of Agriculture, Bureau of Entomology and Plant Quarantine (440) concluded, from a review of all work done in the United States in 1934, that mixtures of 1 part of derris or cube with 3 parts of kaolin (1 percent rotenone) gave definitely unsatisfactory results This material was tested at strengths of 5 and 10 pounds per 100 gallons on varying schedules and in some instances in combination with oil. Neither increases in concentration nor in the number of applications resulted in increased control. The addition of oil gave a certain degree of effectiveness, but this is attributed to the oil rather than to the derris. The kaolin used as a carrier caused an unsightly deposit on the apples that could not be removed by the usual hydrochloric acid wash, therefore otherwise high-quality fruit could not be marketed except at a cannery. However, Robinson removed all traces of derris-kaolin residue from pears by washing them in a solution of sodium silicate.

Boyce (44) in 1935 reported the results of tests in Persian walnuts. Nicotine tannate, nicotine-bentonite, nicotine-mineral oil, rotenone, ground derris, pyrethrum extract, and ground pyrethrum gave unsatisfactory results. Each toxic material was used at the rate of 4 pounds plus 2/3 quart of highly refined light-medium mineral oil, plus 1/3 pint of liquid blood albumin per 100 gallons of water. Basic lead arsenate gave the best control.

F. L. Campbell (62) in 1935 said that derris and cube are so toxic in the laboratory that they should be followed up further. Eyer (115) in 1935 presented the following results of tests of insecticides in New Mexico

Variety	Sound apples after treatment with --		
	Check (no insecticide during season)	Lead arsenate	Pyrethrum-derris-bentonite-sulfur supplement
	Percent	Percent	Percent
Delicious	73.8	88.8	76.6
Stayman Winesap	81.5	84.9	73.0
Gene	47.0	82.2	66.8
Arkansas Black	65.6	95.4	82.2

Childs (71) in 1935 stated that derris and cube had been tested as substitutes for lead arsenate in the Hood River Valley, Oreg., and had been found ineffective or uneconomical for general orchard use.

F. J. D. Thomas (409), Kent, England, reported in 1935 on the control of surface-eating tortricid larvae on apples. Tests were made with derris dust and derris spray against Cacoecia podana Scop., to apply a protective dust to the fruit before an attack began. In the latter part of June moths of this species and also codling moths were beaten from the trees. Two dusts were applied on July 17--one of derris, the other of barium fluosilicate. Subsequent observations and counts on both windfalls and crop showed very little tortrix damage to the fruit on any of the trees, including the undusted controls. Surface damage was mainly due to very young codling moth larvae and not to C. podana. * * * Derris (crude rotenone 3.63 percent), 2 pounds plus soft soap 5 pounds per 100 imperial gallons, reduced the damage 50 percent when applied approximately 9 weeks after petal-fall.

Trappmann and Nitsche (417) in 1935 reported that rotenone sprays and dusts were not effective against the last instars of this species. Dosage was regulated to give a deposit of 0.18 mg. of rotenone per 500 $cc.^2$.

The United States Department of Agriculture, Bureau of Entomology and Plant Quarantine (438, 439), in 1935 assembled the results of codling moth investigations conducted during 1934 by State agencies. At Monroe, Oreg., four cover sprays were applied on the apple trees. Lead arsenate 3 pounds per 100 gallons gave 89.07 percent of clean fruit; rotenone in the last three covers with calcium arsenate in calyx and first cover gave 71.76 percent of clean fruit; and rotenone plus 0.75 percent of oil No. 6 in the last three covers and calcium arsenate 3 pounds per 100 gallons in the calyx and first cover gave 78.41 percent clean fruit. At Talent, Oreg., eight cover sprays were applied to apples and five or six cover sprays to pears. On pears derris with kaolin, 1 percent of rotenone (calyx and first cover lead arsenate), 5 and 10 pounds per 100 gallons, both with and without oil, and powdered cube root with kaolin (rotenone 1 percent) at 10 pounds per 100 gallons, gave much poorer control than did lead arsenate. In 1934 workers in the Division of Fruit Insect Investigations of the Bureau, tested derris in the field at Kearneysville, W. Va.; Saint Joseph, Mo.; Parma, Idaho; Hood River and Talent, Oreg.; and in the laboratory at Takoma Park, Md. Derris powder was toxic to larvae under laboratory conditions. Derris-kaolin applied in the field to apples, from which plugs were made for laboratory testing at Vincennes, Ind., was not toxic. In the field derris, cube, and pyrethrum in admixture with kaolin were all rated ineffective.

Baker and Butler (20) in 1936 reported on tests made on a 20-acre block divided into plots of about 15 trees each. All applications were made with a power sprayer operating at 400 pounds' pressure and carrying 2 single-nozzle guns. Derris alone gave little or no control, but in combination with mineral oil it was more effective though still far from satisfactory. Derris caused no foliage injury. The following table shows the results of field tests of organic substitutes for lead arsenate at St. Joseph, Mo., in 1934. All plats were sprayed with lead arsenate, 3 pounds per 100 gallons, in the calyx spray.

Material used (pounds per 100 gallons unless otherwise stated)	Worm infestation (number of worms per 100 apples)				
	Material used alone		Material used with --		
			Summer oil, 0.5 percent		Fish oil, 0. percent
	Regular schedule[2]	7-day schedule[3]	Regular schedule	7-day schedule	Regular schedule
Lead arsenate 3:100	41.6	-----	-----	-----	-----
Ground derris root 1 part, kaolin 3 parts containing 1 percent rotenone 10:100	172.9	165.2	-----	76.4	-----
The same 5:100	-----	-----	-----	81.3	-----
Lead arsenate 3:100 in first brood; derris as above 10:100 remainder of season	-----	-----	-----	-----	111.3

1/ Beginning with second cover spray.
2/ Nine cover sprays applied at approximately 10- to 12-day intervals.
3/ Fourteen cover sprays applied at approximately 7-day intervals.

The East Malling Research Station, Kent, England (108), in 1936 reported the following results in control: Of the unsprayed apples 13.7 percent were damaged; of those sprayed with derris containing 3.6 percent of crude rotenone at the rate of 2 pounds per 100 imperial gallons plus 5 pounds of soap, 11.4 percent were damaged; and of those sprayed with lead arsenate at the rate of 4 pounds per 100 imperial gallons plus 1 pound of Lethalate wetting preparation, 2.8 percent were damaged.

Farrar (118) in 1936, reporting on the effect of petroleum-oil sprays on insects and plants, stated that emulsions containing extracts of derris and pyrethrum were less toxic to codling moth larvae under field conditions than were the nonimpregnated emulsions. Exposure of derris or pyrethrum products to the action of sunlight and oxygen destroyed their activity toward insects, as is clearly demonstrated by laboratory tests. These same oil emulsions, when tested against codling moth larvae in the laboratory after a relatively short exposure to the air, consistently gave performance superior to nonimpregnated emulsions. The following were tested in admixture with "white oil stock emulsion 200:" Derris 1/2, 1, and 2 pounds per gallon; cube extract; rotenone with and without Penotrol; Derrisol.

Garman (151) in 1936 reported the following results of tests on apples in Connecticut:

Treatment	Fruit showing -- External insect injury	Codling moth entries	Conspicuous spray russet
	Percent	Percent	Percent
Lead arsenate[1] plus flotation sulfur	91.5	0.0	----
Cryolite[2] plus flotation sulfur	65.4	.8	----
Cryolite plus Coposil	48.3	2.0	35.8
Derris spray[3]	32.0	.9	----
Check--pink spray only	24.4	3.9	1.3

1/ Lead arsenate used at 3 pounds per 100 gallons.
2/ Cryolite used at 4 pounds per 100 gallons.
3/ Derris used at 4 pounds per 100 gallons. One extra spray in August. Ground root containing 4 percent rotenone combined with skim-milk powder.

Klinger (237) in 1936 reported that in laboratory tests on fourth instars, rotenone spray or dust gave no mortality in 8 days.

McGovran (262) in 1936 reported that in laboratory tests against larvae oil impregnated with 1 percent of rotenone gave between 40 and 25 percent of entries; nicotine sulfate, 2 percent in oil, gave 100-percent control and was the most effective material for impregnating oil.

The Missouri Agricultural Experiment Station (280) in 1936 reported that rotenone and a number of other chemicals proved far more toxic to the larvae under laboratory conditions than lead arsenate, but in the orchard they did not prove effective or safe.

Siegler and Munger, in a typewritten report to the Division of Fruit Insect Investigations, of the Bureau of Entomology and Plant Quarantine in 1936, stated that a sample of derris containing 3.6 percent of rotenone (15.6 percent total extractives with carbon tetrachloride), used at the rate of 1 pound to 50 gallons of water, was ineffective in laboratory tests against codling moth larvae. Tephrosia virginiana, used at a dosage in which the rotenone content was the same as that of a sample of derris, was not quite so effective as derris, possibly because the percentage of total extractives was only one-half that obtained from derris. Extracts of other plants such as T. piscatoria, Jamaica dogwood, and daisy flowers did not appear to have promise.

Strong in 1936, in a letter to the Chief of the Bureau of Plant Industry transmitted the results of tests with devil's-shoestrings on various insects. A comparison of this insecticide with derris was made against codling moth larvae at Beltsville, Md., using Siegler's apple-plug method, with the following results:

Treatment	Larvae	Successful entrances
	Number	Percent
None	226	95
Tephrosia virginiana (1.72 percent rotenone, 7.5 percent total extractives, carbon tetrachloride) 4 pounds in 100 gallons	40	85
Derris root (3.6 percent rotenone, 15.6 percent total extractives, carbon tetrachloride) 2 pounds in 100 gallons	41	71

Lead arsenate was not used in this series but, on the average, tests carried on by this technique gave approximately 40 percent of successful entrances.

The United States Department of Agriculture on January 13, 1936, issued a press release which called attention to certain disadvantages that bar the use of rotenone insecticides for some types of insects. Derris is not effective against all insects. Although toxic to codling moth larvae in the laboratory, rotenone preparations, exposed to light and air in a thin spray film, decompose too rapidly for economical use.

Allman (12) in 1938 reported the results of a series of experiments in commercial control, carried out during the 1936-37 season at Maimuru (Young) in Australia, the tests including four varieties. The derris and white-oil emulsion specially prepared for the test was ineffective at 1:100, and a residue of derris usually ran to the calyx end of the fruit, resulting in oil staining. Excessive use of the usual white oils has caused a somewhat similar condition, but the presence of the derris powder apparently encouraged this tendency to oil-burn.

Infestation on apple, pear, and plum was mitigated by a product containing 12 percent of powdered Lonchocarpus nicou root (6 percent rotenone) and 88 percent of talcum, according to Etablissements Rotenia, in a letter to R. C. Roark in 1938.

The New York County Agents' Training School (298) in 1938 heard reports on rotenone products. Cube was not a satisfactory control in a moderately infested orchard.

The Ohio Agricultural Experiment Station (318) in 1938 issued a spraying program for the control of insects and diseases attacking fruit crops. Under Ohio conditions the following materials were not recommended for use in the orchard against the codling moth: Natural cryolite, synthetic cryolite, barium fluosilicate, pyrethrum, derris or rotenone, and phenothiazine; and summer oils were not recommended unless fortified with lead arsenate or nicotine.

Roark (357) in 1938 reviewed the comparative action of derris and cube of equal rotenone content on many insects. Reference was made to reports by Haegele and Childs (437, 439) issued by the United States Department of Agriculture, Bureau of Entomology and Plant Quarantine, who tested derris-kaolin and cube-kaolin mixtures of equal strength (1 percent rotenone) on larvae. Neither material appeared to have much effectiveness in control. Although both resulted in fewer stings, there were more worms per 100 apples than when lead arsenate was used.

Webster (476) in 1938 discussed substitutes for lead arsenate and stated that rotenone, because it breaks down quickly in sunlight, has not been of much value.

Agicide DC-4 (rotenone 0.6 percent) at the rate of 4 pounds per 100 gallons of water (0.003 percent rotenone in spray) killed from 50 to 100 percent within 96 hours. -- Agicide Laboratories (8) in 1939.

Siegler (370) in 1940 reported laboratory studies of various sugars and other materials as possible larval attractants for use in increasing the effectiveness of lead arsenate and other stomach poisons. Of the several compounds reported on, brown sugar, because of its availability and low cost, appears to offer greatest promise as a larval attractant. The addition of brown sugar to lead arsenate, calcium arsenate, nicotine bentonite, and phenothiazine considerably increased the toxicity of these insecticides under laboratory conditions. In combination with paris green it decreased the percentage of injury. With pyrethrum, however, brown sugar was not notably effective as an attractant and with derris it had no value. It was thought that in a large measure derris and pyrethrum might have killed the larvae by contact. The derris (5 percent rotenone) used at the rate of 4 pounds per 100 gallons gave 48.5 percent of clean apples, when tested by the apple-plug method. The addition of brown sugar at the rate of 16 pounds per 100 gallons to this spray gave 47.9 percent of clean apples.

The United States Department of Agriculture, Bureau of Entomology and Plant Quarantine (447), in 1939 reported that at Kearneysville, W. Va., cube was tested in two orchards. A proprietary cube mixture (4 percent rotenone) at 2 pounds per 100 gallons was used in the 7- to 10-day schedule but proved ineffective, the number of worms per 100 apples ranging from 49 to 81.

Grapholitha funebrana Tr.

Bovey (43) in 1939 reported that in tests made in Germany, derris dusts containing from 0.8 to 1.0 percent of rotenone did not give as good results against this insect as did nicotine sprays, which gave controls ranging from 75 to 96 percent at a nicotine concentration of from 0.9 to 2.2 percent.

Grapholitha molesta (Busck.), the oriental fruit moth

Driggers (101) in 1929 made laboratory tests to determine the toxicit of sprays to the eggs. An alcoholic extract of cube root at 1:200 gave a control of 4.1 percent; at 1:500, a control of -0.9 percent; and at 1:1,00 a control of 1.1 percent. Derrisol 1:800 plus rosin-fish-oil soap, 1 poun to 50 gallons, gave a control of 6.3 percent as computed by Abbot's formul The greatest control, 85.2 percent, was given by Volck at a strength of 1.25 percent.

Lipp (251) in 1929 reported that derris compound 1:500 seemed to have no repellent action against this insect.

Garman (150) in 1930 reported that in Connecticut peach shoots sprayed with rotenone 0.075 or 0.1 gm. in 100 cc. of water to which 1 or 2 gm. of sirup or honey had been added were placed in cages containing the moths. On the treated peach shoots 854 eggs were deposited, as compared with 2,217 on untreated shoots. White-oil emulsion 1.3 gm., derris preparation 1 gm., and water to 500 cc. killed 60 percent of the eggs; white-oil emulsion 1.6 gm., derris preparation 1 gm., and water to 600 cc. killed 68 percent of the eggs; and white-oil emulsion 1.3 gm., rotenone 1:12,000 (0.5 cc. of a 10 percent solution in acetone), and water to 600 cc. killed 73 percent of the eggs sprayed with the mixture. Rotenone 1:1,000 (1 cc. of a 10-percent solution in acetone), sirup 2 gm., and water to 100 cc., when sprayed on the eggs gave a probable efficiency of about 93 percent, on account of larval mortality after hatching. No insecticide gave sufficient control to warrant recommending it.

Rotenone in oil emulsified in water with powdered milk (rotenone 1:25,000; oil 1.0 percent) killed 96.4 percent of the eggs, but the oil alone killed 92.9 percent. -- Turner (418) in 1932.

The Ohio Agricultural Experiment Station (313) in 1934 reported that combinations of oil with rotenone were among the materials that gave best results in orchard tests. Six applications at weekly intervals reduced injury 36.1 percent. Had the first application been made 2 weeks earlier better control might have been obtained.

Chandler and Flint (69) in 1936 published an account of tests of oil dusts (35 parts sulfur, 25 parts talc, 25 parts lime, 10 parts lead arsenate, and 5 parts oil) against oriental fruit moth in southern Illinois. The addition of derris in place of lead arsenate to these oil dusts did not increase their effectiveness. The same authors (70) in 1938 reported that in Illinois in 1936 a proprietary dust containing oil, sulfur, and talc with lime, in the proportion of 5:57:38, gave 96 percent control and

this was not improved by the use of dusts containing in addition 1 percent of rotenone with or without bentonite sulfur, or 0.5 percent each of rotenone and nicotine. It was as satisfactory to apply the dust at the appearance of the third-generation larvae, about a month before harvest, as during the attack of the second generation.

Malenotti (267) in 1937 reported the results of tests with rotenone spray and dust on infested peaches in the province of Veneto, Italy. Powder containing 0.9 percent of rotenone was sprayed as an aqueous suspension nine times, and dust containing 0.3 percent of rotenone was also applied nine times. Results were unsatisfactory. Trees not sprayed but periodically pruned to remove infested branches yielded 70.3 percent of wormy fruit; those treated with spray yielded 79.5 percent of wormy fruit, and those dusted yielded 89.5 percent wormy fruit.

The Connecticut Agricultural Experiment Station (78) in 1938 reported that experiments with derris were made on a block of Elberta peach trees laid out in Latin-square arrangement. Results showed no improvement over the untreated plots.

Flint, Farrar, and Chandler (136) in 1938 reported that three oil dusts (60 pounds of 300-mesh sulfur, 15 pounds of hydrated lime, 20 pounds of 300-mesh talc, and 5 pounds of oil) containing derris, applied the last of the season, were 37.9 percent efficient in control in 1935 in Illinois. In 1937 5 oil dusts (no derris) gave 70-percent control.

Garman (152) in 1938 reported the results of tests in a Connecticut peach orchard. Spray applications were made on August 5, 14, and 28. Results were as follows:

Material	Fruit infested
	Percent
Ground cube root, 4 lbs. to 100 gal. of water	31.3
Ditto, plus Ultrawet 0.25 to 0.75 lb. to 100 gal.	28.0
Fixed nicotine made with quebracho tannin, the stock containing 4.35 percent of nicotine, 10 lb. in first spray, 12 lb. in second and third applications	23.5
Check--no sprays during August	25.5

Garman concluded: "It will be seen from the data presented that there was no significant difference in the amount of infested or injured fruit from any of the treatments. Separation of the types of injured fruit into old and new did not afford any more favorable data in regard to sprays."

Stearns (393) in 1938 reported on experiments with the following substances, listed in order of efficiency: Lead arsenate, phenothiazine, cryolite, tetramethyl thiuram bisulfide, and derris, used, respectively, at the rate of 2, 4, 3, 4, and 4 pounds per 100 gallons. In each case, 6 pounds of magnetic sulfur was added as a fungicide, 1 pound of rosin residue was added to all the spray mixtures except cryolite, and 4 pounds of zinc sulfate and 5 pounds of hydrated lime were included with lead arsenate. Three applications were made, one immediately after petal fall, one at the shuck-slip stage, and one a fortnight later. Lead arsenate gave slightly better control than the other materials.

Laspeyresia nigricana (Steph.), the pea moth

Miles (276) in 1926 reported good control with the use of a derris spray consisting of 20 pounds of powdered derris to 100 imperial gallons of water. This spray produced the lowest percentage of damage (16 percent) in the threshed peas. The percentages of damaged peas harvested from plots sprayed with derris or nicotine showed little difference from those observed when the green peas were examined; these sprays, therefore, seem to have a permanent effect.

Melissopus latiferreanus (Wlsm.), the filbert moth

Thompson (412) in 1938 summarized results of spray tests in 1937. This is the most important filbert insect pest in Oregon at present. Many sprays and three dusts, including Cubor (0.75 percent rotenone), were tried for control. Results were as follows:

Material	Worms Percent
Lead arsenate plus soap	0.99
Cubor dust	8.6
Unsprayed check	23.3

Olethreutes pruniana (Hbn.)

A product containing 12 percent of powdered Lonchocarpus nicou root (6 percent rotenone) and 88 percent of talcum killed (Penthina) Olethreutes pruniana on cherry and plum, and repelled it on apple, according to a letter from Etablissements Rotenia to R. C. Roark in 1938.

Polychrosis botrana (Schiff.)

Soe Jancke and Roosler (220) under Phalonia ambiguella (Hbn.) on page 100.

Delassus and Laffond (92) in 1936 reported the results of tests of derris against this species on grapes in Algeria. Powder A contained 1.5 percent of rotenone and other derris constituents; powder B, 2.0 percent of rotenone and related substances; powder C, 3 percent. Two applications were made on August 2 and 9, 1935, by hand dusters. On August 4 there was a flight of butterflies of the third generation. Dosages applied were 130 to 160 kg. per hectare per treatment--an excessive amount. Almost complete protection was given by powders A and C; powder B was coarser and did not adhere so well. In 1937 these authors (93) concluded that 15 to 30 kg. of derris dust containing 2 percent of ether extractives per hectare gave satisfactory results. Derris residue on the grapes was visible a month after application but did not interfere with fermentation or impart a taste to the wine.

An anonymous (6) writer for the Palestine Gazette in 1938 reported that during the preceding 2 years substitutes for arsenicals had been tested at the Entomological Laboratory of the Plant Protection Service, Acre Stock Farm and Agricultural Station, for the control of this species. Derris and pyrethrum proved effective in the laboratory but had always been a failure in the vineyard, owing to two facts: (1) The active principles, the rotenone and the pyrethrins, easily break down in the sun and heat of the climate of Palestine in 3 to 4 days. (2) It is practically impossible to apply these dusts so punctually as to meet the larvae just at their emergence or very close to it. The so-called stabilized derris preparations have not proved better than the normal ones.

Jancke and Maercks (219) in 1938 reported on laboratory experiments in Germany to determine the length of time during which sprays of nicotine and sprays or dusts of pyrethrum or derris remain active. The insecticides were applied at usual concentrations to glass dishes, and test insects were placed in them at known intervals after the application, left there for about an hour (uncovered, to preclude fumigant action), then removed to unpoisoned food in clean dishes. The mortality was ascertained after 2 days. Batches of varying numbers of larvae were similarly tested or sprayed directly. When they were sprayed directly, the mortality was estimated after 3 days and was similar (70-81 percent) for crude nicotine and soap, tobacco extract and soap, and preparations of pyrethrum, or pyrethrum and derris. When tested by the first method, the tobacco extract was the most effective spray, giving 75 and 40 percent mortality of larvae placed in the dishes 2 and 24 hours after application. The pyrethrum and pyrethrum-derris sprays were disappointing, the latter giving no mortality. Pyrethrum dust and pyrethrum-derris dust gave percentage mortalities of 100 and 79, respectively, when the interval was 2 hours. A derris dust gave 100-percent mortality when the intervals were 2 and 6 hours, and 95 percent when they were 24 and 48 hours.

Paillot in 1940 (323) briefly summarized the results of experiments on control of the two vine moths (Clysiana) Phalonia ambiguolla (Hbn.) and Polychrosis botrana in several districts in France. Arsenical sprays were reported to be superior to dusts containing 1 percent of rotenone which, however, were more effective than dusts containing barium fluosilicate.

Polychrosis viteana (Clem.), the grape berry moth

At the annual codling moth conference held by the United States Department of Agriculture, Bureau of Entomology (431) at Washington, D. C., in 1930, Runner reported tests of nonarsenicals for use on grapes at Sandusky, Ohio. Three years' work with commercial derris extract in mixtures applied against the grape berry moth had not shown any important gain in control. At a strength of 1:800 it did not seem to destroy the eggs nor have any decided effect in preventing damage from larvae. The same Bureau (433) in 1931 reported that for the control of the grape berry moth several contact materials, including oil emulsions, nicotine sulfate, and derris and pyrethrum extracts, as well as rotenone, have been tested against the second brood of worms, with very disappointing results. The Bureau of Entomology and Plant Quarantine in 1935 (439) reported that derris-kaolin (rotenone 1 percent) at 10 pounds per 100 gallons plus white oil, and derris (rotenone 4 percent) at 2.5 pounds per 100 gallons plus fish oil, reduced damage by the grape berry moth at Venice, Ohio, but caused such serious staining that the grapes were practically unsalable.

Runner (359) in 1932 reported that pyrethrum extract, derris extract, nicotine sulfate, and nicotine tannate were tested against this insect under field conditions but without encouraging results. Failures in control also characterized the use of rotenone, of oil sprays, and of oil in combination with nicotine. While most of the nonarsenical materials mentioned showed decided toxic properties, they apparently either did not remain highly toxic or were too easily washed from the grape clusters to afford protection over the long period needed for adequate control.

Rhopobota naevana (Hbn.), the blackheaded fireworm

The Washington State Agricultural Experiment Station (473) in 1930 reported the results of tests by Crowley with insecticides against cranberry insects. Neoton, a derris derivative, was tried again but proved to be no more effective than the less expensive pyrethrum sprays. Rotenone was tried against this fireworm at the rate of 3 ounces to 100 gallons of water. It killed the larvae at this strength and also repelled chewing insects for several days after the plants were sprayed with it.

The Massachusetts Agricultural Experiment Station (270) in 1937 reported that a spray of 5 pounds of derris powder (4 percent rotenone) and 4 pounds of fish-oil soap in 100 gallons of water, 400 gal. to an acre, killed 75 percent of the worms; 6 pounds of derris powder (4 percent rotenone) and 4 pounds of fish-oil soap in 100 gallons of water, 400 gallons to an acre, killed 85 percent; and 8 pounds of derris (4 percent rotenone) and 3 pounds of fish-oil soap in 100 gallons of water, 400 gallons to an acre, killed 98 percent. While this last spray was very effective, it was too costly to compete as a treatment for this pest; however, it has good long-range promise.

Rhyaciona buoliana (Schiff.), the European pine shoot moth

An anonymous note (4) in August 1933 called attention to the steps being taken by the Bureau of Plant Industry of the New York State Department of Agriculture and Markets to bring under control an infestation in the nurseries of southeastern New York. A control measure worked out by R. D. Glasgow, State entomologist, was being employed. The method consisted of spraying with any one of a number of formulas. It was stated by Dr. Glasgow and B. D. Van Buren that the most successful of these formulas consisted of 1.5 pints of cube extract (5 percent rotenone oil), and 2 gallons of miscible pine oil in 100 gallons of water. The nurserymen were instructed to spray thoroughly between June 25 and July 4, directing the spray branch by branch, downward and inward, so that it might penetrate the needle clusters from the tip toward the base. Two applications, one near the beginning and one near the end of the period named, were advised. This treatment gave good results, even in severe infestations. Glasgow in 1933, in a letter to R. C. Roark reported the results of spraying red pine in New York with a spray containing 2 percent of miscible pine oil and rotenone at the rate of about 1:12,800 parts by weight of the spray. A solid cube extract containing 15 percent of rotenone, dissolved in miscible pine oil, was used. Glasgow said: "A single application of this spray at the right time (July 1932) appears to give excellent control. The improvement is truly spectacular and can be recognized as far as the plats can be seen." Glasgow's excellent results with rotenone sprays were referred to by Friend and West (147) in 1934.

Friend and Hicock (144) in 1935 reported that tests in Connecticut carried out in a red pine plantation have shown that two applications of a suitable insecticide will give fairly good results. A mixture of lead arsenate 1.5 pounds, fish oil 1 pint, and water 50 gallons, applied on June 22 and July 2, gave 86-percent control, based on the number of injured buds. Sprays containing lead arsenate with various other spreaders and stickers, and ground derris (4 percent rotenone) with powdered skim milk were not quite so effective. In 1936 these authors (145) reported further tests. Spraying experiments were carried out in a stand of infested red pines from 20 to 25 feet in height. Two applications were made, one at about the time the eggs began to hatch (June 22) and the other 10 days later (July 2). The incubation period of the eggs under field conditions is approximately 10 days. The following three mixtures were compared: (1) Lead arsenate 1.5 pounds, fish oil 1 pint, water 50 gallons; (2) ground derris root (4 percent rotenone) 1 pound, powdered skim milk 0.5 pound, water 50 gallons; (3) lead arsenate 1.5 pounds, waterproof glue 0.5 pound, bentonite 0.5 pound, hydrated lime 1.5 pounds, water 50 gallons. About 5 gallons of the material were applied per tree. The insecticide must reach the junctions of the needle bases with the twigs, the only point of entrance of the first instar, and a heavy application is necessary. In the first application the derris-skim milk had been diluted to 75 gallons instead of 50, which weakened the comparison of results with those of lead arsenate.

Insecticide	Injured tips	Uninjured tips	Larvae per injured tip	Tips injured	Control
	Number	Number	Number	Percent	Percent
Derris-skim milk	34	174	0.59	16	66
Check	112	127	.74	47	--
Lead arsenate-fish oil	17	226	.53	7	88
Check	150	110	.64	58	--
Lead arsenate-glue bentonite-lime	38	238	.61	14	78
Check	141	80	.74	64	--

The derris-skim-milk mixture might have given better results had it been properly diluted in the first application. Reference is made to a mimeographed circular by Glasgow, who recommended 1.5 pints of a cube or derris extract containing 5 percent of rotenone plus 2 gallons of miscible pine oil in 100 gallons of water, the application to be made on June 25 and July 4 (in New York). Results with derris indicate that the ground root is probably better than the extract.

Potts (332) in 1936 reported that derris coated with linseed oil (derris 4 lb. and 8 lb. to 100 gal. with 1 percent linseed oil) was the most effective insecticide, giving approximately 75-percent control. Other insecticides tried were lead arsenate 3:100 and 6:100 with linseed oil; lime-sulfur 1:20; bordeaux mixture 4-4-50; nicotine tannate 1:400 with 1 percent of linseed oil; and phenothiazine 6:100. In 1937 Potts (334, 335) reported that (a) 1 part of derris resin plus 1/2 part of linseed oil plus 8 parts of water, and (b) 1 part of derris resin plus 5 parts of linseed oil plus 2.5 parts of acetone gave excellent control. Derris and other insecticides were sprayed from an autogiro for the control of this insect. Potts (336) in 1938 reported that the control obtained with derris ranged from 85 to 99 percent. The mixtures contained adhesives and spreaders and were applied by ground equipment. Concentrated spray mixtures were much more effective than standard spray concentrations and can be applied at a small fraction of the cost of mixtures of ordinary spray concentration.

The Connecticut Agricultural Experiment Station (78) in 1938 reported that two applications of ground derris or cube (4 lbs. per 100 gal.) with a suitable spreading and adhesive agent, was much superior to lead arsenate, with fish oil as an adhesive agent, when the latter was used at the rate of 3 pounds per 100 gallons. A modification of the spraying technique may make this method of control economically feasible in forest plantings.

Friend and Plumb (146) in 1938, reporting on tests made in 1936 and 1937, stated that derris (4 percent rotenone, 14 percent ether extractives) plus SS-3 or powdered skim milk gave greater reduction in infestation than did lead arsenate. Cube (same analysis as the derris) was tried with powdered skim milk, milk, rosin residue, and Ultrawet. The authors concluded:

> Field experiments on the control of the European pine shoot moth on red pine in Connecticut have shown that spraying with a mixture of 4 pounds of ground derris root or ground cube root and 1 pound of powdered skim milk in 100 gallons of water is superior to spraying with a mixture of 3 pounds of lead arsenate and 1 pint of fish oil in 100 gallons of water. One application of cube about July 2 is as effective as 3 or 4 applications of lead arsenate at 10-day intervals in June and July. Two applications of cube, one on July 2 and one on July 12, are significantly more efficient in reducing tip injury than one application on July 2. As a spreader and sticker, powdered skim milk is as efficient as any other materials tried at the concentrations used. It was found that spraying during the first half of June did not give good results in controlling the insect in 1936 and 1937.
>
> Derris and cube were equally good. Exposure to sunshine for 166 hours did not completely destroy the insecticidal value of these materials. The laboratory experiments with newly hatched larvae on sprayed twigs show that, after an exposure of 11 days in the field, ground cube root used with powdered skim milk or Ultrawet was as effective in preventing boring as was the lead arsenate and fish-oil combination.

Friend (143) in 1939 reported that two applications of a mixture of 1 pound of powdered skim milk and 4 pounds of ground derris or cube in 100 gallons of water, the first application being made the last week of June or the first week of July and the second 10 days later, gave excellent results on red pine. If control measures are efficiently carried out, treatment every other year should suffice, unless there are untreated infested trees in the immediate vicinity.

Spilonota ocellana (D. & S.), the eye-spotted budmoth

Kelsall et al. (233) in 1926 reported that derris spray, 2 pounds to 100 imperial gallons of water, was less than 10 percent effective against budworms, mostly this species.

Yago (502) in 1933 wrote that this species, formerly abundant in pear orchards in Shizuoka, Japan, had become scarce, probably owing to the use of insecticides, including derris.

Steganoptycha trimaculana Don.

DeBussy, Van der Laan, and Diakonoff (57) in 1936 reported that this species cannot be controlled with derris dusts or sprays because the insects cannot be reached.

Papilionidae

Papilio cresphontes Cram. (P. thoas L.), the orange dog

Andries (13) in 1932 wrote that citrus trees in crops attacked by this species may be sprayed with Derrisol or Katakilla.

Phalaenidae

Agrotis segetum (Schiff.)

Klinger (237) in 1936 reported that tests made in the laboratory with rotenone spray and dust against fourth instars gave no mortality in 8 days.

Agrotis sp.

Trappmann and Nitsche (417) in 1935 reported that rotenone sprays and dusts, regulated to give a deposit of 0.18 mg. of rotenone per 500 $cm.^2$, were not effective against last instars.

Alabama argillacea (Hbn.), the cotton leafworm

The eggs were not affected by a suspension of powdered root of Tephrosia virginiana in water.-- Little (255) in 1931.

Smith, Clark, and Scales, Tallulah, La., in a typewritten report to the Division of Cotton Insect Investigations, Bureau of Entomology and Plant Quarantine, United States Department of Agriculture, in 1934 compared the effectiveness of derris, cube, and other insecticides against the cotton leafworm in cages and in the field. Both derris and cube contained 4 percent of rotenone. The insecticides were applied as a dust according to "average field dusting" practice, with a small hand dust gun. The results were as follows:

Insecticide	Mortality Percent
Cube only	60
Derris only	73
Calcium arsenate	94
Check	1

These results were referred to by Roark (357) in 1938 in a review of the comparative value of cube and derris.

In 1936 Smith, Clark, and Scales (376) reported that in cage tests at Tallulah, La., derris powders containing from 0.4 to 4.0 percent of rotenone were less effective than calcium arsenate in killing leafworms on cotton. In 1937, in a typewritten report to the Division of Cotton Insect Investigations of the Bureau of Entomology and Plant Quarantine they gave the following results of cage tests at Tallulah, La., in 1936:

Treatment	Leafworm control Percent
Cube (4 percent rotenone)	77
Derris (4 percent rotenone)	78
Tephrosia virginiana root (1.7 percent rotenone)	46
Commercial calcium arsenate	89

The Division of Cotton Insect Investigations of the United States Department of Agriculture, in a memorandum to R. C. Roark, reported the following results of tests at Tallulah, La., and Port Lavaca, Tex. in 1936:

Treatment	Leafworm mortality Percent
Derris 40 percent, sulfur 60 percent (rotenone 1.6 percent)	63.5
Derris 20 percent, sulfur 80 percent (rotenone 0.8 percent)	55.7
Derris 10 percent, sulfur 90 percent (rotenone 0.4 percent)	41.1
Derris (rotenone 4 percent)	77.7
Calcium arsenate	89.14
Check	3.37

Smith and Scales (377) in 1937 reported that calcium arsenate either used alone or in mixtures with sulfur, caused a higher mortality of leafworms than did derris, cube, or devil's-shoestrings when tested in cages. Results were as follows:

Treatment	Control Percent
Calcium arsenate	89
Derris (4 percent rotenone)	77
Cube (5 percent rotenone)	76
Devil's-shoestrings (1.7 percent rotenone)	44
Pyrethrum (0.76 percent pyrethrins)	92

Wille, Ocampo, Weberbauer, and Schofield (485), of the Agricultural Experiment Station at La Molina, Peru, in 1937, reported that sprays of cube extract containing 0.05 percent of rotenone had no effect on larvae of Anomis texana Riley and Alabama argillacea (Hbn.), but in another series of tests a spray of 0.01 percent rotenone content gave 75-percent mortality after 8 days, and surviving larvae were unable to molt normally. A suspension of cube dust in water to give a spray containing 0.3 percent of rotenone killed 73 percent of the larvae in 5 days, but was not effective in the field, probably owing to imperfect wetting.

Anomis erosa Hbn.

Butac (58) in 1938 reported that in 1936 cotton plants in one of the plots at the Philippine Carnival Exposition were dusted with derris-gawgaw (50:50, rotenone 1.5 percent) mainly to control the leaf-eating caterpillars especially those of this species, which were abundant on the plants. The dusting was done at about 9 a.m., the plants were examined between 2 and 3 p and the insects found were collected, especially those affected by the treatment. Ninety-six caterpillars, of (Cosmophila) Anomis erosa, all paralyzed, were collected and 61 of them died after 2 days.

Anomis texana Riley

See Wille, Ocampo, Weberbauer, and Schofield (485) under Alabama argillacea (Hbn.), mentioned previously on this page.

Anticarsia gemmatilis (Hbn.), the velvetbean caterpillar

Ellisor and Floyd (109), in 1939, reported tests of insecticides for the control of this insect at Baton Rouge, La. A derris dust containing 1 percent of rotenone plus 1 percent of Vatsol OS killed no larvae after 3 days. Basic copper arsenate gave the best control, 90 percent mortality. Guyton (174) in 1940 reported that timbo-talc dusts (1 + 7 and 1 + 3 containing, respectively, 0.5 and 1.0 percent rotenone) gave from 25 to 41 perc control on peanut plants in Alabama. The best control, 91 percent, was shown by lead arsenate dust applied at the rates of 8 and 10 pounds per acre.

Autographa brassicae (Riley), the cabbage looper

McIndoo, Sievers, and Abbott (264) in 1919 reported that in two cage tests derris, applied at the rate of 1 pound to 25 gallons of water, killed all the larvae within 24 hours.

Kopp (242) in 1924 stated that derris powder 500 gm. to 100 liters of water containing 250 gm. of soap gave excellent results.

White (478) in 1933 published a progress report of experiments on the control of three species of cabbage worms, i.e., loopers, diamondback moths, and common cabbage worms. Tests were made at Chadbourn, N. C., Charleston, S. C., and Baton Rouge, La., by dusting with calcium arsenate, paris green, lead arsenate, derris, pyrethrum, and hellebore. The derris dusts used contained from 3.4 to 4.9 percent of rotenone and from 18.8 to 22.7 percent of carbon tetrachloride extract. Concerning derris the conclusions were:

When used undiluted or mixed with equal parts of finely ground tobacco dust or sulfur, ground derris root proved to be more toxic to each of the three species studies than the other materials tested. It apparently has a residual action, which pyrethrum dust does not have. Plants dusted with derris appear to be more thrifty and freer from thrips than those dusted with other materials. The data indicated that dosages of 3 to 6 pounds (mixed with equal amounts of tobacco dust) per acre per application, applied under favorable conditions, will effectively control the cabbage looper, the common cabbage worm, and the larvae of the diamondback moth. Derris caused certain discomforts to operators, including slight tickling and irritation of the respiratory organs and, if breathed for a long period, slight nausea. No plant injury occurred.

Derris with sulfur, 1:3, and derris, tobacco dust, and sulfur 1:4:5, were also tried. The relative susceptibility of the three species to a mixture of equal parts of derris (rotenone 4.9 percent, total extract 18.8 percent) and tobacco is shown in the following table of results obtained at Chadbourn, N. C.

Relative susceptibility of cabbage worms to derris and tobacco

Time of application	Rate of application/acre	Reduction in number of worms per plant as compared with undusted plots (percent)			
		Loopers	Diamondbacks	Common cabbage worms	All 3 species
p.m.	17	74	100	100	83
a.m.	16	46	69	100	57

White (481) in 1935 summarized the results obtained by the Bureau of Entomology and Plant Quarantine at Chadbourn, N. C., Charleston, S. C., Baton Rouge, La., and Columbus, Ohio, with nonarsenical insecticides for control. As a general insecticide for the control of mixed populations of the four species of cabbage worms involved, derris gave the best results and pyrethrum came next. In comparison, paris green, cryolite, and calcium arsenate were approximately equal in effectiveness but, in general, were inferior to either derris or pyrethrum. Based on comparative efficiency, at economical strengths, derris and pyrethrum were approximately equal in effectiveness in controlling the looper, and either was more effective than paris green, cryolite, or calcium arsenate. In general, better results were obtained with dust mixtures than with sprays. The dusts were applied with rotary-type hand dusters in such a manner as to cover thoroughly all infested portions of the plants, care being taken to reach the insects with the dust whenever possible. The rate of application ranged from 15 to 20 pounds per acre per application, according to the size of the plants. Applications were begun when the worms first appeared on the plants and were repeated as often as was necessary to protect the crop. Usually three applications were made per crop. Derris dusts, either home-mixed or commercial, containing from 0.5 to 1.0 percent of rotenone, gave the most satisfactory results of any of the insecticides tested, in four sections of the Central, Eastern, and Southern States.

Several nonalkaline materials, including finely ground tobacco dust, finel pulverized clay, talc, diatomaceous earth, infusorial earth, and sulfur, proved satisfactory as diluents. Good control was obtained with a derris spray consisting of a suspension of derris-root powder in water diluted to contain from 0.02 to 0.025 percent of rotenone; for example from 2 to 2.5 pounds of derris-root powder containing 4 percent of rotenone per 50 gallo of water. Under some conditions it was necessary to add to the spray a no alkaline spreader or sticker such as high-grade liquid or powdered soap, miscible pine oil, or one of the sulfonated oils. White (480) in 1935 rec mended derris dust (0.5 to 1.0 percent rotenone) for the control of the ca bage looper. Derris spray made by adding the powder to water, and contain ing 0.02 to 0.025 percent of rotenone, also is effective against cabbage w White in 1936 recommended derris dust containing 0.5 to 1.0 percent of rot none for the control of cabbage worms on cabbage and cauliflower at a dosa of 15 to 20 pounds per acre. Based on the relative efficiency at the reco mended dosages of each of the insecticides tested, experiments indicated that derris and cryolite were approximately equal in effectiveness in con- trolling the cabbage looper and that both materials are more effective tha paris green, pyrethrum, or calcium arsenate. It was found to be especially important to start the treatments on the cauliflower while the plants were small, as it was impossible to obtain a good coverage of the insecticides over the heavy foliage of nearly mature plants. The experiments of 1934 on collards indicate that each of the three more common species of cabbage worms may be controlled satisfactorily with a derris-dust mixture contain- ing 0.5 percent of rotenone.

White (482) reported that derris dust containing from 0.5 to 1.0 per- cent of rotenone, applied at the rate of 15 to 20 pounds per acre, is the preferred material for use against cabbage looper. The rotenone content of derris root varies, and purchases should be made on the basis of roten- one content, total extractives, and degree of fineness. For example, a derris-root powder containing 4 percent of rotenone should contain not less than 14 percent of total carbon-tetrachloride or other extractives. In general, the total extract should average approximately 3-1/2 times the rotenone content. The derris-root powder should be of such degree of fineness that not less than 90 percent of it will pass through a 200-mesh sieve and all the material should pass through an 80-mesh sieve.

Tests have shown that neither paris green, nor lead arsenate, nor calcium arsenate will give so effective control of cabbage loopers as will derris dusts containing 1.75 percent of rotenone applied at the rate of 12 to 15 pounds per acre, or pyrethrum dusts containing 0.12 percent of pyre- thrin I and applied at the same rate. Hellebore was found to give better control than the arsenicals but was considerably inferior to the derris and pyrethrum products.—United States Department of Agriculture, Bureau o Entomology (434) in 1933.

In 1934, as reported by the United States Department of Agriculture, Bureau of Entomology and Plant Quarantine (437), Cory led a discussion of field results with arsenical substitutes for the control of vegetable insects. Roney and Thomas, of Texas, reported that derris-sulfur dust (0.5 percent rotenone) successfully controlled the cabbage looper.

W. H. White reported that derris and pyrethrum were approximately equal in effectiveness in controlling the cabbage looper, and either was more effective than paris green, cryolite, or calcium arsenate. In general, dusts gave better results than sprays. Walker and Anderson, of the Virginia Truck Experiment Station, reported that a derris dust (0.5 percent rotenone) gave satisfactory control of the cabbage looper. Headlee, of New Jersey, reported that a dust containing 0.8 percent of rotenone (16 parts derris, 25 parts sulfur, and 59 parts clay or talc), applied at the rate of 15 to 18 pounds per acre without hoods, or 8 to 10 pounds with hoods, was effective against the cabbage looper, the imported cabbage worm, and the caterpillar of the diamondback moth. The Bureau in 1935 stated that laboratory experiments and large field-plot tests to determine the relative toxicity of pyrethrum and derris mixtures for the control of several species of cabbage worms had been carried on at several laboratories. The field-plot tests on cabbage showed definitely that derris-dust mixtures containing from 0.5 to 1.0 percent of rotenone were effective against the common cabbage worm, less effective against the cabbage looper, and still less effective against the diamondback moth. The indications, nevertheless, were that derris powder would be useful in the control of all three species. In general, pyrethrum-dust mixtures were less effective than those of derris against all three species. In 1936 the Bureau (442) reported that on cabbage, derris and cryolite were approximately equal in effectiveness in controlling the cabbage looper, and both were more effective than paris green, pyrethrum, or calcium arsenate. Experiments in California demonstrated that dust mixtures of derris, cube, or pyrethrum gave satisfactory results in the control of the three more common species of cabbage worms on cauliflower. In laboratory tests the ground root of devil's-shoestrings was as effective against the common species of cabbage worms as was derris or cube containing equal percentages of active ingredients.

A derris-dust mixture (20 parts derris of 5 percent rotenone content, 40 parts tobacco dust, and 40 parts 300-mesh dusting sulfur) is very effective in controlling the cabbage looper.--Allen (11) in 1934.

R. E. Campbell in 1935, in a typewritten report to the Division of Truck Crop and Garden Insect Investigations of the Bureau, gave results of field tests at San Fernando, Calif., in March 1934, with derris and cube dusts containing 0.5 percent of rotenone on cabbage. Applications were made at 22 pounds per acre for derris and 30 pounds per acre for cube by means of hand dusters. Derris caused a reduction of 75 percent of loopers and cube a reduction of 34.4 percent.

Crosby and Chupp (86) in 1934 recommended the application of a dust containing 0.5 percent of rotenone at the rate of 25 to 30 pounds per acre for the control of leaf-eating caterpillars, including the cabbage looper, on cabbage, cauliflower, brussels sprouts, broccoli, kale, and similar crops on Long Island.

Gilbert and Popenoe (159) in 1934 recommended rotenone dusts, such as those produced from derris or cube roots, for control of the cabbage looper. Satisfactory results have been obtained by using 10 to 15 pounds per acre of dust containing from 1 to 2 percent of rotenone. Pyrethrum dusts and extracts are also effective. As these dusts and extracts vary in strength they should be used according to the manufacturer's directions.

Harvey and Palm (190) in 1934 reported experimental work done in western New York on the control of the three common species of cauliflow insects, including Autographa brassicae, by the use of arsenicals, derris pyrethrum, and hellebore. Derris-talc dusts (0.5 and 1.0 percent rotenone), Derex (0.55 percent rotenone), and derris-pyrethrum dust (2.5 percent rotenone and 0.5 percent pyrethrins) all gave good results. The der pyrethrum mixture at the dilutions used was very toxic to cabbage worms, did not appear to be superior to derris when used alone. In general, rot none was far superior to calcium arsenate against these caterpillars and appeared to be about equal to or slightly better than lead arsenate. Pyrethrum was more rapid in its action against cabbage worms than rotenone, although the latter material appeared to have a more decided residual eff and gave protection to the plants over a longer period than did pyrethrum Of the three species of caterpillars concerned, the imported cabbage worm was the easiest to control, the diamondback larvae the most difficult. I general, the cabbage looper was not abundant enough to determine definite what effect the materials had on it, but the degree of control obtained w somewhat less than that of the imported cabbage worm. On cauliflower der dust should be applied at the rate of 25 or 30 pounds per acre. During t season of 1933, with moderate infestation, two applications about three w apart gave adequate protection.

Reid (344) in 1934 reported that at Charleston, S. C., derris-root powder continued to prove toxic to the cabbage worms present, including loopers. The degree of control obtained with derris powder was proportio ate to the strength of material used. Best results followed the use of a mixture containing 1.5 percent of rotenone. An increase in this concentration to as high as 3.4 percent in 1933 did not apparently increase the kill. A mixture containing only 0.1 percent of rotenone showed some toxi ity. Reid (346) in 1938 summarized results obtained in tests directed against cabbage worms on cabbage grown at Charleston during the fall and winter of 1937-38. He reported that a population consisting of the cabbage looper and various Agrotinae could be controlled effectively by the use of a dust consisting of calcium arsenate and hydrated-lime mixture (3:1) prior to the heading of the plants, followed by applications of a pyrethrum-talc-dust mixture (0.3 percent total pyrethrins) or a derris-clay-dust mixture (1.0 percent rotenone) at 10-day intervals after the plants had headed; provided the plants had been well protected against cabbage worms before being thinned or transplanted. The pyrethrum-dust mixture and the derris-dust mixture were most effective against the cabbag looper, and the calcium arsenate-dust mixture effective against the Agrotinae. These results were also referred to by the United States Depar ment of Agriculture, Bureau of Entomology and Plant Quarantine (446) in 1938.

Reid and Bare (347) in 1938 reported that against the cabbage looper the 1-percent rotenone and the derris-pyrethrum-dust mixture (0.5 percent rotenone plus 0.2 percent pyrethrins) applied at 7-day intervals were most effective.

Huckett (201) in 1934 reported field tests on Long Island with derris for the control of cabbage worms. The materials used consisted of proprie tary products applied, so far as possible, according to the directions on the package. The infestation was largely due to Pieris rapae (L.), althou as the season advanced from June to July, Plutella maculipennis (Curt.) an Autographa brassicae became increasingly numerous. Applications were made

on June 27-28, July 6, and July 18, under favorable conditions, at rates equivalent to 60 gallons per acre, increasing to 80 gallons for sprays; for dusts, 25 to 28 pounds, 30 pounds, and 36 pounds per acre per each successive application in series 1 and 22 pounds and 33 pounds per acre per successive application in series 2. Derris dusts gave satisfactory results in the field for the control of cabbage worms. A derris-clay dust (0.5 percent rotenone) applied four times at about 15-day intervals during a 10-week period of infestation gave as satisfactory results as five or seven applications at shorter intervals. A derris-clay dust of 0.5-percent-rotenone strength gave as satisfactory results as dusts of 1-percent-rotenone strength. A dust of 0.33-percent-rotenone strength was not so effective. Talc, clay and tobacco dust gave a promise of being satisfactory diluents for derris dusts. Hydrated lime apparently affected adversely the toxicity of derris dusts. Rotenone sprays did not give so high degree of control as dusts, possibly owing to the apparently greater infestation in the sprayed section. A rotenone spray of 1:10,000 dilution was as effective as sprays of 1:5,000. There was very little difference in the comparative merits of the various spreaders used with rotenone when applied as freshly mixed sprays. Proprietary derris products included Hellspra No. 1, Cubor spray, Cubor dust, and Derox.

Huckett (202) in 1936 reported insectary tests with pyrethrum, derris (4.5 percent rotenone and 16 to 18 percent total extractives), and nicotine against the cabbage looper. The results with derris against third instars were as follows:

Spray formula	Mortality after 96 hours
	Percent
Derris powder 2.5 gm., skim-milk powder 2.5 gm., water 500 cc.	72.5 70.5
Derris powder 2 gm., skim-milk powder 2.5 gm., water 500 cc.	61.7 62.7
Derris powder 1.25 gm., skim-milk powder 2.5 gm., water 500 cc.	56.7 57.1
Checks	0.0 5.0

Powdered derris root (4.5 percent rotenone, 15 to 18 percent total extractives), at strengths comparable to 4, 3, and 2 pounds of powder per 100 gallons of water, gave higher mortality of imported cabbage worms than of cabbage looper larvae. The effectiveness obtained against the cabbage looper at the greatest strength of derris was scarcely satisfactory. Huckett (203) in 1938 stated that young larvae of the cabbage looper are susceptible to derris powder but that the elder larvae are resistant.

Huckett and Hervey (204) in 1935 reported that in general the cabbage looper is more difficult to control than the other green worms on cabbage, such as the imported cabbage worm and the diamondback moth--whether because of a difference in immunity to the poison, differences in feeding habits, or other factors is not known. Hervey, Huckett, and Glasgow (189) in 1935 recommended a dust containing 0.5 percent of rotenone made by diluting derris or cube with talc or clay, used at the rate of 20 to 35 pounds per acre. A spray consisting of 4 pounds of derris powder (4 percent rotenone) plus 4 pounds of skim-milk powder per 100 gallons of water may also be used.

McCampbell (259) in 1934 recommended derris dusts for the control of the cabbage looper on cabbage in Colorado.

The United States Department of Agriculture, Bureau of Entomology and Plant Quarantine, (435) in 1934 stated that the preferred dust for the control of the cabbage looper on cabbage is derris or other rotenone dusts and the preferred spray is pyrethrum-derris extract. [For further discussion of dusts and sprays, see (435) under Pieris rapae (L.), p. 106 .]

Walker and Anderson (464) in 1934 reported the following results of tests made in a broccoli field:

Dust	Rotenone content	Amount applied	Control
	Percent	Percent	Percent
Derris-talc	0.5	55	70
Derris-clay	.25	32	68
Derris-clay	.5	42	79
Derris-clay	1.0	40	71
Kubatox	.4	37	65
Cubor dust	---	31	45
Sprayrite	.43	48	44

Pyrethrum-talc dusts containing 0.3 or 0.5 percent of pyrethrins gave better control (96 and 95 percent, respectively) than did the derris dust. Eight different diluents for derris dust were tested, each being mixed with derris powder (4 percent rotenone) in the weight ratio of 1 part of derris to 7 parts of the carrier. Talc gave the best control, closely followed by gypsum and Inert C (a clay). The large amount of gypsum used was due to its greater weight per volume. The newly made lime dust, flour, and coarse tobacco dusts ranked intermediate, whereas the old lime and the zinc sulfate-lime gave the poorest control. Finely ground tobacco dust gave almost as good results as did the talc and gypsum. In 1935 the same authors (465, 466) summarized results obtained with derris and pyrethrum dusts at the Virginia Truck Experiment Station. In 1933 a derris dust containing 0.5 percent of rotenone and a pyrethrum dust containing 0.3 percent of pyrethrins gave satisfactory control of the cabbage looper and of diamond-back moth larvae, whereas dust containing 0.25 percent of rotenone and 0.1 percent of pyrethrins did not give satisfactory control. There was little difference between the effectiveness of gypsum, talc, and inert clay, or a finely ground tobacco dust when used as carriers for derris. A bentonite carrier was not so satisfactory as the others. The addition of 5 percent by weight of finely ground dusting sulfur seemed to improve the effectiveness of a derris-talc dust. Based on rotenone content, a cube dust did not seem to give so satisfactory control of cannage worms as did a derris dust. Walker and Anderson (467) in 1936 reporting experiments made in 1932-36, said that repeated applications of derris and cube dusts containing from 0.5 to 0.75 percent of rotenone and from 2 to 3 percent of total extractive

and pyrethrum dusts containing from 0.3 to 0.5 percent of pyrethrins gave good control of cabbage worms, whereas dust of weaker concentrations were less effective. Derris and cube dusts having approximately the same rotenone and total-ether-extractive content appeared to be about equally effective. Derris dusts (0.75 percent rotenone) gave 68 percent control of the cabbage looper, indicating that the imported cabbage worm is as susceptible to derris, if not more so, than the cabbage looper or the larva of the diamondback moth. Walker and Anderson (468) in 1937 reported that repeated applications of derris and cube dusts containing from 0.5 to 0.75 percent of rotenone and from 2 to 3 percent of total extractives at 7- to 10-day intervals gave good control of the cabbage looper.

Walker (463) in 1937 reported that cube dusts (0.75 percent rotenone) and sprays (3 pounds per 100 gallons), both with and without Ultrawet, were used to control the cabbage looper. In most cases the addition of Ultrawet did not result in increased protection of the plants. The sprays and dusts without Ultrawet usually provided adequate control.

Headlee (186) in 1935 reported good control of cabbage loopers in New Jersey with a dust consisting of 16 parts of ground derris (5 percent rotenone and 18 percent total extractives), 25 parts of sulfur, and the remainder clay or talc. When applied without hoods from 15 to 18 pounds per acre were necessary; and with hoods, from 8 to 10 pounds.

Howard in a typewritten report to the Division, in 1935 stated that derris powder mixed with talc, infusorial earth, or tobacco dust so as to contain from 0.5 to 0.75 percent of rotenone and used at intervals of 7 to 10 days at dosages of 25 to 30 pounds per acre per application was fairly effective against the cabbage looper.

Howard and Davidson (195) in 1935 advised that derris sprays or dusts gave best control of cabbage worms in Ohio. For the control of the looper it was necessary to use derris or cube dusts containing 0.4 to 0.5 percent of rotenone, or to use derris or cube-root sprays containing 0.015 to 0.02 percent of rotenone. Applications were made every 10 to 14 days after large numbers of worms appeared. There was no significant difference in the degree of control obtained from the use of derris-root or cube-root dusts or sprays, provided the rotenone contents were practically equivalent. The addition of spreaders or stickers to derris-root suspensions in water applied as sprays seemed slightly to increase the control obtained. Very little difference in the degree of control resulted from the use of a number of diluents for derris or cube dusts.

Howard, Mason, and Davidson (197) in 1935 reported that derris dust was fairly effective against the looper in Ohio.

The Ohio Agricultural Experiment Station (314) in 1935 reported tests of 23 insecticides against cabbage worms, including the cabbage looper, the imported cabbage worm, and the diamondback moth. The control obtained by any toxic agent was greater when the material was applied in dust form than when applied as a spray. On the basis of marketable cabbage harvested, 5 materials, differing little in efficiency from one another, were definitely superior to the other 18. These 5, listed in order of their effectiveness, were as follows:

1. Paris green 1 part, hydrated lime 2 parts, flour 5 parts
2. Paris green 1 part, hydrated lime 7 parts.
3. Derris powder (5 percent rotenone) 1 part, pyrethrum powder 4 parts, diatomaceous clay 5 parts.
4. Barium fluosilicate 1 part, flour 7 parts.
5. Derris powder (5 percent rotenone) 1 part, diatomaceous clay 9 parts.

Where yield data were available, plots treated with paris green produced the greatest tonnage, followed by those treated with derris powder, barium fluosilicate, natural cryolite, and calcium arsenate, in the order named. The same station (315) in 1936 reported that 6 of the most promising insecticides (including derris) for controlling 3 species of cabbage worms, including the looper, were tested in 1935. The insecticid were used in various strengths and with different diluents, stickers, and spreaders. The highest percentage (97 percent) of marketable heads was produced on plots sprayed weekly with paris green (2 pounds to 50 gallons of water), sulfated alcohol being used as a wetting agent. Average of 90 to 93 percent of marketable heads were produced on plots dusted at weekly intervals with derris-powder-flour (0.5 percent rotenone). The same station in 1937 (316) reported that the most successful control of 3 species of cabbage worms including the looper was obtained from paris green. Paris green sprays, 2 pounds per 50 gallons, gave from 81 to 93 percent of marketable heads; paris green dust, 1 pound plus 12.5 pounds o flour, gave 87 percent; derris dust, 1 pound of 4-percent derris plus 7 pounds of flour, gave 58 percent; and derris spray, 1.5 pounds of 4-perce derris plus 2 ounces SS-3 to 50 gallons of water, gave 70 percent of marketable heads. In 1938 (317) this station reported that derris powder talc dust apparently protected cabbage better than did the other material used. Three applications of sprays and dusts were made during the season on July 28, August 10, and August 24, 1937. The crop was cut between September 26 and October 2. The derris powder used contained 4 percent of rotenone. The results were as follows:

Treatment	Weight of cabbage		
	Gross per acre 1/	Trimmed per acre 2/	Loss
	Pounds	Pounds	Percent
Derris powder 1 lb., talc 7 lb.	31,698	29,857	6
Derris powder 1.5 lb. Grasselli spreader 4 oz. Water 50 gal.	29, 448	26,994	8

1/ Trimmed to meet U.S. No. 1 grade, with the exception of worm injury which was not removed.

2/ Weight after removal of worm injury.

The Indiana Agricultural Experiment Station (213) in 1935 reported that the cabbage looper is harder to control than the other cabbage worms. Three series of experiments were conducted using in comparison derris,

pyrethrum, arsenical, and fluosilicate insecticides. In all cases the derris and pyrethrum insecticides proved more efficient than the arsenicals or fluosilicates.

Roney and Thomas (358) in 1935 reported excellent control of three species of cabbage worms, Pieris rapae, Autographa brassicae, and Plutella maculipennis, in Galveston County, Tex., with pyrethrum and derris dusts. Diluents used were 300-mesh sulfur, a finely ground clay, and fuller's earth. Tests were made with the following derris mixtures: (1) 10 parts of derris and 90 parts of sulfur; (2) 10 parts of derris, 15 parts of Powco A, and 75 parts of sulfur; and (3) 10 parts of derris, 15 parts of Powco A, and 75 parts of fuller's earth. Each of these mixtures contained 0.5 percent of rotenone. It was concluded that a dust containing 10 percent of derris or 0.5 percent of rotenone and 90 percent of 300-mesh conditioned sulfur is more effective and economical than any other dust or combination used for controlling cabbage worms. Derris is slower than pyrethrum in its reaction on insects, and little benefit can be seen within 48 hours following an application. Pyrethrum is limited more than derris as to usefulness in dry or irrigated areas.

The South Carolina Agricultural Experiment Station (381) in 1935 reported that experiments of the 1934-35 season indicated that a dust mixture consisting of derris powder and clay, and containing 0.5 percent of rotenone, was approximately as toxic, and in some cases superior to, undiluted calcium arsenate, to paris green and lime (1:9), and to synthetic cryolite and clay (1:3), when used against the cabbage looper.

F. L. Thomas (410) in 1935 recommended 1 part of derris containing 5 percent of rotenone mixed with 9 parts of finely ground conditioned sulfur for the control of cabbage worms including this species. Mr. Thomas (411) in 1936 reported that in Texas derris-sulfur dust (0.5 percent rotenone) gave good results in the control of the cabbage looper.

The Bermuda Department of Agriculture (34) in 1936 reported that two dusts containing derris, Cooper's Drymac and Sherwin-Williams' Rotodust, were tried against the looper on cabbage. Three applications were made and each dust gave a significant degree of control.

The Colorado Agricultural Experiment Station (73, 74, 75) in 1936 reported that in control of the cabbage looper, the imported cabbage worm, and the diamondback moth pyrethrum and rotenone gave very satisfactory results at reasonable cost. Against cabbage worms pyrethrum- and rotenone-bearing materials were more effective as dusts than as sprays. The imported cabbage worm is controlled with pyrethrin- and rotenone-bearing dusts of lower strengths than will control the cabbage looper and the diamondback moth. Derris and cube dusts were equally effective when used at the same rotenone content, although the cube appeared somewhat more erratic when used during cool weather in the fall. Rotenone and pyrethrins are known to break down more rapidly in direct sunlight; however, there were no significant differences in the results from morning and from evening applications.

This Station reported that the 1935 infestation on cabbage and cauliflower consisted of the cabbage looper, the alfalfa looper, and the diamondback moth. These are more difficult to kill than the imported cabbage worm.

Dusts carrying 0.2 percent of pyrethrins or 0.75 percent of rotenone, wh is higher than called for in most recommendations and also higher than t contents of most commercial dusts, failed to give satisfactory control. This station in 1937 (76) reported that seasonal tests failed to give a isfactory control of cabbage loopers.

Fenton (129) in 1936 compiled information on mixtures of sulfur wit derris used for the control of this species.

Gui (171), of the Ohio Agricultural Experiment Station, in 1936 reported that in 1934 a spray of 1 part of Rotecide plus 1 part of New Eve green to 800 parts of water controlled 71.1 percent of the cabbage loope A derris-clay dust (0.5 percent rotenone) gave 74.6 percent control. In 1938 Gui (172) reported that for the protection of cabbage against cabba worms, including this species, the crop should be dusted or sprayed at 1 intervals with paris green or derris powder. Derris-powder dusts should contain not less than 0.5 percent of rotenone, and 1 pound of derris pow (4 percent rotenone) should be used to 7 pounds of the diluent. Desirab diluents for derris powder are flour, talc, diatomaceous clay, dusting gypsum, and finely ground tobacco stems. Derris-powder sprays should consist of 1.5 pounds of derris powder (4 percent rotenone) in 50 gallon of water. When other grades of derris powder are used, dosage should be so calculated that the spray contains 0.015 percent of rotenone. A spre er and sticker should be used. Federal regulations prohibit excessive residues of poison on marketed cabbage; therefore paris green should not be applied after the heads begin to form. Derris powder may be used aft that date or throughout the season if desired. There are no regualtions at present concerning residues of rotenone on fruits and vegetables.

The New Jersey Agricultural Experiment Station (293) in 1937 reporte that derris dusts gave satisfactory results against cabbage worms, includ ing this species.

Shropshire and Kadow (369) in 1936 recommended derris and cube for control of the cabbage looper. These materials are most effective when applied as a dust late in the afternoon. The dust should contain at least 0.5 percent of rotenone and should be applied at the rate of 20 to pounds per acre, before the worms become abundant, applicat being repeated at intervals of 10 days to 2 weeks or as often as necessar Unlike metallic poisons, derris products are safe to use on crucifers up to the time of cutting. Derris sprays can be used for the control of cabbage worms, if applied according to the manufacturers' directions.

The Texas Agricultural Experiment Station (404) in 1936 reported tha derris was more effective than cube against the cabbage looper, regardles of the carrier used, according to tests conducted at Weslaco and Winterha in 1935. The derris mixtures and the cube mixtures were more effective against the larvae of the diamondback moth than against the cabbage loope Derris-sulfur (15:85) or cube-sulfur (15:85) containing 0.75 percent of rotenone gave better control of cabbage worms on the average than either lead arsenate or barium fluosilicate, in the lower Rio Grande Valley, the Winter Garden, or Galveston County. This station in 1937 reported that results in two series of experiments indicated very little difference bet sulfur and fuller's earth when they were mixed with cube for the control of the cabbage looper.

The cabbage looper is more resistant than Pieris rapae to rotenone dust. When it is young a dust containing 0.5 percent of rotenone gives satisfactory control but a dust containing 0.75 percent of rotenone should probably be used. The applications should be made before the loopers become half grown. --Howard and Mason (196) in 1937.

Hutson (209) in 1937 recommended derris dusts or sprays for the control of the cabbage looper.

Kelsall and Stultz (234) in 1937 reported that in laboratory tests derris-gypsum dusts containing 5 and 12.5 percent of derris (4 percent rotenone) caused mortalities of 33 and 50 percent, respectively, in 1 day. In the field derris gave fair control, pyrethrum excellent control.

The Louisiana Agricultural Experiment Station (257) in 1937 recommended derris dust (1 percent rotenone) for the control of cabbage worms, including the cabbage looper. The same station (258) in 1938 published a summary of entomological progress, in which C. E. Smith reported that in reducing cabbage looper populations derris dust containing 1.0 percent of rotenone was superior to all other treatments; derris dust containing 0.5 percent of rotenone and synthetic cryolite was next in effectiveness and superior to dusts containing 0.1 and 0.05 percent of pyrethrin I.

The New York Agricultural Experiment Station (302) in 1937 reported that in 1935 infestation by the cabbage looper increased seriously on late-grown cauliflower and cabbage. The larvae were not readily killed by applications of rotenone-containing sprays or dusts, especially after they had attained medium size. Insectary tests showed that the larvae could be killed by contact applications of dusts containing pyrethrins. This station (303) in 1938 reported that field trials with derris, cube, timbo, and pyrethrum powders for cabbage worm control indicated clearly that pyrethrum mixtures were more effective where the cabbage looper was the predominant species. Mixtures of comparable strength containing cube and pyrethrum powders were not so effective as those containing pyrethrum powder alone. Spray mixtures were less effective than dust mixtures.

The New York County Agents' Training School (299) in 1938 discussed the control of vegetable insects. Glasgow, Huckett, Harvey, and others recommended rotenone dusts and sprays as follows: Rotenone dust containing 1 percent of rotenone proved to be one of the most effective treatments for cabbage looper control. The drawback to its use is its cost, as compared with that of lead arsenate. Compared with lead arsenate spray, rotenone dust gave as good or better immediate kill of both the imported cabbage worm and the cabbage looper but the lead arsenate spray had a greater residual effect and remained effective longer. The rotenone dust gave a better immediate kill and was about equal or better in residual effect. On Long Island rotenone-containing dusts were also used largely in 1938 as a substitute for pyrethrum dust, and in the absence of serious cabbage looper attack they afforded protection.

The North Central States Entomologists (309) in 1938 discussed the control of certain insects by the use of cube and derris. Compton reported that rotenone-bearing dusts or sprays, and lead arsenate dusts or sprays gave the best results. Both these materials were effective against

cabbage loopers if applied when the worms were very small. Nothing gave exceptionally good results against full-grown cabbage loopers. White remarked that derris and cube dusts control the cabbage looper to some extent if applied while the worms are small.

C. E. Smith (372, 373) in 1937 reported tests made at Baton Rouge, La. In field experiments involving several species of cabbage worms, including the looper, a dust mixture of peat moss containing 2 percent of nicotine was distinctly inferior to derris-dust mixtures containing 0.5 and 1.0 percent of rotenone, as well as to an undiluted tricalcium arsenate. There was practically no difference between the efficiency of the derris dust containing 0.5 percent of rotenone and that of calcium arsenate, but a derris-dust mixture containing 1.0 percent of rotenone was distinctly superior to the other three materials tested, when applied at intervals of 2 weeks. Field tests at Baton Rouge showed that derris-dust mixtures containing 1.0 or 0.5 percent of rotenone were superior to nicotine-peat dust in controlling the more common species of cabbage worms, including the cabbage looper.

Parks and Pierstorff (324) in 1938 recommended a rotenone spray or dust to control the cabbage looper on cabbage and spinach.

Gunderson (173) in 1938 recommended derris with or without sulfur for the control of cabbage worms, including the looper. Flour, sulfur, pearl dust, gypsum, and other carriers are given as diluents for preparing derris dust. A 1-percent-rotenone dust is usually strong enough for all needs.

Roark (357) in 1938 reviewed the comparative action of derris and cube of equal rotenone content on many insects. Reference was made to a typewritten report by R. E. Campbell to the Division of Truck Crop and Garden Insect Investigations in 1934 in which he said that derris caused a reduction of 75 percent and cube a reduction of 34.4 percent in numbers of cabbage loopers (0.5 percent rotenone in each dust), and to Walker and Anderson (465) who in 1935 reported that, based on rotenone content, a cube dust did not seem to give quite so satisfactory control of cabbage loopers as did a derris dust.

Agicide DC-4 (rotenone 0.6 percent) at the rate of 4 pounds per 100 gallons of water (0.003 percent rotenone in spray) killed from 50 to 100 percent within 96 hours. -- Agicide Laboratories (8) in 1939.

Crosby et al. (87) in 1939 wrote that rotenone dust is not entirely effective against large cabbage loopers, but that these can be controlled with a pyrethrum dust containing from 0.5 to 0.6 percent of pyrethrins or an impregnated dust containing from 0.3 to 0.5 percent of pyrethrins. Since the looper, as well as green cabbage worms and diamondback moth larvae, is a problem under Long Island conditions, growers may generally choose pyrethrum dust as the most effective material for controlling all three pests. A grower who wishes to economize on the cost of his insecticides may use a rotenone dust early in the season and transfer to a pyrethrum dust later (about August 15 on Long Island) or when loopers are present. Each dust should be applied at the rate of 25 to 50 pounds per acre per application.

Haude, in advertising literature published by John Powell and Co., New York, N. Y., in 1939, recommended cube or derris dust (0.75 percent rotenone) at 25 to 30 pounds per acre, or spray, 5 pounds of powder (4 percent rotenone) per 100 gallons of water, for the control of the cabbage looper.

Jones (226) in 1939 recommended derris or cube for the control of the cabbage looper.

Nettles (291) in 1939 recommended derris dust (0.75 percent rotenone) at the rate of 15 to 20 pounds per acre for the control of the cabbage looper in South Carolina.

Smith and Reid (374) in 1939 reported tests against the three common species of cabbage caterpillars, including the cabbage looper, using four insecticides, i.e., pyrethrum-talc (1:2); derris-dust mixtures containing 0.5 and 1.0 percent of rotenone, respectively; and a combination of derris-pyrethrum (0.5 percent rotenone and 0.2 percent total pyrethrins), applied at 7-, 10-, and 14-day intervals. The results indicated that pyrethrum was more effective than derris for the cabbage looper. The combination of derris and pyrethrum was most satisfactory for the three species as a whole, and resulted in the best yields. While no differences could be detected between the 7-day and 10-day applications, both were decidedly more effective than the 14-day applications.

Autographa californica (Speyer), the alfalfa looper

Currie (88) in 1934 reported that in the Salinas, Calif., area derris dust had given good results on alfalfa loopers. "Liquid Rotenone" at 1:400, applied at the rate of 300 gallons per acre, and dust applied at 20 to 25 pounds per acre gave good results against the alfalfa looper attacking young lettuce.

The Colorado Agricultural Experiment Station (76) in 1936 reported that the 1935 infestation on cabbage and cauliflower consisted of the cabbage looper, the alfalfa looper, and the diamondback moth. These are more difficult to kill than the imported cabbage worm. Dusts carrying 0.2 percent of pyrethrins or 0.75 of rotenone, which is higher than most recommendations and also higher than the contents of most commercial dusts, failed to give satisfactory control.

Autographa chalcytes (Esp.)

The New South Wales Department of Agriculture (297) in 1938 reported that this pseudolooper may be controlled by spraying with lead arsenate at the rate of 1 pound of powder in 40 imperial gallons of water. It would be inadvisable to use lead arsenate on vegetables such as lettuce, spinach, and beans, which are to be used as food. If the pest be sufficiently serious, a spray consisting of derris powder, 1 pound in 40 gallons of water, may be of value in control.

Autographa falcifera (Kby.), the celery looper

The Idaho Agricultural Experiment Station (210) in 1939 reported that preliminary observations indicated possible effectiveness of rotenone dust against this insect.

Autographa signata (F.)

Van der Laan (245) in 1938 reported that in laboratory experiments a dust mixture containing 1 percent of rotenone gave 80 percent of mortality in 2 days.

Barathra brassicae (L.)

Klinger (237) in 1936 reported that laboratory tests with rotenone spray and dust gave no mortality in 8 days on fourth instars of (Mamestra) Barathra brassicae.

An anonymous writer (5) in 1937 wroto that this species is sensitive to derris powder (0.75 percent rotenone). Care should be taken to reach the caterpillars in their hiding places.

According to Etablissements Rotenia in 1938, in a letter to R. C. Roar a product containing 12 percent of powdered Lonchocarpus nicou root (6 percent rotenone) and 88 percent of talcum mitigated this insect on cauliflowe

Warwick (471) in 1938 reported that derris dust and, preferably derris spray is suitable for the control of cabbage moths.

Cameron (59) in 1939 recommended derris dust for destroying cabbage moth larvae in Scotland.

Speyer, Read, and Orchard (383) in 1940 reported that sprays containing derris or Lonchocarpus powders were very effective in rendering foliage of cauliflower and broccoli distasteful to both tomato and cabbage moth caterpillars. In many experiments but few caterpillars actually died from contact with the powders or from eating treated foliage. The deterrent action of these powders, however, obviated serious injury to the plants and also prevented the caterpillars from obtaining sufficient nourishment to enable them to pupate. Caterpillars of cabbage butterflies were usually killed by contact with the powders. Derris powder (proprietary brands containing a spreader) was applied at the rate of 1 pound to 20 gallons water. Lonchocarpus powder prevented feeding by the caterpillars when used at a strength equivalent to 1 pound to 40 imperial gallons of water, with 4 pounds of soft soap or 3 to 4 fluid ounces of liquid Agral as a spreader. Saponin, sulfonated Lorol, and casein did not wet the foliage of vegetables so adequately as did the soap or Agral.

Brithys crini (F.)

A derris dust containing 0.5 percent of rotenone gave complete control of this larvae. -- Van der Vecht (454) in 1936.

Brithys pancratii (Cyr.)

Worsley (500) in 1936 reported that a concentration of 2.45 percent for both derris and Mundulea bark killed 100 percent of caterpillars of this species dipped for 10 seconds in the solution.

Brotolomia meticulosa (L.)

This pest on roses was killed by a product containing 12 percent of powdered Lonchocarpus nicou root (6 percent rotenone content) and 88 percent of talcum, according to Etablissements Rotenia in 1938, in a letter to R. C. Roark.

The Experimental and Research Station, Cheshunt, England (113), in 1939 stated that derris dust prevented the feeding of caterpillars of the angle-shades moth.

Busseola fusca (Fuller)

Ripley (349) in 1926 reported results of tests with proprietary derris products against the maize stalk borer in South Africa. Kymac at 1:300 burned the plants and did not control the borer; it was recommended that, to avoid burning the young maize, Derrisol be used at 1:150, the highest concentration practicable for large-scale use. In 1927 this author (350) reported that a case of delayed plant poisoning had followed the use of Derrisol, but that this did not occur in the Cedara experimental plots, even when Derrisol was used at much stronger concentrations than those recommended for trial. For other purposes Derrisol was found to be an excellent insecticide. The Union of South Africa Department of Agriculture (424) in 1927 referred to work by Ripley against the stalkborer and stated that the sheep dip Kymac at 1:200 proved safe for top-dressing young maize plants. In 1928 Ripley (351) reported that Kymac at 1:250 is a safe top-dressing for maize if used at the rate of 10 cc. of liquid per plant. At 1:100, Kymac caused severe burning and reduced the yield 25 to 38 percent.

Ripley and Hepburn (352) in 1928 reported that a water suspension of powdered derris root (1:90) was much more effective than dry powder (1:12) as top-dressing against this insect. Pulvex (ground derris root) at 1:450 by weight, and Kymac (sheep dip containing derris extract) at 1:250 are about equal in effectiveness and in cost. Pulvex does not injure maize foliage but, according to these authors (353) in 1929, Kymac at concentrations greater than 1:250 burns maize foliage. It was concluded that Pulvex in water 1:450 by weight was the most suitable of the derris products studied. The same authors (354) in 1930 reported that Pulvex, 1 pound to 40 imperial gallons of water used as a top-dressing against the insect, increased the corn yield 13 percent and was harmless to the foliage; Kymac, 1 pound to 25 imperial gallons, gave an increase of 27 percent in yield but injured the foliage. Derrisol, 1 part to 1,000 parts of water by measure, was recommended. Preliminary experiments with a Derrisol-cryolite mixture gave promising results.

Pulvex has been tried, but in 1930 Ripley and Hepburn (354) found that Derrisol gave better results. It does not harm the plants, even in excessive strength and has superior penetration and adhesion. Derrisol should be diluted 1:1,000 in water and about 1 dessert spoonful of the liquid put into the crown or top of the maize plant. The correct time to make the first application is when a small percentage of plants show perforated inner leaves and about 33 percent show mottled leaves. One gallon of Derrisol is sufficient to top-dress 45 acres of maize and one native can top-dress from 1 to 3 acres per day. These authors (355) in 1934 reported

on adhesives for cryolite suspensions. Derrisol, 0.6 cc. to 1 gm. of synthetic cryolite (in water suspension), was unsatisfactory as an adhesive, but it increased the adhesiveness of oil-cryolite suspensions about 16 percent.

The Southern Rhodesia Department of Agriculture (382) in 1929 reported that some experiments in top-dressing maize against the borer were carried out with 2 proprietary insecticides and derris powder. All gave a satisfactory kill, but only derris failed to scorch the plants.

Chorley (72) in 1932 stated that Derrisol showed a 91-percent kill of the young larvae in a trap crop of small maize plants. Further tests showed treated rows to be infested to the extent of 16 percent with an average of 0.25 larva per plant, while untreated plants were 97 percent infested, with an average of 5.38 larvae per plant.

The Kenya Colony Department of Agriculture (235) in 1931 stated that experiments had been conducted with Derrisol during the preceding season. At a dilution of 1:1,000 Derrisol had been recommended in South Africa. It was found necessary to use a strength of 1:600 before complete success was attained. Maize growers suffering losses from this pest are strongly recommended to use Derrisol as a top dressing.

Andries (13) in 1932 wrote that this product is the most efficient top-dressing against the borer in maize. At least 24 hours after application must be allowed before the maximum killing results can be observed.

Haines (178) in 1933 reported that in South Africa top-dressing is one of the effective and practical control methods. Top-dressing means applying an insecticide to the top or crown of the maize plant for the purpose of destroying the young larvae, or grubs.

Lefevre (249) in 1935 referred to experiments in South Africa. The control measures recommended included top-dressing with Derrisol (1:150) at the rate of 10 cc. per plant.

Du Plessis (103) in 1936 stated that in South Africa the average annual loss caused by this insect, the most serious pest with which the maize farmer has to contend, is about $1,500,000. Under intensive systems of farming, top-dressing with Derrisol and the cutting out of infested plants are very effective methods of control.

The Kenya Colony Department of Agriculture (236) in 1936 reported that complete control was obtained by the application of Derrisol.

Calogramma festiva (Donov.)

A derris dust containing 0.5 percent of rotenone gave complete control of the larvae. -- Van der Vecht (454) in 1936.

Ceramica picta (Harr.), the zebra caterpillar

The United States Department of Agriculture, Bureau of Entomology and Plant Quarantine (437), reported that at the 1934 meeting of the American Association of Economic Entomologists Cory led a discussion of field results with arsenical substitutes for the control of vegetable insects. Huckett and Hervey of New York stated that the zebra caterpillar had been practically unaffected by applications of derris, cube, or pyrethrum powder. These results were also published by Huckett and Hervey (204) in 1935.

Hervey, Huckett, and Glasgow (189) in 1935 reported that this insect is very resistant to derris dust.

Howard, in a typewritten report to the Division of Truck Crop and Garden Insect Investigations, of the Bureau, in 1935 reported that derris root mixed with talc, infusorial earth, or tobacco dust so as to contain from 0.5 to 0.75 percent of rotenone, and used at intervals of 7 to 10 days at dosages of 25 to 30 pounds per acre per application, was not very effective.

Howard, Mason, and Davidson (197) in 1935 reported that derris dust was not very effective.

White (480) in 1935 stated that derris was ineffective.

Huckett (202) in 1936 reported insectary tests with pyrethrum, derris, and nicotine against third instars. The derris contained 4.5 percent rotenone and 16 to 18 percent total extractives. The results were as follows:

Spray formula	Mortality after 96 hours Percent
Derris powder 2.5 gm., skim-milk powder 2.5 gm., water 500 cc.	10.2
Derris powder 2 gm., skim-milk powder 2.5 gm., water 500 cc.	8.7
Derris powder 1.25 gm., skim-milk powder 2.5 gm., water 500 cc.	7.8
Check	3.6

Powdered derris root (4.5 percent rotenone, 15 to 18 percent total extractives) at strengths comparable to 4, 3, and 2 pounds of powder per 100 gallons of water, was ineffective against the zebra caterpillar. Huckett (203) in 1938 stated that, in recent developments in cabbage worm control on Long Island, the larvae of the zebra caterpillar were largely immune to derris powder but that pyrethrum dust was effective.

The New York State Agricultural Experiment Station (301) in 1936 reported that not all cabbage worms were killed by rotenone-containing powders, for example the zebra caterpillar. Contact dusts containing pyrethrum or nicotine were highly toxic to the early stages of larval development of this insect.

Cirphis unipuncta (Haw.), the armyworm

The Nova Scotia Department of Agriculture (310) in 1938 reported that derris as a poison bait was ineffective.

Earias fabia (Stoll)

Butac (58) in 1938, reporting on the life history and habits of the cotton bollworms in the Philippines with suggestions for their control, stated that on March 2, 1936, 5 caterpillars of the spotted bollworm were dusted in the laboratory with a 50:50 mixture (by weight) of derris dust (rotenone about 3 percent) and "gawgaw." One hour after dusting the caterpillars were paralyzed and all died within a day. On March 24, the test was repeated on 10 caterpillars. It was observed, too, that the larvae were paralyzed within 1 hour after dusting and all were dead on the second day. Cotton plants in one of the plots at the Philippine Carnival Exposition were dusted in 1936 with derris-gawgaw, mainly to control leaf-eating caterpillars, which were abundant on the plants. The dusting was done at about 9 a.m. Between 2 and 3 p.m. the plants were examined and the insects collected, especially those affected by the treatement. They included five caterpillars of Earias fabia, all of which were paralyzed and died after 2 days.

Heliothis armigera (Hbn.), the corn earworm; the bollworm; the tomato fruitworm

Ditman and Cory (99) in 1931 reported tests with proprietary derris products for the control of the corn earworm. Derrisol at 1:100 permitted a 95-percent infestation, seriously burned 16 percent of the plants, and produced a trace of burning in an additional 59 percent. Pulvex was harmless to the vegetation but permitted a 95-percent infestation.

Burdette (53) in 1932 reported results of tests in which the moths, after feeding on an invert sugar sirup (Syrline) containing rotenone, were placed in cages. No moths were dead at the end of 48 hours. Similar results were obtained with lead arsenate, zinc arsenite, sodium arsenite, and arsenious acid. Rotenone, sodium arsenite, and arsenious acid made the sirup spray slightly less attractive. In 1934 he (54) reported that the moths could be attracted to Syrline (8 lb. to 50 gal. of water) sprayed on the corn foliage. An acetone extract of derris added to the sirup was ineffective in producing kill but did act as a repellent.

The South Carolina Agricultural Experiment Station (380) in 1932 reported that dusting every other day with Kubatox gave no control in sweet corn. This station (381) in 1935 reported that experiments of the 1934-35 season indicated that a dust mixture consisting of derris powder and clay and containing 0.5 percent of rotenone was not so effective against corn earworms on cabbage as were the arsenicals.

The United States Department of Agriculture, Bureau of Entomology and Plant Quarantine (437) reported that at the 1934 meeting of the American Association of Economic Entomologists Cory led a discussion of field results with arsenical substitutes for the control of vegetable insects. Roney and Thomas, of Texas, reported that derris-sulfur dust (0.5 percent rotenone) successfully controlled this species on tomatoes. Huckett and Hervey, of New York, reported that neither derris nor cube was satisfactory for use against the corn earworm. Headlee, of New Jersey, stated that of all the insects that have been tested the only one which decidedly does not respond to derris is the corn earworm. Walker and Anderson, of the Virginia Truck Experiment Station, reported that derris dust had practically no effect on the corn earworm. Wymore of Davis, Calif., reported very little benefit from one application of rotenone dust for control of this species on tomatoes. Shropshire, of Des Plaines, Ill., reported tests against tomato fruitworms. A 0.5-percent rotenone dust with a gypsum carrier gave no kill of worms in the laboratory when fed to worms. In field tests this dust with a talc carrier gave a slight decrease in initial worm population, prevented further infestation, and gave a fair reduction in fruit injury. A 0.5-percent-gypsum dust, when applied to wet worms, thoroughly coating the body, gave a greater kill than the same dust fed to worms in the laboratory. Dipping worms in a Derrisol-Penetrol mixture gave similar results. Neither materially affected the feeding of the worms except for the first day. The Bureau (443) in 1937 reported that cube and derris dusts gave negative results against the corn earworm on lima beans.

Currie (88) in 1934 reported that in the Salinas, Calif., area derris dust gave good results against small corn earworms.

Headlee (186) in 1935 reported that the corn earworm was able to withstand large dosages of derris taken internally, and the caterpillar may be rolled in ground derris, yet be apparently unhurt. However, this lack of response is apparently due to the failure of the derris extract to get into the caterpillar's tissues, because it yields to hypodermic injection of derris extract.

Huckett and Hervey (204) in 1935 reported that neither derris nor cube were satisfactory for use against the corn earworm.

Roney and Thomas (358) in 1935 reported excellent control of the tomato fruitworm in Galveston County, Tex., with pyrethrum and derris dusts. Diluents used were 300-mesh sulfur, a finely ground clay, and fuller's earth. Tests were made with the following derris mixtures: (1) 10 parts of derris and 90 parts of sulfur; (2) 10 parts of derris, 15 parts of Powco A, and 75 parts of sulfur; and (3) 10 parts of derris, 15 parts of Powco A, and 75 parts of fuller's earth. Each of these mixtures contained 0.5 percent of rotenone. The authors concluded that a dust containing 10 percent of derris or 0.5 percent of rotenone and 90 percent of 300-mesh conditioned sulfur was more effective and economical than any other dust or combination used for controlling cabbage worms. Derris is slower than pyrethrum in its reaction on insects and little benefit can be seen within 48 hours following an application. The experiments also indicated that pyrethrum is more limited than derris in regard to its usefulness in dry or irrigated areas.

F. L. Thomas (410) in 1935 recommended 1 part of derris (5 percent rotenone) mixed with 9 parts of finely ground conditioned sulfur for the control of the tomato fruitworm. Mr. Thomas (411) in 1936 reported that in Texas derris-sulfur dust (0.5 percent rotenone) gave good results in the control of the tomato fruitworm, reducing the injury from 50 to 7 percent when applied at the rate of 20 to 25 pounds per acre.

Tischler (413) in 1935 studied the mechanism of how derris kills insects. Tests made with insects such as corn earworms led to the conclusion that derris inhibits oxygen utilization by the tissues and that its detrimental effects are general, rather than specific to any organ.

Veitch (457) in 1935 reported that in Queensland no really satisfactory spray was available for dealing with this pest, although the derris used for the cabbage moth and center-grub control may have had a slight adverse influence on corn earworm infestations.

Walker and Anderson (465) in 1935 reported that derris and pyrethrum dusts had practically no effect on the corn earworm.

White (480, 481) in 1935 wrote that derris is ineffective against the corn earworm. In 1937 he (482) stated that neither derris nor pyrethrum, at the dilutions tested, was effective in combating the corn earworm on cabbage.

App, in a typewritten report to the Division of Cereal and Forage Insect Investigations, Bureau of Entomology and Plant Quarantine, United States Department of Agriculture, said that in 1936 he had tested a derris-talc dust containing 1 percent of rotenone against the corn earworm in Puerto Rico. Four applications of dust at 3-day intervals on December 27, December 30, January 2, and January 5 were necessary to keep the silks covered from the time the first silks appeared until they had dried up. This rotenone dust gave 35.51-percent control, as compared with 1.78-percent control from a lead arsenate-talc (8 + 2) dust.

Barber, in typewritten reports to the same Division, stated that in 1936 he made tests in southern Florida with dusts consisting of derris plus sulfur, derris plus talc, and derris sprays (2 or 4 lb. per 100 gal.), plus sodium lauryl sulfate or sodium butyl phenyl phenol sulfonate as a wetting agent and bentonite (4 lb. per 100 gal.) as a sticker. All tests indicated poor control of the corn earworm by derris. In 1937 he reported the results of laboratory tests in dusting or spraying corn ears to prevent attack by earworm larvae. Powdered derris (rotenone 4 percent) and derris extract (5 gm. rotenone per 100 cc. alcohol) were tested. Powdered derris was used in 11 tests, diluted with talc to 1:10 and with sulfur to 1:9. It proved to be the least effective of the dusts studied, only 20.2 percent of the ears being protected, and only 33.2 percent of the larvae being destroyed. Derris was used in 13 tests at the rates of 2 or 4 pounds per 100 gallons of water, with stickers or a spreader alone, or in combination. This material was wholly ineffective in protecting ears or destroying larvae. An alcoholic extract of rotenone was used in 12 tests, 5 with spreaders and 7 with stickers. Used with spreaders, the material was ineffective, but it seemed to be more effective when used with stickers, an average of 23.9 percent of the ears being protected, and an average of 37.5 percent of larvae being

destroyed. When used with spreaders no ears were protected and no larvae killed. Barber also reported on tests on insecticides against the corn earworm at Homestead, Fla., from February to April 1937. Soybean oil and derris (100 cc. of oil plus 1 level teaspoonful of derris powder), injected into the corn ears with a needle nozzle according to the procedure described in United States Department of Agriculture ET-92, was slightly more effective than oil alone. Soybean oil plus solid derris extract was applied to corn ears with a needle nozzle. The percentage of ears infested was 12, as compared with 45.8 in the check and 8 for ears treated with soybean oil plus phenothiazine. Soybean oil plus solid derris extract, applied with an oil can, gave perfect control. When used alone and applied with a needle nozzle, soybean oil gave the poorest control (56 percent of ears infested) of any of the 5 oils tested. Nujol plus solid derris extract, applied by means of an oil can, destroyed 100 percent of the larvae; Nujol alone permitted 8 percent of the ears to become infested. In all cases 1 level teaspoonful of solid derris extract (resinate) was added to 100 cc. of oil. Barber also reported tests made in Dade County, Fla., during February and March 1939 with insecticides for the control of the corn earworm in sweet corn. Derris extract plus mineral oil; derris extract plus cottonseed oil; and rotenone in pine oil, derris powder, timbo powder, and Foliafume were tested; also pyrethrins plus rotenone plus cuprous cyanide. Oil containing rotenone was not effective, nor was Foliafume. Pyrethrins in oil were effective.

Brannon (46) in 1936 reported that no significant control of the corn earworm on lima beans on the Eastern Shore of Virginia was obtained with derris-talc dusts containing 0.75 or 1.0 percent of rotenone, and that sprays of powdered derris and cube roots containing 0.025 percent of rotenone gave even poorer control.

Essig and Michelbacher (112) in 1936 reported on tomato insects of California. In order to avoid the deposit of a residue, a few growers had used a derris dust for the control of Heliothis armigera. In places it was the only material applied; in others it followed an application of an arsenical or fluosilicate dust. The authors stated: "Where used alone, we were unable to detect any worthwhile protection but, since so few fields were dusted and the observations were so limited, we are not in a position to judge its effectiveness."

Fenton (129) in 1936 called attention to work done by Roney at the Texas Truck Crop Experiment Station. Successful control was obtained by the use of a dust consisting of 15 pounds of pyrethrum A dust; 10 pounds of a 5 percent rotenone-bearing powder; and 75 pounds of 99 percent of 325-mesh conditioned dusting sulfur, applied at the rate of 20 to 25 pounds to the acre at intervals of a week or 10 days beginning as soon as the tomato plants were placed in the field. The important factors seem to be early application and complete coverage.

Hansberry and Richardson (183) in 1936 reported the median lethal dose of rotenone in mg. per gm. of body weight for corn earworm larvae to be more than 0.49.

Derris was ineffective against the corn earworm. -- Hutson (208, 209) in 1936 and 1937.

E. P. Jones (223) in 1936 reported that in laboratory tests 4 pounds of Derridis plus 8 ounces of spreader to 177 imperial gallons of spray killed 54 percent of the first instars in 24 hours and 80 percent in 48 hours. Of the second instars 20 percent were killed in 24 hours and 44 percent in 48 hours. In another test Derridis, 4 pounds, plus 8 ounces of spreader to 100 imperial gallons of spray, killed 5.3 percent of the first instars in 24 hours and 42 percent in 48 hours. Derrisol proved a complete failure either as a contact or a stomach insecticide. In field tests Derridis at 4 pounds to 100 imperial gallons gave a control of 4.93 percent during 2 weeks and 7.64 percent during 1 month against Heliothis obsoleta on citrus trees. Derrisol at 1:500 was very disappointing.

Reid (345) in 1936 reported that the strengths of derris- or pyrethrum-dust mixtures recommended for the common species of cabbage worms were not effective in controlling the larvae of the corn earworm. In summarizing results obtained at Charleston, S. C., during the fall and winter of 1937-38, Reid (346) stated that a population consisting of the cabbage looper and various Agrotinae (principally the corn earworm and several species of climbing cutworms) can be controlled effectively by the use of a dust mixture consisting of calcium arsenate and hydrated lime (3:1) prior to the heading of the plants, followed by applications of a pyrethrum-talc-dust mixture containing 0.3 percent of total pyrethrins, or a derris-clay-dust mixture containing 1.0 percent of rotenone, at 10-day intervals after the plants have headed, provided the plants had been well protected against cabbage worms before being thinned or transplanted. The pyrethrum-dust mixture and the derris-dust mixture were most effective against the cabbage looper, and the calcium arsenate-dust mixture most effective against the Agrotinae. These results are also reported by the United States Department of Agriculture, Bureau of Entomology and Plant Quarantine (446) in 1938.

Turner (420) in 1936 reported that the derris spray recommended for European corn borer control will not affect the corn earworm.

Laboratory and field tests led to the conclusion that "one can safely give up hope of controlling this species by means of derris powder." Larvae having more than one-third of the body length covered with rotenone did not die and developed normally. -- Van der Vecht (454) in 1936.

The Georgia Experiment Station (156) in 1938 reported that during the early summer of 1937, in several parts of the State, tomatoes suffered severe injury from the corn earworm. Some growers resorted to rotenone dusts, "but the corn earworm is known to be peculiarly resistant to this material."

Gunderson (173) in 1938 recommended derris for the control of the corn earworm. Flour, sulfur, pearl dust, gypsum, and other carriers are given as diluents. A 1-percent-rotenone dust was generally strong enough for all needs. Derris spray, 5 pounds per 100 gallons, also controlled this pest.

G. D. Jones (224) stated that in 1938 in instructions issued for the control of garden pests a dust containing 0.5 to 1.0 percent of rotenone had proved satisfactory in controlling the tomato fruitworm. As diluents use clay, talc, cheap flour, or sulfur, and prepare by mixing 1 part of derris to 4 to 8 parts of the carrier. Hydrated lime cannot be used as a carrier because of harmful chemical reactions.

The Louisiana Agricultural Experiment Station (258) in 1938 published a summary of entomological progress, in which C. E. Smith reported that against larvae of the corn earworm the inorganic materials (paris green, calcium arsenate, and cryolite) were superior to the organic materials (derris-root powder and pyrethrum-flowers powder).

Michelbacher and Essig (274) in 1938 described tests against the fruitworm on tomatoes. The materials, replicated twice, were applied to plots approximately 0.1 acre in area and were placed along the edge of the experimental series located at San Jose and Santa Clara, Calif. A dust containing 80 percent of sulfur and 20 percent of derris (0.75 percent rotenone) was ineffective.

Against the corn earworm, none of the synthetic or plant insecticides, including derris, compared in toxicity to lead arsenate. -- New Jersey Agricultural Experiment Station (294) in 1938.

The North Central States Entomologists (309) in 1938 discussed the control of certain insects by the use of cube and derris. W. H. White remarked that cube and derris do not control the corn earworm.

Wilcox and Stone (483) in 1938 reported that cube-dust mixtures containing as high as 2 percent of rotenone gave inferior results and are not recommended for use against the tomato fruitworm.

Haude, in advertising literature by John Powell and Co., New York, N. Y., in 1939, wrote that preliminary tests indicated that rotenone dusts are effective for the control of the young cotton bollworms, especially if sulfur is used as the diluent. A 0.5-percent-rotenone dust applied before the infestation became heavy was effective against young tomato fruitworms. Early applications at 20 to 25 pounds per acre, repeated at weekly or 10-day intervals, and complete coverage are essential.

Although rotenone dust has been recommended for controlling this insect on corn, tomato, and eggplant, experimental results have been very inconsistent. The Texas and Illinois State Experiment Stations have shown that a 0.5-percent-rotenone dust is effective against the early stages, but this has not been substantiated by work in New York, New Jersey, and California. When the worms are in the early stages, a dust containing 0.5 percent of rotenone with sulfur as the diluent is recommended.

Moreland and Gaines (281) in 1939 reported the results of tests made in 1936 in the Brazos River bottoms, Tex., with dust insecticides for the control of the bollworm on cotton. Calcium arsenate, calcium arsenate plus paris green (5 and 10 percent), calcium arsenate plus cube (0.8 percent rotenone in the mixture), and calcium arsenate plus 50 percent of

sulfur were equally effective against the bollworm. All plots received calcium arsenate in the foregoing mixtures at the rate of 7.76 to 9 pounds per acre. When the rate of application of calcium arsenate was reduced to 7 pounds per acre, as in the mixture of calcium arsenate plus lime, the yield was likewise reduced. Pyrethrum plus sulfur dust (0.09 percent total pyrethrins) did not prove effective against these pests.

Wilcox and Stone (484) in 1940 reported that cube dusts were tried in 1937 at Costa Mesa, Calif., for control of the tomato fruitworm. Three applications were made June 10, June 24, and July 8. Results were as follows:

Treatment	Tomatoes			Fruitworm control
	Examined	Injured	Injured	
	Number	Number	Percent	Percent
Cube (1 percent rotenone)	6,773	1,080	16.0	5.9
Cube (1.5 percent rotenone)	6,412	1,087	16.9	.6
Cube (2 percent rotenone)	6,675	957	14.3	15.9
Check	18,149	3,092	17.0	----
Natural cryolite 60 percent + talc 40 percent (best control)	8,024	287	3.6	78.8

Heliothis assulta Guen.

Van der Laan (245) in 1938 reported that in laboratory experiments this species was only slightly affected by derris dust.

Heliothis virescens (F.), the tobacco budworm

Chamberlin and Madden (67) in 1937 reported that cube exerts only a very limited control.

Laphygma exigua (Hbn.), the beet armyworm

One of the materials tested for the control of the asparagus caterpillar was rotenone. Undiluted lead arsenate dust was the most effective of the materials tried. -- Florida Agricultural Experiment Station (138) in 1934.

Dusting or spraying with derris had only slight effect on this species. Dusts containing 0.5 percent of rotenone killed 20 to 30 percent of the half- to nearly full-grown larvae. -- Van der Vecht (454) in 1936.

Bouhelier (41) in 1940 reported on the control of this species on various cultivated plants in Morocco. Since the use of arsenicals on market-garden crops is prohibited, sprays containing derris extract, nicotine, or nicotine sulfate were tested on infested tomatoes, but the results were unsatisfactory.

Mamestra oleraceae (L.)

An anonymous writer (5) in 1937 wrote that this species has been effectively checked with a concentration of 0.75 percent of rotenone.

Naranga aenescens (Moore)

The Institute of Physical and Chemical Research (214) Tokyo, Japan, in 1927 reported that Neoton at the rate of 1 pound in 40 imperial gallons of water, sprayed on the eggs soon after oviposition and kept from rain, gave a mortality of 4.6 percent.

Nephelodes emmedonia (Cram.), the bronzed cutworm

Kelsall and Stultz (234) in 1937 reported that derris-gypsum dust (0.4 percent rotenone) killed 21 percent in 2 days. After 2 weeks a considerable number of derris-treated caterpillars were still alive. These cutworms were collected in the field and treated in the laboratory.

Ophiusa melicerta Drury

The larvae are remarkably sensitive to derris powder. A dust containing 0.5 percent of rotenone was completely effective against almost full-grown larvae. -- Van der Vecht (454) in 1936.

Panolis flammea (Schiff.)

Weis (477) in 1931 reported that third instars were very sensitive to Polvo; 0.09 mg. per caterpillar was fatal in 2 to 3 days. Fourth instars were more resistant. Dusting of mouth parts had no result because the large particles adhered poorly and fell off. Polvo possessed repellent properties against the second instars and most of the fourth instars.

Schwerdtfeger (366) in 1932 reported experiments on the control of this species with several proprietary insecticides, including one emulsion (Derrothan) and two powders (Derrothan I and Derrothan II) containing derris or extracts thereof. The powders, tested at 50 kg. per hectare, caused 100-percent mortality in 24 hours; and the emulsion also was very effective.

Panolis griseovariegata (Goeze)

Tragardh (416) in 1935 reported that the principal forest lepidopterous insects in Europe dusted with arsenicals or other insecticides during 1925 to 1934 are, in decreasing extent: Panolis griseovariegata, Bupalus piniarius (L.), Lymantria monacha (L.), Tortrix viridana (L.), Dendrolimus pini (L.), and Porthetria dispar (L.). During the preceding decade about

100,000 hectares in Europe had been dusted either from aeroplanes or from the ground, the former method being used about twice as often as the latter. The use of a ground duster presupposes that the ground is fairly even and also that the trees are planted in rows between which the vehicle can move. It is used when the areas are fairly small, not exceeding 100 hectares. In Germany several preparations containing a mixture of pyrethrum and rotenone were used during the last 2 years with great success.

Peridroma margaritosa (Haw.), the variegated cutworm

Washburn (472) in 1934 reported that derris was ineffective as a stomach poison to last instars of (Lycophotia) Peridroma margaritosa. Kale leaves were dusted and made into sandwiches, so that there would be no contact between the dust and the bodies of the larvae. Thirty larvae were fed sandwiches of 10 percent ground derris dust (6 percent rotenone) in diatomaceous earth, with no ill effects whatever; 30 larvae were fed pure ground derris dust (6 percent rotenone) with no ill effects; 30 fourth instars were fed derris dust (6 percent rotenone) with no ill effects; 20 fourth instars were put on leaves freshly dusted with pure derris dust and showed no ill effects. The only effect noted was that the derris seemed to be somewhat repellent, as the larvae did not eat so freely of the treated material as they did of the untreated.

Plathypena scabra (F.), the green clover worm

Brannon (47) in 1937 reported that recent experiments at the Norfolk, Va., laboratory, designed to determine the relative effectiveness of derris, derris-sulfur, cube, cube-sulfur, pyrethrum-sulfur, and sulfur alone, applied as dusts or as sprays for the control of the Mexican bean beetle in association with the green clover worm infesting snap beans, showed that in general the dusts were more effective than sprays for the control of the latter insect on beans. The derris and cube-dust mixtures contained 0.5 percent of rotenone, the derris and cube sprays contained 0.015 percent of rotenone, and the pyrethrum-sulfur dust mixture contained 0.1 percent of total pyrethrins. Wettable sulfur was used as a spray at the rate of 2 pounds to 50 gallons of water. It was also noted that sulfur dust alone gave foliage protection against the green clover worm comparable with that obtained when sulfur was used in combination with derris, cube, or pyrethrum, and that a derris-sulfur dust gave better protection than a derris-talc mixture. These results indicate that sulfur acts as a repellent against this species and that in instances where this pest occurs in association with a Mexican bean beetle infestation, sulfur should be used as a diluent for derris or cube for the combined control of the two insects.

Haude in 1939 stated in advertising literature published by the John Powell Co., New York, N. Y. that rotenone dusts may be used to control green clover worms where it is desired to avoid poisonous residues.

Polia oleracea (L.)

Lloyd (256) in 1920 reported tests of preparations made by Tattersfield of tuba root (derris) against larvae of the glasshouse tomato moth, (1) as a dry dust alone and in dilution with powdered earth; (2) with saponin in water suspensions at various strengths from 0.25 percent to 10 percent by

weight of the powdered root, mixed and strained through muslin; (3) with saponin in water suspensions of an alcoholic extract (6 times the strength of the powdered root) at various strengths from 0.08 percent to 2 percent by weight. Tomato plants in pots were dusted or sprayed with these, then infested with larvae collected in nurseries. The dusting was unsatisfactory, as it soiled the plants and encouraged the growth of molds. The water suspensions of the powdered root killed the larvae at a 10-percent strength, but a 5-percent strength failed to do so within a reasonable time. These strong mixtures also soiled the foliage. Suspensions of the alcoholic extract proved to be very satisfactory sprays on an experimental scale. A series of 18 experiments showed that 1 part of this substance by weight in 1,000 parts of water is a sufficiently potent spray. A plant sprayed with this was infested with 12 half-grown larvae confined to 1 leaf by means of a sleeve. Two days later 7 of these were dead, and 8 days after confinement they were all dead. Ten more half-grown larvae were then placed on another leaf, and 10 days later all these were dead. The spray therefore remained potent for 20 days. The foliage of the plant was not damaged, and the fruit set normally. This plant at the end of the experiment was photographed with a control plant of the same age which, without spraying, was infested with 10 half-grown larvae at the time the second lot was released on the sprayed plant. They ate an entire leaf each day and had destroyed the plant by the time those on the protected leaf were all dead. Similar experiments were carried out with strengths of 5, 2-1/2, 1-2/3, 1-1/4, and 5/8 pound of the alcoholic extract in 100 imperial gallons of water, respectively, and each plant was infested with 22 larvae as described above. The results varied little from those detailed, except that with the weakest strength the death rate was somewhat slower. None of the plants were damaged, and the substance appears to be safe to use, but no large-scale experiments were carried out.

The Experimental and Research Station of the Nursery and Market Garden Industries' Development Society Ltd., of Cheshunt, England (113), in 1939 stated that in order to obtain complete control of all instars of the tomato moth a rotenone content of 0.007 percent in the spray was necessary.

Speyer, Read, and Orchard (383) in 1940 reported that sprays containing derris or Lonchocarpus powders were very effective in rendering foliage of cauliflower and broccoli distasteful to caterpillars of tomato and cabbage moths. In many experiments carried out but few caterpillars actually died as the result of contact with the powders, or of eating foliage upon which they had been deposited. The deterrent action of the powders, however, obviated any serious injury to the plants and also prevented the caterpillars from obtaining sufficient nourishment to enable them to pupate. Derris powder was applied in the form of proprietary brands containing a spreader at the rate of 1 pound to 20 gallons of water. In small-scale experiments Lonchocarpus powder prevented feeding by the caterpillars when used at a strength equivalent to 1 pound to 40 gallons of water with 4 pounds of soft soap or 3 to 4 fluid ounces of liquid Agral as a spreader. Saponin, sulfonated lorol, and casein did not wet the foliage of vegetables so adequately as did the latter agents.

Prodenia eridania (Cram.), the southern armyworm

Wisecup (489) compared the relative value of derris and cube, both as sprays and as dusts, against the southern armyworm at Sanford, Fla., in 1933. Small and large larvae were introduced into cages with the following rotenone-containing dusts or sprays on sweetpotato leaves:

Derris spray, 5 percent of rotenone, 1 part in 200
Derris dust, 3 percent of rotenone, 0.3 mg. per square inch
Proprietary cube extract, 1.6 percent of rotenone, 1 part in 200
Proprietary cube dust, 0.57 percent of rotenone, 0.3 mg. per square inch

The derris, with the greater rotenone content, appeared somewhat more repellent, showing less feeding at the end of 2 days, when all the larvae were removed to fresh, untreated food. The end results after a week's time were disappointing, as no material had given a kill of over 33 percent; however, the derris gave consistently better kills, both as dust and spray, indicating that the rotenone must be taken into account when a derris or cube product is being recommended. Wisecup (491) in 1936 reported that laboratory tests made at Sanford with half-grown larvae indicated in general, that poisoned-bait mixtures consisting of bran, cottonseed meal, or corn meal, paris green, cryolite, phenothiazine, or cube, with sirup and ground lemons, were not sufficient to overcome the attractiveness of the natural green food of these larvae. Paris green and synthetic cryolite were much superior to cube.

Stahl (390) in 1934 reported that derris dust had a repellent effect. The feeding of the armyworm decreased as the concentration of rotenone in the dust increased from 0.1 to 3.0 percent, but there was some feeding in all cages.

The United States Department of Agriculture, Bureau of Entomology and Plant Quarantine (441) in 1935 reported that toxicity tests in the laboratory indicated that this insect, while repelled by derris, was not otherwise affected. The Division of Control Investigations, of the Bureau (444) has made many tests with derris and cube dusts. The results may be summarized as follows:

Instar	Rotenone content of dust	Minimum dosage of dust containing 100-percent mortality in 48 hours.
	Percent	Micrograms per cm.^{2}
First	4.5	90
Second	4.5	120 (21 percent mortality)
Third	4.5	100 (14 percent mortality)
Fourth	1.0	110 (3 percent mortality)
Fifth	5.4	125 (20 percent mortality)

The Department in a press release dated January 13, 1936, called attention to certain disadvantages that bar the use of rotenone insecticides for some types of insects. Derris is not effective against all insects. It repels, but has no other effect on the southern armyworm.

Sullivan, Phillips, and McGovran (396) in 1938 reported that a single spray test indicated that an extract of the fruit of the Amur cork tree (Phellodendron amurense) of China and Japan possessed low toxicity to the larvae, but this also applies to derris and pyrethrum.

Wisecup and Reed (493) in 1938 reported tests made at Sanford, Fla., which showed that poisoned baits containing 1, 2.5, or 7 pounds of cube per 100 pounds of standard bait (50 lbs. bran, 50 lbs. cottonseed meal, 1 gal. molasses and water as needed to moisten) were ineffective against southern armyworm larvae.

Woke (495) in 1938 reported studies on the action of insecticides on the alimentary canal of insects. The epithelial cells of larvae that were killed 60 to 80 hours after they had ingested rotenone or phenothiazine presented no abnormalities definitely attributable to the action of the poisons, whereas the arsenicals caused marked disintegration of the epithelial cells, and barium fluosilicate caused the epithelial layer to be thrown into charactoristic folds, probably as a result of an action of barium on the unstriated muscle fibers. Woke (496) in 1938 also reported the results of experiments to determine the biological disposition of rotenone after its ingestion using sixth instars reared on turnip plants and cut lettuce. Rotenone was fed to the larvae in sandwiches and, after intervals of time, acetone extracts of the tissues, gut contents, and feces were prepared and tested against mosquito larvae for the determination of toxicity. Suitable checks were employed. The results showed that the larva, after ingesting 5 mg. of rotenone, eliminates all or most of the substance with its feces. This result was substantiated by chemical tests.

Prodenia litura (F.)

DeBussy (56) in 1922 reported the results of tests of various materials on the larvae. This lepidopterous insect is of great importance in relation to tobacco culture in Deli, Sumatra. The finely ground root of Derris elliptica (toeba) was used as a decoction in water up to 10 gm. per 100 cc., yet in no case did it kill more than two out of five half-grown caterpillars.

Dusting or spraying with derris had only slight effect. The dusts contained from 0.5 to 2.8 percent of rotenone; the spray, 0.11 percent of rotenone. -- Van der Vecht (454) in 1936.

Sonan (379) in 1937 reported that derris dusts were ineffective against the gray-streaked moth in Formosa.

Butac (58) in 1938 reported that in 1936 cotton plants in one of the plots at the Philippine Carnival Exposition were dusted with derris-gawgaw (50:50, rotenone 1.5 percent), mainly to control the leaf-eating caterpillars which were abundant on the plants. The dusting was done about 9 a.m. Between 2 and 3 p.m. the plants were examined and the insects found were collected, especially those affected by the treatment. Sixteen vigorous larvae of Prodenia litura were collected and none died.

Van der Laan (245) reported in 1938 that in comparative field tests at Deli, Sumatra, in 1937 derris dusts containing 1.5 and 2.5 percent of rotenone proved inferior to a 5-percent lead arsenate dust in protecting tobacco against lepidopterous larvae. In experiments against the larvae in seed beds, a derris-dust mixture containing 3 percent of rotenone gave better results than a spray of derris powder mixed with water to give a rotenone content of 1 in 10,000, but was less effective than a spray of 1.5 percent of lead arsenate. In laboratory experiments the larvae proved almost insensitive to derris dust.

Merino and Otanes (273) in 1938 recommended derris powder for dusting and spraying against cabbage caterpillars, except this cutworm.

Prodenia sp.

Derris spray is not effective against Prodenia larvae. -- Deli Proefstation (94) at Medan, Sumatra, in 1929.

Spodoptera mauritia (Boisd.)

The Federated Malay States Department of Agriculture (123) in 1934 reported that during the previous year 78 spraying experiments, 9 dusting experiments, and 145 other experiments with derris extracts had been carried out. Spraying and dusting experiments were made on 6,010 larvae of this species. These insects thrive well in captivity and are easily obtained when the question of replenishment of stock arises.

Spodoptera pecten Guen.

Miller (279) in 1935 published a report on the toxic value of different species of Derris, describing 347 tests in which aqueous solutions, extracts, and dusts of 3 types of Derris root and 3 constituents of derris were tested against several species of insects and against fish and rats. The samples consisted of Derris elliptica grown at two localities and of D. malaccensis var. sarawakensis. The D. elliptica from one locality had a higher rotenone and ether-extract content than that grown at the other. In the D. malaccensis var. sarawakensis the rotenone content was low but the ether extract was high. One of the principal test insects was the larva of the noctuid moth Spodoptera pecten. Stock solutions of the 3 kinds of derris roots were prepared at the rate of 75 gm. of fresh root per liter of water, this amounting to from 21 to 29 gm. of dry root per liter. These solutions were preserved by the addition of formalin. By the addition of barium hydroxide or calcium hydroxide to these aqueous solutions the solids were precipitated. This sludge, when dried and powdered, was used in the dusting experiments. The insect tests were made by spraying, dusting and immersion. In most of the tests the mortality counts were based on examination of the insects on the third day after the test. The results of the spraying and immersion tests indicated that the insecticidal properties of the 3 kinds of derris tested were about the same. The conclusion was drawn from these tests that the rotenone content is not necessarily a reliable index to the toxic value of derris root. Rotenone, deguelin, and toxicarol were only moderately toxic to the insects. The aqueous solutions of derris root or crushed freshly harvested roots were toxic to the larvae without actual contact, indicating that derris may yield a volatile toxic substance. Fluids obtained from derris by steam distillation were also toxic to larvae of the same 2 species when immersed therein, killing 19 percent of S. pecten. The indications were that derris may affect the nervous system of insects through the integument and may also act as a repellent.

The Imperial Institute (211) in 1938 reported information on derris taken from a half-yearly report of the Federated Malay States Department of Agriculture. Repetitions of earlier experiments on the asphyxiant properties of derris had been carried out. Fresh crushed roots of derris from 3 localities all exerted a lethal distance effect on larvae of this species. The rotenone content, dry basis, of the roots used ranged from 7.04 to 0.34 percent, but this did not appear to affect its killing power. Fresh-water extract of derris roots gave negative results, as did pure rotenone 13.25 percent, ether extract 30.2 percent (dry basis) also gave negative results; but when this powder was ground to a paste with water it exerted an action similar to fresh crushed roots, but slightly less rapidly. Controls to all these experiments gave negative results. Spraying experiments with derris extracts were temporarily discontinued owing to inaccuracies of the apparatus. Dusting was tried with more success and 1,000 larvae were dusted, with fairly consistent results. The best dilution of dust appeared to be 10 percent of powdered derris and 90 percent of talc. Results have been expressed as weight of dust projected and reduced to weight of derris powder in the mixture and plotted against percentage kill, thus giving a more accurate picture.

Taeniocampa gothica (L.)

Gimingham and Tattersfield (161) in 1928 reported the results of laboratory tests with nonarsenical insecticides for control of biting insects. An extract of black haiari stems was tested on (Monima) Taeniocampa gothica. The insects were slightly affected; there was appreciable feeding but very little growth. Soap, 0.25 percent, was added to this extract. Tattersfield and Gimingham (401) reported that young larvae of this noctuid moth were highly resistant to an old extract of black haiari stems.

Triphaena pronuba (L.)

The Experimental and Research Station of the Nursery and Market Garden Industries' Development Society Ltd., of Cheshunt, England (113), in 1939 reported that derris dust was effective against caterpillars of the yellow underwing moth on carnations.

Phalaenidae (unidentified sp.)

Derris was not effective in a bait fed to cutworms, either in the insectary or in the field; but derris spray was observed to kill certain noctuid moths. -- Kelsall et al. (233) in 1926.

The Institute of Physical and Chemical Research (214) Tokyo, Japan, in 1927 reported that 1 pound of Neoton in 24 imperial gallons of water had no effect on cutworms.

Campbell (60) in 1932 reported experiments by Reynolds, who fed cabbage-leaf sandwiches containing an unknown quantity of rotenone to undetermined species of cutworms. Although the leaf disks were treated with rotenone suspension up to 1:200, the larvae fed freely and were not affected by rotenone. This unidentified cutworm is the only lepidopterous larva so far tested that seems resistant to rotenone as a stomach poison.

Derris was not effective against cutworms. -- Alabama Polytechnic Institute (10) in 1935.

The South Carolina Agricultural Experiment Station (381) in 1935 reported that experiments of the 1934-35 season indicated that a dust mixture of derris powder and clay, containing 0.5 percent of rotenone, was not so effective as the arsenicals against cutworms on cabbage.

Tischler (413) in 1935 reported that studies on the heart rates of various insects (including tomato cutworms) showed that the rate of pulsation was markedly decreased before the insects exhibited incoordinated movements. Other tests made with tomato cutworms led to the conclusion that derris inhibits oxygen utilization by the tissues and that its detrimental effects are general, rather than specific to any organ. Derris must penetrate into the insect body to produce toxic effects. This fact was evidenced by the low toxicity of derris as a spray or dust to cutworms, which, however, are susceptible to derris when a water extract is injected into the blood stream. It is not understood why derris penetrates readily into some insects and into others with difficulty. Derris extract enters the insect body through the alimentary canal, the spiracles and tracheal system, and the external integument. Derris powder enters by way of the alimentary canal, and also is probably extracted by the water of the body exudates and of body fluids by a process of osmosis, and is then absorbed through the integument.

White (480) in 1935 stated that derris is ineffective against cutworms. In 1936 and 1937 he (482) stated that neither derris nor pyrethrum, at the dilutions tested, had been effective in combating cutworms on cabbage.

Reid (345, 348) in 1936 reported that the strengths of derris or pyrethrum-dust mixtures recommended for the common species of cabbage worms were not effective in controlling cutworms on cabbage. Reid (346) in 1938 summarized results obtained in insecticide tests directed against cabbage worms on cabbage grown at Charleston, S. C., during the fall and winter of 1937-38. He reported that a cabbage worm population consisting of the cabbage looper and various Agrotinae (principally the corn earworm and several species of climbing cutworms) was controlled with a dust mixture of calcium arsenate and hydrated lime (3:1) prior to the heading of the plants, followed by applications of a pyrethrum-talc-dust mixture containing 0.3 percent of total pyrethrins, or a derris-clay-dust mixture containing 1.0 percent of rotenone, at 10-day intervals after the plants have headed; provided the plants had been well protected against cabbage worms before being thinned or transplanted. The experiment demonstrated that the pyrethrum and derris-dust mixtures were most effective against the cabbage looper and that the calcium arsenate-dust mixture was most effective against the Agrotinae. These results were referred to in the 1938 annual report of the United States Department of Agriculture, Bureau of Entomology and Plant Quarantine (446).

The United States Department of Agriculture, Bureau of Entomology and Plant Quarantine (442), in 1936 reported that in the fall of 1935 several species of cutworms were destructive to cabbage in several plantings at Charleston, S. C., but the derris dusts used were not effective against these noctuids.

The Louisiana Agricultural Experiment Station (258) in 1938 published a summary of entomological progress in that State, in which C. E. Smith reported that against larvae of Agrotinae, the true cutworms, the inorganic materials (paris green, calcium arsenate, and cryolite) were superior to the organic materials (derris and pyrethrum powders).

At a meeting of the North Central States Entomologists (309) in 1938, W. H. White remarked that cube and derris do not control the Agrotinae.

Phaloniidae

Phalonia ambiguella (Hbn.)

See Paillot (323) under Polychrosis botrana, on page 60.

Gessner (157) in 1929 reported tests in Germany with a Korean preparation [Neoton?] from the roots of Derris elliptica at a concentration of 100 gm. per 45 liters of water, to which was added 100 gm. of cottonseed oil plus soft soap. Before it was used the spray material was allowed to stand for 2 hours, with repeated stirring. This spray was ineffective in combating the pupae of (Conchylis) Phalonia ambiguella and the larvae of (C.) Phalonia roserana. Nicotine caused high mortality.

Jancke and Roesler (220) in 1939 reported the results of laboratory experiments carried out in the Rhineland in February-April 1939, in which pupae of the vine moths (Clysia) Phalonia ambiguella and Polychrosis botrana (Schiff.) in trap bands of corrugated cardboard were left in position on small sections of the card and sprayed with various mixtures. An insecticide should give at least 95-percent mortality to be effective, but this percentage was not given by a 5-percent emulsion of tar distillate alone or with 0.2 percent of nicotine, 1 percent of a preparation of pyrethrum, or 1 percent of derris; by a proprietary winter-oil spray; or by nine mineral oils in various combinations with nicotine, pyrethrum, or derris. Field tests with the mixtures were carried out in several localities in the Rhineland, but no satisfactory mortality was obtained, as measured by the numbers of adults subsequently caught in trap glasses.

Phalonia sp.

Frydlender (148) in 1933 wrote that insecticides derived from derris have been on the French market for several years. The Association Viticole Champenoise, "deceived by pyrethrum soap, have had recourse to Katakilla, an English product made from derris, to combat the 'Cochylis' (vine moth)."

Phycitidae

Citripestis sagittiferella (Moore)

Pagden (322) in 1931 wrote that derris and haiari may be used as stomach poisons for the control of this species on citrus.

Ephestia cautella (Walk.), the almond moth

Craufurd-Benson (85) in 1938 reported that the larva was not susceptible to a derris insecticide when dipped in it.

Ephestia elutella (Hbn.), the tobacco moth

Resistant to derris powder. -- Anonymous (5) in 1937.

Craufurd-Benson (85) in 1938 reported that a derris insecticide had very slight effect on the larva when tested by dipping.

Etiella zinckenella (Treit.), the lima bean pod borer

The United States Department of Agriculture, Bureau of Entomology and Plant Quarantine (442) in 1936 reported that derris tested on three species of pod borers attacking beans in Puerto Rico was less effective than fluorine compounds and that none of the rotenone products tested could be recommended.

The Puerto Rico Experiment Station of the United States Department of Agriculture (450) in 1938 reported on work done in 1937. Of the three pod borers, Maruca testulalis (Geyer), Fundella cistipennis (Dyar), and Etiella zinckenella, which infest beans in Puerto Rico, larvae of M. testulalis constituted approximately 85 percent of the entire pod-borer population. Derris-powder sprays were ineffective in controlling bean pod borers. In tests with Challenger lima beans, sprays consisting of derris alone and in combination with other insecticides were also ineffective. The insecticides used were derris alone, derris in combination with fish oil, derris plus a commercial sticker and spreader, derris with nicotine sulfate and soap, derris with a proprietary organic thiocyanate insecticide and a commercial sticker and spreader, and a proprietary organic thiocyanate insecticide and a commercial sticker and spreader without derris.

Fundella cistipennis (Dyar)

See the United States Department of Agriculture, Puerto Rico Experiment Station (450) and the United States Department of Agriculture, Bureau of Entomology and Plant Quarantine (442) under Etiella zinckenella (Treit.), p. 101.

Mineola scitulella Hulst

Haegele (175) in 1932 described spraying tests for the control of this species, a pest of prunes in southwestern Idaho. Cubor, a preparation of pyrethrum and rotenone, applied in a concentration of 1:200 to two plots, killed 27 and 29 percent, respectively, of the larvae.

Mineola vaccinii (Riley), the cranberry fruitworm

The Washington Agricultural Experiment Station (473) in 1930 reported the results of tests by Crowley with insecticides against cranberry insects. Neoton was no more effective than the less expensive pyrethrum sprays. Rotenone was tried against the cranberry fruitworm at the rate of 3 ounces to 100 gallons of water. It killed fruitworm larvae at this strength and also acted as a repellent to chewing insects for several days after the plants were sprayed with it.

The Massachusetts Agricultural Experiment Station (270) in 1937 reported that in tests against the cranberry fruitworm a spray of 10 pounds of derris powder (4 percent rotenone) and 2 pounds of fish-oil soap in 100 gallons of water, applied at the rate of 400 gallons per acre on July 13, controlled the insect much better than any insecticide ever tried before. It was estimated that the worms took less than 10 percent of the berries, as compared with 35 to 90 percent on surrounding areas. The treatment did not seem to affect the vines or crop. The derris spray was also used early

in August on plots where fruitworms were abundant and killed fully one-third of the worms in the berries. In 1938 this station (271) reported that a spray consisting of 8 pounds of derris powder (4 percent rotenone) and 2 pounds of soap in 100 gallons of water, applied at the rate of 400 gallons per acre on July 10 and again on July 20, controlled this insect almost completely on a bog where the worms took 40 percent of the crop on untreated check areas. Ten pounds of cube powder (4 percent rotenone) and 2 pounds of soap in 100 gallons of water, applied at the rate of 400 gallons per acre, also gave good control. Goulac, Ultrawet, calcium caseinate, SS-3, Ortho liquid spreader, coconut-oil soap, and resin fish-oil soap were tried as spreaders for the derris and cube sprays, and the soaps gave the best results. With either derris or cube powder, two sprays seem to be advisable for control of the fruitworm, one to be applied when about three-fourths of the bloom is past, the other about 10 days later. Small sample lots of the berries should be examined before a bog is sprayed, to determine the abundance and condition of the fruitworm eggs present. In 1939 this station (272) reported that 7 pounds of derris powder (4 percent rotenone) and 2 pounds of soap in 100 gallons of water gave as good control as sprays containing more derris. Two applications at the rate of 400 gallons an acre were necessary, one when about a third of the bloom was past and the other 10 days later. Cube dusts, used when rotenone-bearing sprays are most effective, killed the worms fully as well as did the sprays. One dust containing 2 percent of rotenone and an activator controlled the fruitworm almost completely and such a dust may prove to be a satisfactory control. The rotenone-bearing sprays killed most of the worms as they were entering their first berry near the stem end.

The dusts killed most of them while they were hatching from the egg or soon after they hatched and before they left the cup formed by the calyx lobes of the berry.

The Massachusetts Agricultural College in an Extension Service chart in 1937 recommended derris powder (4 percent rotenone), 10 pounds plus soap 2 pounds in 100 gallons of water, at the rate of 400 gallons per acre, for combating the fruitworm on cranberries. The first application should be made soon after the vines go out of bloom and a second spray 10 days later. Derris spray should not be used near a ditch or stream because it kills fish.

Haude in advertising literature published by John Powell and Co., New York, N. Y., in 1939 reported that in Massachusetts a spray of 8 pounds of cube or derris powder (4 percent rotenone) and 2 pounds of soap in 100 gallons of water, at 400 gallons per acre, applied on July 10 and 20, gave control of this insect. Soap gave the best results of the commercial spreaders used.

Plodia interpunctella (Hbn.), the Indian meal moth

Craufurd-Benson (85) in 1938 reported that the larva was not susceptible to a derris insecticide when dipped in it.

Zophodia convolutella (Hbn.) (syn., Z. grossulariae Riley), the gooseberry fruitworm

The New York State Agricultural Experiment Station (302) reported in 1937 that powdered derris or cube root, applied either as a spray or a dust, proved to be the most successful insecticide. For the dust, a mixture of cube or derris root with some inert carrier, such as talc, to give a 0.5-percent-rotenone content is suggested. For the spray, use 3 pounds of the undiluted root in 100 gallons of water. Two treatments are advised for heavy infestations. The first should be timed to coincide with the petal-fall spray on apples, the second 10 to 14 days later. A single treatment 5 to 7 days after petal-fall spray should handle a light-to-moderate infestation. The same station (303) in 1938 reported excellent control of this insect in heavily infested currant fields with a dust or a spray of powdered derris or cube root. Two pounds per 100 gallons of a derris or cube root containing about 5 percent of rotenone is the suggested spray formula, and a dust should contain about 0.5 percent of rotenone.

Hammer (182) in 1936 recorded tests made in New York. Powdered derris and cube root (5 percent rotenone) gave good control when used in sprays. The best results were obtained from two applications of either of these materials, used at the rate of 2 pounds in 100 gallons of water. The first application was made on May 21 (1 day after the calyx spray was begun on McIntosh apples) and a second on June 3. Almost as good results were obtained from one application using 4 pounds of derris or cube in 100 gallons of water, applied on May 29, just as the worms were beginning to web the clusters together. In sprays, derris gave slightly better results than cube. Dust mixtures containing either derris or cube root (0.5 percent rotenone) gave good control but were slightly inferior to the sprays. There was no apparent difference in toxicity between derris and cube dusts. Both clay and talc proved satisfactory as diluents. These results were referred to by Roark (357) in 1938 in reviewing the comparative action of derris and cube of equal rotenone content on many insects.

Haude in 1939 stated in advertising literature published by John Powell and Co., New York, N. Y., that this worm may be controlled by sprays (3 pounds of powdered derris or cube containing 5 percent of rotenone in 100 gallons of water) or dusts (0.5-percent-rotenone dust with sulfur or talc as the diluent).

Pieridae

Colias philodice eurytheme Bdv., the alfalfa caterpillar

L. G. Jones (225) reported that in 1938 laboratory and field tests at Sacramento, Calif., with cube dust applied to growing alfalfa at the rate of 40 pounds per acre (rotenone 0.32 to 5 percent), disclosed that rotenone did not cause satisfactory mortality of all larval instars and of pupae of (Eurymus) Colias eurytheme. The cube dust or concentrate was diluted with varying percentages of talc, sulfur, and wheat flour. No kill was noted in any rotenone combination with these materials nor from the undiluted cube (5 percent rotenone) dust.

Pieris brassicae (L.)

Fryer, Stenton, Tattersfield, and Roach (149) in 1923 reported that extracts of Derris elliptica had been shown to have high insecticidal value, particularly for caterpillars. The dry root itself may be used, finely powdered and worked up with water and soap, or other emulsifying reagent. As the pure poisons found in derris root are solids and only slightly soluble in water, their toxicity appears to depend upon the degree of dispersion. A biological method of determining insecticidal properties qunatitatively is described. It depends on dipping insects, for a constant period of time (10 seconds), in known strengths of highly dispersed suspensoids in dilute aqueous solutions of saponin. The results obtained agreed with those given by the chemical method already described. To caterpillars of this insect rotenone and derrid (derris resins) are of the same order of toxicity as nicotine.

Van der Laan (244) in 1936 reported that this species is sensitive to derris.

Thalenhorst (406) in 1937 reported tests of proprietary derris, pyrethrum, and nicotine dusts. Derris gave the best results.

Etablissements Rotenia, in a letter to R. C. Roark in 1938, stated that this pest on cauliflower was killed by a product containing 12 percent of powdered Lonchocarpus nicou root (6 percent rotenone content) and 88 percent of talcum.

Pieris protodice B. & L., the southern cabbage worm

A derris-dust mixture (20 parts derris of 5-percent-rotenone content, 40 parts of tobacco dust, and 40 parts of 300-mesh dusting sulfur) is very effective in controlling the southern cabbage worm. -- Allen (11) in 1934.

Haude in advertising literature published by John Powell and Co., New York, N. Y., in 1939 recommended cube or derris dust (0.5 percent rotenone).

Pieris rapae (L.), the imported cabbage worm

See Colorado Agricultural Experiment Station (73, 74, and 76) on pp. 76-77 United States Department of Agriculture, Bureau of Entomology and Plant Quarantine (437) on p. 69 , Crosby et al. (87) on p. 79 , Hervey and Palm (190) on p. 71 , Huckett (201) on p. 71 , Ohio Agricultural Experiment Station (314) on p. 74 , Roney and Thomas (358) on p. 76 , and White (478) on p. 67 , under Autographa brassicae (Riley).

A spray of 2.5 pounds of derris plus 3 pints of Sunoco oil (as spreader) per 100 imperial gallons of water gave a mortality of over 90 percent of imported cabbage worms on cabbage. Dusts of hydrated lime and derris were not so effective. The authors concluded that the moisture usually retained by cabbage foliage undoubtedly assisted in bringing out the toxic properties of derris. These tests were made in 1924 and 1925 and were reported by Kelsall et al. (233) in 1926.

Large larvae on cabbage were all killed by a dust consisting of 1 part of rotenone and 99 parts of diatomaceous earth. -- Davidson (90) in 1930.

Davidson and Jones (91) in 1931 reported on the change in aqueous suspension. Rotenone in solution in pyridine, or in acetone to which tannic acid has been added, rapidly loses its insecticidal effectiveness. This loss in toxicity is accompanied by a decrease in optical activity and a progressive yellowing of the solution. Atmospheric oxidation of the rotenone appears to account for these changes. The yellow crystalline material resulting from the oxidation of rotenone in pyridine solution was tested on goldfish and insects and was found to be much less toxic than rotenone. In acetone or in alcohol rotenone decomposes very slowly. In aqueous suspensions made from fresh acetone and alcohol stock solutions rotenone loses toxicity upon standing. A suspension of rotenone in water at 1:50,000 killed 100 percent of Pieris rapae larvae on potted cabbage plants in a greenhouse, whereas the yellow decomposition material, even at 1:12,500, killed none.

Rotenone suspended in water 1:1,000, sprayed on leaves and fed to fifth instars as a sandwich, killed all; at 1:5,000 it killed 20 percent. -- F. L. Campbell (60) in 1932.

Tests have shown that neither paris green, nor lead arsenate, nor calcium arsenate will give as effective control of imported cabbage worms as will derris dusts containing 1.75 percent of rotenone, applied at the rate of 12 to 15 pounds per acre, or pyrethrum dusts containing 0.12 percent of pyrethrin I and applied at the same rate. Hellebore was found to give better control than the arsenicals but was considerably inferior to the derris and pyrethrum products. -- United States Department of Agriculture, Bureau of Entomology (434) in 1933.

Stahl (589) in 1933 reported that at Sanford, Fla., rotenone 1.6 percent at 1:200 and rotenone 5 percent at 1:800 did not appear to be sufficiently toxic, either as a contact or a stomach poison. Derris dust (3 percent rotenone), 1 part in 4 parts of an inert carrier, gave very good kill, even without the addition of pyrethrum powder. This combination having approximately 0.6 percent of rotenone gave better results as a contact dust than did a proprietary cube dust of the same rotenone content.

A derris-dust mixture (20 parts of derris of 5-percent-rotenone content, 40 parts of tobacco dust and 40 parts of 300-mesh dusting sulfur) is very effective. -- Allen (11) in 1934.

The United States Department of Agriculture, in a press release dated January 13, 1936, called attention to certain disadvantages that bar the use of rotenone insecticides for some types of insects. Derris is not effective against all insects but does kill the common cabbage worm.

The United States Department of Agriculture, Bureau of Entomology (435) in 1934 issued recommendations for the control of some important truck-crop insects. The preferred dust for the control of the common cabbage worm on cabbage was derris or other rotenone dusts and the preferred spray was pyrethrum-derris extract combined.

> Derris dusts containing 0.5 percent to 1.5 percent rotenone have given very promising results in 4 sections of the Eastern and Southern States. Satisfactory diluents for the derris root powder are finely ground tobacco dust, finely pulverized clay, or talc. Clay and talc have the advantage of being more economical in cost and more readily available in some sections than tobacco dust. Both have the disadvantage of leaving an objectionable whitish deposit on the cabbage when applied near the harvesting period. The use of tobacco dust eliminates the appearance of undesirable deposits on the plant and, under favorable climatic conditions, may aid in the control of aphids. Derris retains its insecticidal value longer than does pyrethrum. In Ohio excellent results were obtained with commercial dusts containing approximately 0.55 percent of rotenone against the cabbage looper and the common cabbage worm. Sulfur has been used successfully as a diluent on cabbage and squash. Commercial pyrethrum-derris extracts in combination have given good results in Ohio, when used at twice the strength recommended by the manufacturers.

At the 1934 meeting of the American Association of Economic Entomologists, reported by the United States Department of Agriculture, Bureau of Entomology and Plant Quarantine (437), Cory led a discussion of field results with arsenical substitutes for the control of vegetable insects. Roney and Thomas of Texas reported that derris-sulfur dust (0.5 percent rotenone) successfully controlled the imported cabbage worm. W. H. White reported that as a control for the imported cabbage worm derris was more effective than pyrethrum, paris green, cryolite, or calcium arsenate, whereas pyrethrum was superior to the last three materials. In general, dusts gave better results than sprays.

The United States Department of Agriculture, Bureau of Entomology and Plant Quarantine (441) in 1935 reported that field-plot tests on cabbage showed definitely that derris dusts containing from 0.5 to 1.0 percent of rotenone are effective against the imported cabbage worm. Pyrethrum dusts are less effective. The Bureau (442) in 1936 reported results of various tests with rotenone, derris, and cube. On cabbage, derris-dust mixtures were more effective against the imported cabbage worm than pyrethrum, cryolite, or calcium arsenate. Experiments in California demonstrated that dust mixtures of derris, cube, or pyrethrum gave satisfactory results in the control of the three more common species of cabbage worms on cauliflower. In laboratory tests the ground root of devil's-shoestrings was as effective against the common species of cabbage worms as derris or cube containing equal percentages of active ingredients.

The Division of Control Investigations of the Bureau (444) in 1938 reported results of tests with derris and cube on the imported cabbage worm, as follows:

Material	Instar	Dosage per sq. cm.	Mortality	
		Micrograms	Percent	Hours
Derris (rotenone 4.5 percent; total extractives 19 percent) as a dust	Fourth	100	100	48
Do.	do.	100	100	72
Do.	Third	120	100	48
Do.	do.	120	100	72
Do.	Second	120	100	48
Do.	do.	120	100	72

M.l.d. of derris and cube powders in 48 hours

Instar	M.l.d.
Fifth	---
Fourth	100 (5)
Third	120
Second	120
First	---

The Bureau (448) in 1939 quoted the county agent of Crawford County, Ind., as reporting that rotenone-sulfur dust used against the imported cabbage worm gave 100-percent kill in every case.

Crosby and Chupp (86) in 1934 recommended the application of a dust containing 0.5 percent of rotenone at the rate of 25 to 30 pounds per acre for the control of leaf-eating caterpillars, including the imported cabbage worm, on cabbage, cauliflower, brussels sprouts, broccoli, kale, and similar crops on Long Island.

Gilbert and Popenoe (159) in 1934 wrote that rotenone dusts, such as those produced from derris or cube roots, had given the best control. Satisfactory results were obtained by using 10 to 15 pounds per acre of dust containing from 1 to 2 percent of rotenone. Pyrethrum dusts and extracts were also effective. As these dusts and extracts vary in strength they should be used according to the manufacturer's directions.

Used as a test insect by Ginsburg and Granett (165) in 1934. See under Bombyx mori L., on p. 9.

McCampbell (259) in 1934 recommended derris dusts for control in Colorado. Two or three dustings with a product containing 1 percent of rotenone, applied at the rate of 15 to 30 pounds per acre, protected the 1933 cabbage crop in the Denver section against this species.

W. J. Reid (344) in 1934 reported that at Charleston, S. C., derris-root powder continued to prove toxic to the species of cabbage worms present, including common cabbage worms. The degree of control obtained with derris powder was proportionate to the strength of material used. Best results followed the use of a mixture containing 1.5 percent of rotenone. An increase in this concentration to 3.4 percent in 1933 did not apparently increase the kill. A mixture containing only 0.1 percent of rotenone showed some toxicity.

Swingle (397) in 1934 compared the action of derris and pyrethrum. Films of gelatine were impregnated with derris or pyrethrum by adding 0.7 percent of the powder to a 10-percent solution of gelatin and were dried at room temperature on a piece of tinned sheet metal. Cabbage-leaf sandwiches were made with 7/8-inch circular discs of this impregnated gelatin and tests were made with full-grown cabbage worms. Derris under these conditions acts as a powerful stomach poison but has no contact action on larvae allowed to crawl over the derris-gelatin film. Pyrethrum, on the other hand, has no effect as a stomach poison but is a potent contact poison. (Also reported by the United States Department of Agriculture, Bureau of Entomology and Plant Quarantine (441) in 1935.)

R. E. Campbell (63) in 1935 reported that in laboratory tests cube dusts have been slightly more toxic than have derris dusts with an equivalent rotenone content. Talc was used as a diluent in each case, and applications were made with a precision duster at a dosage of 1 gm. per plant. Mr. Campbell, in a typewritten report to the Division of Truck Crop and Garden Insect Investigations, of the Bureau of Entomology & Plant Quarantine, stated that he made field tests at San Fernando, Calif., in March 1934 with derris and cube dusts containing 0.5 percent of rotenone on cabbage. Applications were made by means of hand dusters at the rate of 22 pounds per acre for derris and 30 pounds per acre for cube. Derris destroyed 54 percent, as compared with 47.7 percent for cube.

Headlee (186) in 1935 reported effective control on cabbage and cauliflower with a derris dust containing 0.8 percent of rotenone and 2.8 percent of total extractives. This dust consists of 16 parts of ground derris (5 percent rotenone and 18 percent total extractives), 25 parts of sulfur, and the balance clay or talc. From 15 to 18 pounds per acre were required when applied without hoods and from 8 to 10 pounds with hoods.

Hervey, Huckett, and Glasgow (189) in 1935 recommended a dust containing 0.5 percent of rotenone, made by diluting derris or cube with talc or clay, used at the rate of 20 to 35 pounds per acre. A spray of 4 pounds of derris powder (4 percent rotenone) plus 4 pounds of skim-milk powder per 100 gallons of water may also be used. Huckett and Hervey (204) reported in 1935 that dusts containing 0.5 percent of rotenone were effective.

Howard, in a typewritten report to the Division of Truck Crop and Garden Insect Investigations in 1935, stated that derris root mixed with talc, infusorial earth, or tobacco dust so as to contain from 0.5 to 0.75 percent of rotenone, and used at intervals of 7 to 10 days at dosages of 25 to 30 pounds per acre per application, was very effective. Derris dusts were more effective than derris powder in water, but the latter was more effective than the derris extract in water used as a spray. Cube root, used either as a dust or a spray, gave similar results to derris, provided the rotenone content was the same.

Howard and Davidson (195) in 1935 advised that derris sprays or dusts were the best insecticides for the control of cabbage worms in Ohio. Derris or cube dust containing 0.05 to 0.1 percent of rotenone applied at the rates of from 20 to 25 pounds per acre, gave good control of the imported cabbage worm. Three or four applications were necessary in some instances. Good results were also obtained by the application of derris- or cube-root sprays containing 0.01 percent of rotenone.

Howard, Mason, and Davidson (197) in 1935 reported the same results. Ground pyrethrum powder from which the pyrethrins had been extracted proved to be a suitable diluent.

List and Sweetman (253) in 1935 reported the results of tests with derris, cube, pyrethrum, paris green, cryolite, calcium arsenate, and lead arsenate, applied as dusts with the Root hand duster, against cabbage worms in Colorado. Dosage varied but did not exceed 10 pounds per acre. The diluent was Celite FC, a diatomaceous earth, 5 percent of which is coarser than 150-mesh and 10 percent coarser than 325-mesh. All dusts were prepared by mixing in a ball-mill type mixer 15 minutes. Pyrethrum powder containing 0.18 percent of pyrethrins, derris powder, containing 0.5 percent of rotenone, and cube powder containing 0.5 percent of rotenone were equally efficient. In another series, pyrethrum powder containing 0.18 percent of pyrethrins, derris powder containing 0.5 percent of rotenone, cube powder containing 0.5 percent of rotenone, and a mixture containing 12.5 percent of paris green were all of equal value. A dust containing 0.1 perdent of rotenone was as effective as one containing 0.4 percent of rotenone. Tests showed no significant difference between dusts, containing 0.5 percent and 0.4 percent of rotenone. No significant difference was found between dusts containing 0.3 percent of rotenone and 0.6 percent of rotenone. Morning and evening applications of a cube dust containing 0.5 percent of rotenone were not significantly different.

The South Carolina Agricultural Experiment Station (381) in 1935 reported that a dorris powder-clay-dust mixture containing 0.5 percent of rotenone was a pproximately as toxic, and in some cases superior to, undiluted calcium arsenate, paris green and lime (1:9) and synthetic cryolite and clay (1:3).

L. A. Strong in a letter dated July 6, 1935, to Houghton and Byrne, Sydney, Australia, stated that in laboratory tests with the ground root of Tephrosia virginiana, which did not contain any rotenone, approximately 36.6 percent of the quarter-grown larvae of the imported cabbage worm were killed, as compared with a 35.0-percent kill from the use of clay alone. Clay is one of the common diluents for rotenone-containing dusts. The total extractives of the Tephrosia were not known, but probably did not exceed 3 or 4 percent. Applications of Tephrosia dust containing 0.097, 0.067, 0.042, and 0.105 percent of rotenone killed from 94.4 to 98.3 percent of quarter-grown larvae. These results indicated that the presence of rotenone in Tephrosia does aid materially in increasing its toxicity to quarter-grown larvae under laboratory conditions.

F. L. Thomas (410) in 1935 recommended 1 part of derris (5 percent rotenone) mixed with 9 parts of finely ground conditioned sulfur for the control of cabbage worms, including this species. In 1936 Mr. Thomas (411) reported that in Texas derris-sulfur dust (0.5 percent rotenone) gave good results.

White (480) in 1935 recommended derris dust (0.5 to 1.0 percent rotenone) and derris spray (0.02 to 0.25 percent rotenone) for the control of this insect. Later he (481) summarized the results obtained by the Bureau of Entomology and Plant Quarantine at Chadbourn, N. C., Charleston, S. C., Baton Rouge, La., and Columbus, Ohio, with nonarsenical insecticides for the control of four species of cabbage worms including the imported cabbage worm. As a general insecticide for the control of mixed populations, derris gave the best results and pyrethrum came next in effectiveness. Based on the comparative efficiency, at economical strengths, of each of the insecticides tested against each of the principal species present, the experiments indicated that as a control for the imported cabbage worm derris was more effective than pyrethrum, paris green, cryolite, or calcium arsenate, while pyrethrum was superior to the three last materials. White in 1936 recommended derris dust containing 0.5 to 1.0 percent of rotenone for the control of cabbage worms on cabbage and cauliflower at a dosage of 15 to 20 pounds per acre. It was found to be especially important, however, to start the treatments early in the development of the cauliflower, while the plants were small, since it was not possible to obtain a good coverage of the insecticides over the heavy foliage of nearly mature cauliflower plants. The experiments in 1934 on collards indicated that each of the three more common species of cabbage worms may be controlled satisfactorily with a derris-dust mixture containing 0.5 percent of rotenone. White (482) in 1937 reported that derris dust containing from 0.5 to 1.0 percent of rotenone applied at the rate of 15 to 20 pounds per acre, was the preferred material for use against the imported cabbage worm, the cabbage looper, and the diamond-back moth on cabbage. The rotenone content of derris root varies, and purchases should be made on the basis of rotenone content, total extractives, and degree of fineness. For example, a derris-root powder containing 4 percent of rotenone should contain not less than 14 percent of total carbon-tetrachloride or ether extractives. In general, the total extract (either by carbon-tetrachloride or ether) should average approximately three and one-half times the rotenone content. The derris root powder should be of such degree of fineness that not less than 90 percent

of it will pass through a 200-mesh sieve and all the material should pass through an 80-mesh sieve.

The Colorado Agricultural Experiment Station (75) reported in 1936 that during 1934 the insect infestation on cabbage and cauliflower consisted largely of the imported cabbage worm. A satisfactory control was obtained with pyrethrum dusts containing 0.18 percent of pyrethrins and with derris or cube dusts containing 0.5 percent of rotenone. The minimum amount of material and the number of applications to give seasonal protection remain to be determined. The infestation of the imported cabbage worm was so light in 1935 that this part of the work could not be completed. This station (76) in 1937 reported that rotenone was found to be superior to pyrethrins in controlling the imported cabbage worm, and that 2.84 pounds of rotenone dust per acre gave a significant kill.

Cottier (83) in 1936 reported excellent control of white butterfly larvae on cabbage in New Zealand by the application of derris dusts and sprays. Derris plus summer-oil spray gave excellent control, whereas the oil sprays alone gave poor control. Dusts were slightly superior to the spray. Cottier recommended application of a dust containing from 0.5 to 0.75 percent of rotenone at the rate of 20 to 25 pounds per acre. He also tested a number of proprietary derris dusts and sprays. In 1939 Cottier (84) reported that in New Zealand derris sprays and dusts, at least when fresh, gave excellent control. Some of the derris-spray materials, however, had markedly deteriorated in killing power in their second season. One of the proprietary powders (D. P. No. 6) gave good results when bought on the market, although it was not possible to tell when it was manufactured; and another (D. P. No. 8), although it also contained pyrethrum extract, gave good results after storage for three seasons; therefore a considerable variation is to be expected with commercial brands of derris-spray powders. On the other hand, all derris dusts of 0.75-percent-rotenone content retained their killing power well. In the field D. P. No. 2, which contained 0.5 percent of rotenone, gave good control of caterpillars when applied at 20 to 25 pounds per acre. Summer-oil sprays even at 1:60 did not give satisfactory results, but when derris spraying powder was added to the oil excellent results were obtained.

Gui (171) in 1936 reported that in 1934 a spray of 1 part Rotecide plus 1 part New Evergreen to 800 parts water controlled 95.7 percent of the imported cabbage worm, and that a derris-clay dust (0.5 percent rotenone) gave 100-percent control. In 1938 Gui (172) reported that for the protection of cabbage against three species of cabbage worms, including the imported cabbage worm, the crop should be dusted or sprayed at 10-day intervals with paris green or derris powder. Derris-powder dusts should contain not less than 0.5 percent of rotenone, and 1 pound of derris powder of 4-percent-rotenone content should be used to 7 pounds of the diluent. Desirable diluents are flour, talc, diatomaceous clay, dusting gypsum, and finely ground tobacco stems. Derris-powder sprays should consist of 1.5 pounds of derris powder (4 percent rotenone) in 50 gallons of water, used with a spreader and sticker. When other grades of derris powder are used, spray should contain 0.015 percent of rotenone.

Federal regulations prohibit excessive residues of poison on marketed cabbage; therefore, paris green should not be applied after the heads begin to form. Derris powder may be used after that date or throughout the season. There are no regulations concerning residues of rotenone on fruits and vegetables.

Huckett (202) in 1936 reported insectary tests with pyrethrum, derris, and nicotine. The derris contained 4.5 percent rotenone and 16 to 18 percent total extractives. The mortalities of fourth instars 96 hours after the derris treatment were as follows:

Spray formula	Mortality Percent
Derris powder 2-½ gm.,	90.8
skim-milk powder 2-½	82.5
gm., water 500 cc.	
Derris powder 2 gm.,	87.5
skim-milk powder 2½ gm.,	74.2
water 500 cc.	
Derris powder 1-¼ gm.,	81.7
skim-milk powder 2-½ gm.,	65.0
water 500 cc.	
Checks	10
	10

Powdered derris root (4.5 percent rotenone, 15 to 18 percent total extractives) at strengths comparable to 4, 3, and 2 pounds of powder per 100 gallons of water gave higher mortality of the imported cabbage worm than of the cabbage looper. Huckett (203) in 1938 stated that in experiments on Long Island young and old larvae of Pieris rapae were susceptible to derris powder.

Van der Laan (244) and DeBussy et al. (57) in 1936 reported that this species is sensitive to derris.

The New Jersey Agricultural Experiment Station (293) in 1937 reported that derris dusts had given satisfactory results against cabbage worms, including this species.

The Ohio Agricultural Experiment Station (315) in 1936 reported that six of the most promising insecticides (including derris) for controlling three species of cabbage worms, including the imported cabbage worm, were tested in 1935. The insecticides were used in various strengths and with different diluents, stickers, and spreaders. The highest percentage (97 percent) of marketable heads was produced on plots sprayed weekly with paris green (2 lb. to 50 gal. of water), with a sulfated alcohol as a wetting agent. Averages of 90 to 93 percent of marketable heads were produced on plots dusted at weekly intervals with derris powder and flour (0.5 percent rotenone). This station (316) in 1937 reported that the best control of three species of cabbage worms, including the imported cabbage worm, was obtained from the use of paris green. Paris green sprays (2 lb. per 50 gal.) gave from 81 to 93 percent of marketable heads; paris green dust (1 lb. + 12.5 lb. flour) gave 87 percent; derris dust (1 lb. of 4-percent derris + 7 lb. flour) gave 58 percent; and derris spray (1.5 lb. of 4-percent derris + 2 oz. SS-3 to 50 gal. of water) gave 70 percent.

According to Penick and Co. (326) in 1936, Foliafume (which contains derris and pyrethrum extracts) should be diluted with water 1:400 for use against cabbage worms.

Shropshire and Kadow (369) in 1936 recommended derris and cube for the control of the imported cabbage worm, the cabbage looper, and larvae of the diamondback moth. Against cabbage worms these materials are most effective when applied as a dust late in the afternoon. This dust should contain at least 0.5 percent of rotenone and should be applied at the rate of 20 to 30 pounds per acre, before the worms become abundant, repeating applications at intervals of 10 days to 2 weeks, or as often as necessary. Unlike metallic poisons, derris products are safe to use on crucifers up to the time of cutting. Derris sprays, while not commonly recommended, can be used for the control of cabbage worms. They should be used according to the manufacturer's directions.

Walker and Anderson (467) in 1936, reporting on experiments conducted in 1932 concluded that repeated applications of derris and cube dusts containing from 0.5 to 0.75 percent of rotenone and from 2 to 3 percent of total extractives, and pyrethrum dusts containing from 0.3 to 0.5 percent of pyrethrins gave good control of cabbage worms, whereas dusts of weaker concentrations were less effective. Derris and cube dusts having approximately the same rotenone- and total-ether-extractive content appeared to be about equally effective for the control of these pests. Derris dusts (0.75 percent rotenone) gave 78-percent control of the imported cabbage worm. This indicates that the imported cabbage worm is as susceptible to derris, if not more so, than the cabbage looper or the larvae of the diamondback moth. The same authors (468) in 1937 reported that repeated applications of derris and cube dusts containing from 0.5 to 0.75 percent of rotenone and from 2 to 3 percent of total extractives, at 7- to 10-day intervals, gave good control of the imported cabbage worm.

Walker (463) in 1937 reported the results of tests of cube dusts (0.75 percent rotenone) and sprays (3 lb. per 100 gal.) to control the imported cabbage worm, both with and without Ultrawet. In most instances the addition of Ultrawet did not result in increased protection of the plants.

Wisecup (490) in 1936 reported that at Sanford, Fla., a cube-dust mixture containing 0.055 percent of rotenone was very effective in killing quarter-grown larvae of the imported cabbage worm, and this dilution is the most suitable of any tested for use in obtaining comparative results of the reactions of insecticides to larvae of P. rapae. In 1938 Wisecup (492) reported that insecticidal dusts made from the powdered roots of Derris elliptica, Lonchocarpus sp., and Tephrosia virginiana, diluted with clay to contain uniform percentages of rotenone, were tested in the laboratory against larvae of this species. For each material used, 180 uniform quarter-grown and an equal number of half-grown larvae were used. There was no significant difference in insecticidal efficiency between the averages of derris and of cube powders containing nearly equal percentages of rotenone and total extractives. One sample of cube, however, was definitely inferior, contrary to what would have been expected from the chemical analyses. Samples of T. virginiana diluted 1:3 with clay, with resulting rotenone contents as low as 0.042 percent, were so toxic to quarter-grown larvae that no comparisons could be made. The same dilutions of Tephrosia tested with the more resistant half-grown larvae did not differ significantly among themselves except for the sample ground coarser than 60 mesh, which was inferior to the best. The best sample of diluted Tephrosia was not inferior to a derris dust containing 0.5 percent of rotenone and was superior to one containing 0.1 percent. Materials were diluted with clay to contain 0.1 percent of rotenone for tests with quarter-grown larvae and 0.5 percent of rotenone for half-grown larvae.

Wisecup and Reed (494) in 1938 reported on a study of the decrease in effectiveness of cube when exposed to weathering in Florida. The source of rotenone in the first six tests was sample of powdered cube root containing 6 percent of rotenone and 20.5 percent of total carbon-tetrachloride extractives, whereas that in the last two tests was a different sample of powdered cube root containing 6.9 percent of rotenone and only 15.9 percent of total carbon-tetrachloride extractives. Four of the treatments in each test were applied as sprays and four as dusts, with one untreated control. The dusts were always mixed in the proportion of 1 part of cube to 9 parts of diluent. The diluents were talc, clay, tobacco dust, and sulfur purchased from local distributors. The sprays were made up to contain 2 pounds of cube per 50 gallons of water, and the adherent or spreading agents added at the rate of 1:800, or 1:500, the quantity being kept constant in any one test. The proprietary spreaders or adherents used were: (1) A sulfonated, partly oxidized, petroleum hydrocarbon, (2) alkylphenylbenzenesulfonic acid, and (3) calcium caseinate. Eight combinations of cube were applied to cabbage in the field and, after 5 days of exposure to weathering, samples were fed to imported cabbage worms under controlled laboratory conditions to obtain relative mortality records. Eight replicates of each of these tests were made under widely different weather conditions. There was a uniform decrease in mortality

for all combinations, but the cube remaining after 5 days killed an average of 42 percent of the test insects, as compared with a 17-percent mortality in the controls, indicating that, on the average, toxic material still remained after 5 days' exposure to weathering. Spray suspensions of cube with adherents and spreaders gave a greater total mortality over a period of 5 days than did dusts with four different diluents. However, the kind of spreader or the kind of diluent made no appreciable difference, indicating that the choice of either could be based on availability and price. Although the water suspension without adherents or spreaders utilized only about half as much cube per acre as did the dusts, it gave equally good kills. Precipitation was second to duration of exposure in causing decreases in the effectiveness of dube dusts and sprays. This was indicated by a significant correlation ($r = 0.74$) between the decrease in mortality during 4-day periods of exposure and the logarithms of the total precipitation recorded during these respective periods.

The imported cabbage worm can be controlled with a rather dilute rotenone dust. -- Howard and Mason (196) in 1937.

Hutson (209) in 1937 recommended derris for the control of the imported cabbage worm. A good insecticidal dust contains 0.5 to 0.75 percent of rotenone. Suitable diluents are talc, clay, bentonite, chalk, tobacco dust, flour, or sulfur. Five pounds ground derris with 1 pound of powdered skim milk, 2 gallons of skim milk, 3 pounds of thoroughly dissolved soap, or 3 to 6 ounces of one of the sulfated alcohols make 100 gallons of effective spray.

Kelsall and Stultz (234) in 1937 reported laboratory tests of derris (4 percent rotenone) as a dust, with gypsum as a diluent. Results were as follows:

Concentration of derris	Mortality	
Percent	Percent	Days
5	100	2
	67	1
12.5	80	2
	100	1

A derris-gypsum dust containing 5 percent of derris gave a thorough and practical control in field tests.

Manschke (268) in 1937 reported on tests carried out with aqueous suspensions of derris-root powder against a number of insects. The results against imported cabbage worms on cabbage are given in the accompanying tabulation. In the sprays tested the amount of derris powder ranged from 0.45 to 1.36 kg. in 378.5 liters of spray.

Insecticide	Mortality Percent
0.91 kg. of derris root (4 percent rotenone) in 378.5 liters water + 21.25 gm. of 40-percent coconut-oil soap per 3.785 liters	93

The New York Agricultural Experiment Station (302) in 1937 reported that field tests of powdered derris, cube, and timbo root of comparable analytical quality showed that such powders were about equal in effectiveness. Dusts of 0.5-percent-rotenone content gave optimum results and those of 0.33-percent-rotenone content gave results that were commendably satisfactory, considering costs. Spray mixtures containing 4 pounds of a good grade of powdered root in 100 gallons of water, with a sticker, gave fair results, but were not so effective as the dusts.

C. E. Smith (372, 373) in 1937 reported tests made at Baton Rouge, La. In field experiments involving several species of cabbage worms -- principally Autographa brassicae (Riley), Hellula undalis (F.), and Pieris rapae (L.) -- a dust mixture of peat moss containing 2 percent of nicotine was distinctly inferior in insecticidal efficiency to derris-dust mixtures containing 0.5 and 1.0 percent of rotenone, as well as to an undiluted tricalcium arsenate. There was practically no difference between the efficiency of the derris dust containing 0.5 percent of rotenone and that of calcium arsenate, but a derris-dust mixture containing 1.0 percent of rotenone was distinctly superior to the other three materials tested, when applied at intervals of 2 weeks.

Derris powder (4 percent rotenone) at 2 pounds per 100 gallons of water plus about 2 pounds (anhydrous basis) of coconut-oil soap reduced the population 93 percent 24 hours after application. -- C. L. Smith (375) in 1937.

Gunderson (173) in 1938 recommended derris with or without sulfur for the control of cabbage worms, including the imported cabbage worm. Flour, sulfur, pearl dust, gypsum, or other carrier was recommended as a diluent. A 1-percent-rotenone dust is generally strong enough for all needs.

The Louisiana Agricultural Experiment Station (258) in 1938 published a summary of entomological progress in that State. C. E. Smith reported that against the imported cabbage worm derris dusts containing 1.0 and 0.5 percent of rotenone were most effective. Paris green and lime (1:9) was the only other treatment that showed comparative effectiveness.

The New York County Agents' Training School (299) in 1938 discussed the control of insects attacking vegetables. Glasgow, Huckett, Hervey, and others recommended rotenone dusts and sprays for the control of the cabbage looper and the imported cabbage worm as follows: Rotenone dust containing 1 percent of rotenone has proved to be one of the most effective treatments for cabbage worm control. The drawback to the use of this material is its cost, as compared with that of

the lead arsenate treatments. Compared with the lead arsenate spray, rotenone dust will give as good or better immediate kill of both species of cabbage worms, but the lead arsenate spray has a greater residual effect and will, therefore, remain effective on the plants over a longer period. Compared with lead arsenate dust, the rotenone dust gives a better immediate kill and is about equal or better in residual effect. On Long Island rotenone-containing dusts were used largely in 1938 as a substitute for pyrethrum dust, and in the absence of serious cabbage looper attack they provided the needed protection.

The North Central States Entomologists (309) in 1938 discussed the control of certain insects by the use of cube and derris. Compton reported a heavy infestation of cabbage worms in northern Illinois in 1937, including the imported cabbage worm. Control experiments included tests extending over a period of several weeks during the latter part of the summer, with lead arsenate, calcium arsenate, cryolite, cube, pyrethrum, and several proprietary materials, applied by means of a Niagara traction duster with trailer or Bean power sprayer. Rotenone-bearing dusts or sprays, and lead arsenate dusts or sprays gave the best results in these tests. W. H. White remarked that derris and cube dusts satisfactorily controlled the cabbage worm.

Parks and Pierstorff (324) in 1938 recommended rotenone dust for the control of the imported cabbage worm.

Reid and Bare (347) in 1938 reported that against the imported cabbage worm the 0.5-percent rotenone, the 1-percent rotenone, and the derris-pyrethrum dust (0.5 percent rotenone + 0.2 percent pyrethrins) were significantly different and significantly superior to the pyrethrum. Against this species, the 7- and the 10- to 11-day intervals were superior to the 14-day interval.

Roark (357) in 1938 reviewed the comparative action of derris and cube of equal rotenone content on many insects. He referred to List and Sweetman (253) who in 1935 tested cube and derris on Pieris rapae in Colorado and found them to be of equal value when diluted to a rotenone content of 0.5 percent; Howard, who, in a typewritten report to the Division of Truck Crop and Garden Insect Investigations, of the Bureau of Entomology and Plant Quarantine, United States Department of Agriculture, in 1935 stated that cube and derris dusts or sprays gave similar results, provided the rotenone content was the same; and to Campbell, who, in a typewritten report to the same Division, stated that in field tests on cabbage with cube and derris dusts containing 0.5 percent of rotenone, derris destroyed 54 percent of the imported cabbage worms, as compared with 47.7 percent for cube. In 1935 Campbell (63) reported that cube dust was slightly more toxic to the imported cabbage worm than derris dust with an equal rotenone content.

Agicide DC-4 (rotenone 0.6 percent) at the rate of 4 pounds per 100 gallons of water (0.003 percent rotenone in spray) killed from 50 to 100 percent within 96 hours. -- Agicide Laboratories (8) in 1939.

Crosby, Chupp, and Leiby (87) in 1939 recommended a dust containing at least 0.5 percent of rotenone at the rate of 25 to 30 pounds per acre for control.

Haude in advertising literature published by John Powell and Co., New York, N. Y., in 1939 recommended a cube or derris dust (0.5 percent rotenone) at 25 to 30 pounds per acre; or a spray, 5 pounds of powder of 4-percent-rotenone content per 100 gallons of water.

Jones (226) in 1939 recommended derris or cube for control.

Nettles (291) in 1939 recommended derris dust (0.75 percent rotenone) at the rate of 15 to 20 pounds per acre for control in South Carolina.

Smith and Reid (374) in 1939 reported tests against the three common species of cabbage caterpillars, including the imported cabbage worm, using four insecticides, i.e., pyrethrum-talc (1:2); derris-dust mixtures containing 0.5 and 1.0 percent of rotenone, respectively; and a combination of derris-pyrethrum (0.5 percent rotenone and 0.2 percent total pyrethrins), applied at 7-, 10-, and 14-day intervals. The results indicted that pyrethrum was less effective than derris against imported cabbage worm. The combination of derris and pyrethrum was most satisfactory for the three species as a whole, and resulted in the best yields. Although no differences could be detected between the 7- and 10-day applications, it was demonstrated that both were decidedly more effective than the 14-day applications.

The New Zealand Department of Scientific and Industrial Research (305) in 1940 reported that numerous analyses made on ground derris roots at the Dominion Laboratory, to ascertain physical and chemical standards for certification of derris products, have shown that statements made by manufacturers as to the rotenone content are merely relative and that it is necessary to correlate them with some standard method of analysis. Furthermore, it is necessary to consider such a physical property as fineness of division of the dust particles (hitherto ignored in experimental work), since this materially influences coverage and, consequently, disease control.

Speyer et al. (383) in 1940 reported that sprays containing powders made from derris or Lonchocarpus were very effective in rendering foliage of cauliflower and broccoli distasteful to caterpillars of the tomato and cabbage moth. Few caterpillars actually died from contact with the powders or from eating sprayed foliage. The deterrent action of the sprays, however, obviated any serious injury to the plants and also prevented the caterpillars from obtaining sufficient nourishment to enable them to pupate. Caterpillars of Pieris rapae, on the other hand, were usually killed by contact with the powders. Derris powder (proprietary brands containing a spreader) was applied at the rate of 1 pound to 20 gallons of water. Lonchocarpus powder prevented feeding by the caterpillars in small-scale experiments when used at a strength equivalent to 1 pound to 40 imperial gallons of water with 4 pounds of soft soap or 3 to 4 fluid ounces of liquid Agral as a spreader. Saponin, sulfonated lorol, and casein did not wet the foliage of vegetables so adequately as did the soap and Agral.

Pieridae (unidentified sp.)

Kearns (229) in 1934 reported that the larvae of the cabbage butterfly were easily controlled by a derris spray.

Warwick (471) in 1938 reported that derris dust and, preferably, derris spray controlled both the large white butterfly and the small white butterfly on cabbage.

Plutellidae

Plutella maculipennis (Curt.), the diamondback moth

See the Colorado Agricultural Experiment Station (73, 74, 76) on pp.76, 77 , in the United States Department of Agriculture, Bureau of Entomology and Plant Quarantine (437), on p. 70 , Crosby et al. (87), on p. 79 , Hervey and Palm (190) on p. 77 , Huckett (201), on pp. 71, , the Ohio Agricultural Experiment Station (314, 317) on p 74, 75, Roney and Thomas (358) on p. 76 , and White (478), on p. 67 , under Autographa brassicae (Riley).

Bange (22) in 1927 reported the use of a decoction of Derris elliptica roots against caterpillars. Because it is not entirely effective, lead arsenate was mixed with it.

Morgan (283) in 1929 described tests with insecticides in New South Wales at a time when the moth was unusually abundant. After a second application of a proprietary derris compound as a spray it was evident that the plants were not sufficiently protected from the larvae, and further testing of this spray was abandoned.

Jarvis (221) in 1931 recorded comparative tests with Katakilla (2 lb. to 40 imp. gal. of water) and nicotine sulfate (1/2 pt. plus 2 lb. of lead arsenate to 40 imp. gal.). Katakilla killed 80 percent of the pupae and 87.5 percent of the larvae, as compared with 26.6 percent of the pupae and 33.3 percent of the larvae killed by the nicotine and lead arsenate spray. The plants treated with Katakilla were cleaner and better grown.

Andries (13) reporting on the control of plant pests in Southern Africa in 1932, wrote that Derrisol and Katakilla at 1:800 are effective against the diamondback moth near the time of marketing.

The United States Department of Agriculture, Bureau of Entomology (434) in 1933 reported that tests have shown that neither paris green, lead arsenate, nor calcium arsenate will give as effective control of the larvae as will derris dusts containing 1.75 percent of rotenone, applied at the rate of 12 to 15 pounds per acre, or pyrethrum dusts containing 0.12 percent of pyrethrin I and applied at the same rate. Hellebore was found to give better control than the arsenicals but was considerably inferior to the derris and pyrothrum products.

R. E. Campbell, in a typewritten report to the Division of Truck Crop and Garden Insect Investigations of the Bureau of Entomology and Plant Quarantine, stated that he made field tests at San Fernando, Calif., in 1934 with derris and cube dusts containing 0.5 percent of rotenone on cabbage, applying 22 pounds per acre for derris and 30 pounds per acre for cube, by means of hand dusters. Derris destroyed 58.6 percent of the diamondback caterpillars, as compared with 60.5 percent for cube.

Crosby and Chupp (86) in 1934 recommended the application of a dust containing 0.5 percent of rotenone at the rate of 25 to 30 pounds per acre for the control of leaf-eating caterpillars, including this species, on cabbage, cauliflower, brussels sprouts, broccoli, kale, and similar crops on Long Island.

McCampbell (259) in 1934 recommended derris dusts for control on cabbage in Colorado.

Reid (344) in 1934 reported that at Charleston, S. C., derris powder continued to prove toxic to the species of cabbage worms present, including diamondback moths. The degree of control obtained with derris powder was proportionate to the strength of material used. Best control followed the use of a mixture containing 1.5 percent of rotenone. An increase in this concentration to as high as 3.4 percent in 1933 apparently did not increase the kill. A mixture containing only 0.1 percent of rotenone showed some toxicity.

The United States Department of Agriculture, Bureau of Entomology, (435), in 1934 made the same recommendation for the control of diamondback moth on cabbage as for the imported cabbage worm (q.v.).

Walker and Anderson (464) in 1934 reported the following results of tests made in a broccoli field to control larvae of the diamondback moth:

Dust	Rotenone content	Amount applied	Control
	Percent	Ounces	Percent
Derris-talc --------	0.5	53	94
Derris-clay --------	.25	32	75
Derris-clay --------	.5	42	87
Derris-clay --------	1.0	40	90
Kubatox ----------	.4	37	84
Cubor dust ---------	---	31	82
Sprayrite ----------	.43	48	91

Pyrethrum-talc dusts, containing 0.3 or 0.5 percent of pyrethrins, gave poorer control (84 and 85 percent, respectively) than did the derris dusts.

Badertscher and Wotherspoon (19) in 1935 compared the stability of treated and untreated derris and pyrethrum powders in tests made on the larvae of the diamondback moth. Exposure to a light from a Uviarc Mercury vapor lamp operating on 118 volts with a current of 4.8 amperes and 450 watts for 24 hours destroyed about half the toxicity of a derris powder containing 6 percent of rotenone and 18 percent of acetone extractives. Treated powders (treatment not described) prolonged the life of these powders when exposed to light. The authors concluded:

> That derris powder requires at least twice as long as pyrethrum to lose most of its toxicity when exposed to the action of air and sunlight in the summer time.
>
> That the rapidity of the loss of toxicity in pyrethrum powder and in derris powder is largely directly dependent upon the intensity and duration of the light.
>
> That derris powder loses its toxicity relatively much slower than pyrethrum powder when exposed to air in the absence of direct light.
>
> That treated derris powder after exposure to light and air shows an efficiency from 34 to 93 percent greater than untreated derris powder similarly exposed.

The United States Department of Agriculture, Bureau of Entomology and Plant Quarantine (437) reported that at the 1934 meeting of the American Association of Economic Entomologists Cory led a discussion of field results with arsenical substitutes for the control of vegetable insects. Roney and Thomas, of Texas, reported that derris-sulfur dust (0.5 percent rotenone) controlled this species. W. H. White reported that derris and calcium arsenate were approximately equal in effectiveness in controlling the larvae of this moth, whereas pyrethrum, cryolite, and paris green were comparatively less effective. In general, dusts gave better results than sprays. Walker and Anderson, of the Virginia Truck Experiment Station, reported that it was necessary to use 40 to 50 pounds per acre of a derris dust containing 0.75 percent of rotenone in order to control a heavy infestation of larvae on heading broccoli. The Bureau (441) in 1935 reported that field-plot tests on cabbage have shown definitely that derris-dust mixtures containing from 0.5 to 1 percent of rotenone were effective against the common cabbage worm, less effective against the cabbage looper, and still less effective against the diamondback moth. The indications, nevertheless, are that derris powder will be a useful material in the control of all three species. In general, pyrethrum-dust mixtures were less effective than those of derris against all three. The Bureau (442) in 1936 reported that on cabbage, derris and calcium arsenate were approximately equal in effectiveness in controlling the larvae of this species and were more effective than pyrethrum, cryolite, or paris green. Experiments in California demonstrated that dust mixtures of derris, cube, or pyrethrum gave satisfactory results in the control of the three more common species of cabbage worms on cauliflower. In laboratory tests the ground root of devil's-shoestrings, a domestic product, was found to be as effective against the common species of cabbage worms as derris or cube containing equal percentages of active ingredients.

Tischler (413) in 1935 studied the mechanism of how derris kills insects. Studies on the heart rates of various insects (including diamondback cabbage worm) showed that the rate of pulsation was markedly decreased before the insects exhibited incoordinated movements. Other tests made with insects including this species led to the conclusion that derris inhibits oxygen utilization by the tissues and that its detrimental effects are general rather than specific to any organ.

Hervey, Huckett, and Glasgow (189) in 1935 recommended a dust containing 0.5 percent of rotenone, made by diluting derris or cube with talc or clay and used at the rate of 20 to 35 pounds per acre for the control of larvae of this species. A spray consisting of 4 pounds of derris powder (4 percent rotenone) plus 4 pounds of skim-milk powder per 100 gallons of water may also be used.

Houghton and Byrne, in a letter to the Chief of the Bureau of Entomology and Plant Quarantine of the United States Department of Agriculture, in 1935 wrote as follows concerning the use of derris as an insecticide in Australia:

> We have been getting very good control of cabbage moth with derris dust containing no rotenone whatsoever, but with a total of ether extractives in the finished dust of 2.92 percent.

Howard, in a typewritten report to the Division of Truck Crop and Garden Insect Investigations of the Bureau, in 1935 stated that derris root mixed with talc, infusorial earth, or tobacco dust so as to contain from 0.5 to 0.75 percent of rotenone and used at intervals of 7 to 10 days at dosages of 25 to 30 pounds per acre per application was found to be fairly effective against the diamondback caterpillar.

Howard, Mason, and Davidson (197) in 1935 reported that derris dust was fairly effective.

This species is more resistant than Pieris rapae to rotenone dust but may be satisfactorily held in check if the applications are not delayed too long. -- Howard and Mason (196) in 1937.

Dusts containing 0.5 percent of rotenone are effective. -- Huckett and Hervey (204) in 1935.

Morgan (283) in 1935 recommended dusting with lead arsenate plus an equal part of hydrated lime or kaolin until the cabbage begins to heart, then treating with 1 part of finely powdered derris root mixed with 9 parts of talc. He said:

> In the writer's experiments for the control of cabbage moth with a dust consisting of 1 part of finely powdered derris root in 9 parts of talc, 80 percent of the caterpillars on cabbages of various sizes up to the early stages of hearting were destroyed when the dust was applied at the rate of 1 pound to every 400 to 500 plants. In 5 preliminary tests on plots each comprising 10 cabbages,

dusted at weekly intervals beginning 3 weeks after transplanting, the derris dust and a 50-percent lead arsenate dust each gave effective control up to the time when hearting began, the untreated plants in the control plots being heavily infested. The 2 treatments were continued during the late stages of growth, while the hearts were forming, and in each of 5 tests derris proved more effective than lead arsenate on plants approaching maturity. Of a total of 50 cabbages treated, derris gave 47 marketable hearts, lead arsenate 38, and the untreated plants 9.

In field experiments where 4 dustings at 7- to 10-day intervals were applied to cabbages during their early stages of growth, 1 part of finely powdered derris root mixed with 9 parts of talc was not appreciably less effective than a dust consisting of equal parts of lead arsenate and kaolin.

Headlee (186) in 1935 reported effective control on cabbage and cauliflower with a derris dust containing 0.8 percent of rotenone and 2.8 percent of total extractives. This dust consists of 16 parts of ground derris (5 percent rotenone and 18 percent total extractives), 25 parts of sulfur, and the balance clay or talc. Fifteen to 18 pounds per acre were required when applied without hoods and from 8 to 10 pounds when applied with hoods.

The South Carolina Agricultural Experiment Station (381) in 1935 reported that experiments of the 1934-35 season indicated that a derris powder and clay dust mixture containing 0.5 percent of rotenone is approximately as toxic as, and in some cases superior to, undiluted calcium arsenate, to paris green and lime (1:9), and to synthetic cryolite and clay (1:3).

F. L. Thomas (410) in 1935 recommended 1 part of derris containing percent of rotenone mixed with 9 parts of finely ground conditioned sulfur for the control of this species in Texas. In 1936 Mr. Thomas (411) reported that in Texas derris-sulfur dust (0.5 percent rotenone) gave good results in control when applied at the rate of 20 to 25 pounds per acre.

Veitch (457) in 1935 reported that in Queensland derris dusts in preliminary trials gave good results, but have not been so extensively tested as derris spray, which is now recommended in place of lead arsenate because it gives even better control and leaves no injurious residue.

Walker and Anderson (465) in 1935 summarized results obtained with derris and pyrethrum dusts at the Virginia Truck Experiment Station. In 1933 a derris dust containing 0.5 percent of rotenone and a pyrethrum dust containing 0.3 percent of pyrethrins gave satisfactory control of the larvae, while dusts containing 0.25 percent of rotenone and 0.1 percent of pyrethrins did not. In 1934, under conditions of very heavy larval infestation on heading broccoli, it required from 40 to 50 pounds per acre of a derris dust containing 0.75 percent of rotenone, applied with a traction duster, to control this pest. There did not appear to be very much difference between the effectiveness of gypsum, talc, and inert clay, or a finely ground tobacco dust when used as carriers for derris for the control of cabbage worms. A bentonite carrier did not appear to give as

satisfactory results as the other carriers. The addition of 5 percent by weight of finely ground dusting sulfur seemed to improve the effectiveness of a derris-talc dust. Based on rotenone content, a cube dust did not seem to give so satisfactory control of cabbage worms as did a derris dust. In 1936 these authors (461) reported tests made in 1932-36 for the control of cabbage worms. They concluded that repeated applications of derris and cube dusts containing from 0.5 to 0.75 percent of rotenone and from 2 to 3 percent of total extractives, and pyrethrum dusts containing from 0.3 to 0.5 percent of pyrethrins gave good control, whereas weaker concentrations of rotenone and pyrethrins were less effective. Derris and cube dusts having approximately the same rotenone and total-ether-extractive content appeared to be about equally effective. Derris dusts (0.75 percent rotenone) gave 65 percent control of the larvae of the diamondback moth. These results indicated that the imported cabbage worm is as susceptible to derris as the cabbage looper and the larva of the diamondback moth, if not more so. Walker and Anderson (468) in 1937 reported that repeated applications of derris and cube dusts containing from 0.5 to 0.75 percent of rotenone and from 2 to 3 percent of total extractives at 7- to 10-day intervals gave good control of the larvae of the diamondback moth. In 1937 they reported that a derris powder supposed to contain 5 percent of rotenone actually contained 2.19 percent and 9.82 percent of extractives. This test indicated that the nearly full-grown larvae are resistant to derris dust but the newly hatched larvae are susceptible, and that repeated applications of derris dust containing 0.33 percent of rotenone at the rate of 35 pounds per acre at 7 to 10-day intervals will kill the young worms as they hatch, resulting in good control. The resistance of the nearly full-grown larvae probably accounts for the poor control obtained with derris in 1934, as a large percentage of the larvae were nearly full grown at the time the dusting was done. Kale plants infested with newly hatched larvae of the diamondback moth were dusted on October 31 and November 10 at the rate of about 25 pounds per acre with derris-talc and cube-talc dusts containing 0.5 percent of rotenone, both in combination with and without Aresket. The derris-talc, derris-Aresket-talc, and cube-talc dusts gave 82 percent control and the cube-Aresket-talc dust gave 87 percent control, indicated very little difference between the effects of any of the dusts and that either a derris-talc or a cube-talc dust containing approximately 0.5 percent of rotenone and 2 percent of total extractives, if applied when the larvae are young, will give a satisfactory control.

White (480, 481) in 1935 recommended derris dust (0.5 to 1 percent rotenone) and derris spray (0.02 to 0.025 percent rotenone) for the control of the larvae. He also summarized the results obtained by the Bureau of Entomology and Plant Quarantine at Chadbourn, N. C., Charleston, S. C., Baton Rouge, La., and Columbus, Ohio, with nonarsenical insecticides for the control of the four species of cabbage worms, including the diamondback moth:

> Based on the comparative efficiency, at economical strengths, of each of the insecticides tested against each of the principal species of cabbage worms present, the experiments indicated that derris and calcium arsenate were approximately equal in effectiveness in controlling the larvae of the diamondback moth, while pyrethrum, cryolite, and paris green were comparatively less effective for control of this species.

White (482) in 1936 and again in 1937, recommended derris dust containing 0.5 to 1.0 percent of rotenone for the control of cabbage worms on cabbage and cauliflower at a dosage of 15 to 20 pounds per acre. The experiments indicated that derris and calcium arsenate are approximately equal in effectiveness in controlling the larvae of the diamondback moth, while pyrethrum, cryolite, and paris green are relatively less effective. It was found to be especially important to start the treatments early in the development of the cauliflower, since it was not possible to obtain a good coverage over the heavy foliage of nearly mature plants. The experiments on collards in 1934 indicated that each of the three more common species of cabbage worms may be controlled satisfactorily with a derris-dust mixture containing 0.5 percent of rotenone.

Van der Vecht (454) of Buitenzorg, Java, in 1936 reported that tests of derris against this species yielded the same results as against Crocidolomia binotalis.

The New Jersey Agricultural Experiment Station (293) in 1937 reported that derris dusts gave satisfactory results on cabbage worms, including this species.

The New South Wales Entomological Branch (296) in 1936 described the use of derris powder for controlling the larvae. For cabbage and cauliflower, lead arsenate was mixed with an equal part of kaolin, while pure derris powder was mixed with 8 parts of kaolin or talc. On no account should lime be mixed with derris, as it reduces its efficiency.

The Ohio Agricultural Experiment Station (315) in 1936 reported that six of the most promising insecticides (including derris) were tested in 1935 against cabbage worms, including this species. The insecticides were used in various strengths and with different diluents, stickers, and spreaders. The highest percentage (97 percent) of marketable heads was produced on plots sprayed weekly with paris green (2 lb. to 50 gal. of water) in which a sulfated alcohol was used as a wetting agent. Averages of 90 to 93 percent of marketable heads were produced on plots dusted at weekly intervals with derris powder and flour (0.5 percent rotenone). The same station (316) in 1937 reported that the most successful control of cabbage worms, including this species, was obtained from the use of paris green. Paris green sprays (2 lb. per 50 gal.) gave from 81 to 93 percent of marketable heads; paris green dust (1 lb. + 12.5 lb. flour) gave 87 percent; derris dust (1 lb. of 4-percent derris + 7 lb. flour) gave 58 percent; and derris spray (1.5 lb. of 4-percent derris + 2 oz. SS-3 to 50 gal. water) gave 70 percent of marketable heads.

Shropshire and Kadow (369) in 1936 recommended derris and cube for the control of this species. Against cabbage worms these materials are most effective when applied as a dust containing at least 0.5 percent of rotenone late in the afternoon at the rate of 20 to 30 pounds per acre. Applications should be made before the worms become abundant, being repeated at intervals of 10 days to 2 weeks, or as often as necessary to prevent further injury. Unlike metallic poisons, derris products are safe to use on crucifers up to the time of cutting. Derris sprays, while not commonly recommended, can be used for the control of cabbage worms. They should be used according to the manufacturer's directions.

The Texas Agricultural Experiment Station (404) in 1936 reported that derris was considerably more effective than cube against the larvae, regardless of the carrier used, according to tests conducted at Weslaco and Winterhaven in January 1935. The derris mixtures and the cube mixtures were more effective against the larvae of this moth than against the cabbage looper. On the average, derris-sulfur (15:85) or cube-sulfur (15:85) containing 0.75 percent of rotenone gave better control of cabbage worms than either lead arsenate or barium fluosilicate in the lower Rio Grande Valley, the Winter Garden, or Galveston County.

The Colorado Agricultural Experiment Station (76) in 1937 reported that the larvae of this species rank about midway between the imported cabbage worm and the cabbage looper in resistance to pyrethrins and rotenone.

Hutson (209) in 1937 recommended derris dusts or sprays for control.

Kelsall and Stultz (234) in 1937 reported laboratory tests of derris (4 percent rotenone) as a dust. Gypsum was used as a diluent. Results were as follows:

Concentration of derris Percent	Mortality in 1 day Percent
5	0
12.5	40

Craufurd-Benson (85) in 1938 reported that experiments were made in breeding this species in a greenhouse, under standardized conditions for use as a test insect for evaluating derris insecticides by the author's dipping method. The result was a failure, because larvae of the same age showed wide variation in size and instar, and even with careful grading for size and age the results were still unreliable.

Dibble, of the Michigan Agriculture Extension Service, in a "bug flash" in 1938, recommended pyrethrum or derris dusts or sprays for control on cauliflower and cabbage.

Gui (172) in 1938 reported that for protection against cabbage worms, including this species, the cabbage should be dusted or sprayed at 10-day intervals with paris green or derris powder. Derris-powder dusts should contain not less than 0.5 percent of rotenone. One pound of derris powder (4 percent rotenone) should be used to 7 pounds of the diluent. Desirable diluents are flour, talc, diatomaceous clay, dusting gypsum, and finely ground tobacco stems. Derris-powder sprays should consist of 1.5 pounds of derris powder containing 4 percent of rotenone in 50 gallons of water. When other grades of derris powder are used, dosage should be so calculated that the spray contains 0.015 percent of rotenone. A spreader and sticker should be used. Federal regulations prohibit excessive residues of poison on marketed cabbage; therefore, paris green should not be applied after the heads begin to form. Derris powder may be used after that date or throughout the season if desired. There are no regulations concerning residues of rotenone on fruits and vegetables.

The Louisiana Agricultural Experiment Station (258) in 1938 published a summary of entomological progress in that State. C. E. Smith reported that against the larva derris dust (1.0 percent rotenone) and undiluted calcium arsenate were about equal in effectiveness and were superior to the other treatments.

Water suspensions and alcoholic extracts of Derris elliptica grown at Bangalore, India, were effective. -- Mysore, India, Department of Agriculture (287) in 1938.

The North Central States Entomologists (309) in 1938 discussed the control of certain insects by the use of cube and derris. Compton reported that there was a heavy infestation of cabbage worms in northern Illinois in 1937, including this species. Control experiments included tests with lead arsenate, calcium arsenate, cryolite, cube, pyrethrum, and several proprietary materials, applied by means of a Niagara traction duster with trailer or Bean power sprayer. Tests were extended over a period of several weeks late in the summer. Rotenone-bearing dusts or sprays and lead arsenate dusts or sprays gave the best results. W. H. White remarked that derris and cube dusts control Plutella to some extent, if treatment is applied while the worms are in the younger stages.

Parks and Pierstorff (324) in 1938 recommended rotenone dust for the control of this species.

Reid and Bare (347) in 1938 reported that against this species the 1-percent rotenone and the derris-pyrethrum dust mixture (0.5 percent rotenone plus 0.2 percent pyrethrins), at 7- or 10- to 11-day intervals between applications, were most effective.

Roark (357) in 1938 reviewed the comparative action of derris and cube of equal rotenone content of many insects. Reference was made to Campbell, who in 1934, in a typewritten report to the Division of Truck Crop and Garden Insect Investigations, of the Bureau of Entomology and Plant Quarantine of the United States Department of Agriculture, stated that derris dust (0.5 percent rotenone) destroyed 58.6 percent and cube dust 60.5 percent of the diamondback moth caterpillars. He also referred to Walker and Anderson (465), who in 1935 reported that cube dust did not seem to give quite so satisfactory control of these larvae as did a derris dust, but in 1937 they (469) reported that a derris-Aresket-talc dust gave 82 percent control and a cube-Aresket-talc dust of the same (0.5 percent) rotenone content gave 87 percent control. The dusts were applied at the rate of about 25 pounds per acre.

The Division of Control Investigations, Bureau of Entomology and Plant Quarantine, United States Department of Agriculture (444) in 1938 reported results of tests with derris and cube on certain insects as follows:

Material	Test insect Diamondback cabbage worm	Dosage per cm.^{2}	Mortality in 48 hours
		Micrograms	Percent
Derris (rotenone 5.4 percent; total extractives 15.5 percent) as a dust	Fourth instar	140	100
	Second instar	140	100
Derris-talc dust (rotenone 1 percent)	Fourth instar	170	100
	Second instar	170	100
Derris-talc dust (rotenone 0.5 percent)	Fourth instar	140	100
Cube (rotenone 4.4 percent; total extractives 20.7 percent) as a dust	Fourth instar	140	100
	Second instar	140	100

M. l. d. of derris and cube powders in 48 hours

Insect	Instar				
	Fifth	Fourth	Third	Second	First
Diamondback cabbage worm	---	140 (0.5)	---	140 (0.5)	---

Agicide DC-4 (rotenone 0.6 percent) at the rate of 4 pounds per 100 gallons of water (0.003 percent rotenone in spray) killed from 50 to 100 percent within 96 hours. -- Agicide Laboratories (8) in 1939.

In experiments with insecticides derris dust (1 percent rotenone) or paris green plus wood ash (2:15) gave 99- to 100-percent mortality of the larvae. Paris green is cheaper than derris, but is dangerous to use and stains the vegetables. Pyrethrum powder (1.3 percent pyrethrins) plus wood ash (1:6) gave almost as good results. The pyrethrum had a more rapid effect on the larvae than the derris, but did not protect the plants so long. The insecticides should be applied four times at weekly intervals and at the rate of 22-1/2 pounds per acre. -- Ghesquiere (158) in 1939.

Haude, in advertising literature published by John Powell and Co., New York, N. Y., in 1939 recommended cube or derris dust (0.5 percent rotenone) at 25 to 30 pounds per acre or spray (5 pounds of powder of 4 percent rotenone content) per 100 gallons of water.

Nettles (291) in 1939 recommended derris dust (0.75 percent rotenone) at the rate of 15 to 20 pounds per acre.

Smith and Reid (374) in 1939 reported tests against the three common species of cabbage caterpillars, including the diamondback moth, using four insecticides, i.e., pyrethrum-talc (1:2); derris-dust mixtures containing 0.5 and 1.0 percent of rotenone, respectively; and a combination of derris-pyrethrum (0.5 percent rotenone and 0.2 percent total pyrethrins), applied at 7-, 10-, and 14-day intervals. The results indicated that pyrethrum was less effective than derris for control of diamondback moth. The combination of derris and pyrethrum was most satisfactory for the three species as a whole, and resulted in the best yields. Although differences could be detected between the 7-day and the 10-day applications, it was demonstrated that both were decidedly more effective than the 14-day applications.

H. T. Pagden (322) in 1931 stated that neither derris sprays, with or without agral, nor pyrethrum sprays or dusts gave satisfactory control of Plutella on cabbages. Nicotine extract, 0.05 percent, gave better results.

The New Zealand Department of Scientific and Industrial Research (305) in 1940 reported that tests at Owairaka showed that best control of this pest on cabbages was obtained with derris dusts, which proved to be more efficient than nicotine sulfate spray or lead arsenate and calcium arsenate sprays. Arsenates when applied as dusts gave unsatisfactory results.

Psychidae

Clania (Cryptothelea) minuscula Butl.

Yago (502) in 1933 wrote that this species, formerly abundant in pear orchards in Shizuoka, Japan, had become scarce, probably owing to the use of insecticides, including derris.

Thyridopteryx ephemeraeformis (Haw.), the bagworm

Hamilton (180) in 1938 reported that in only one out of four tests were bagworms on evergreen trees satisfactorily controlled by a cube or derris spray (4 lb. of powder containing 4 percent rotenone plus 4 lb. of rosin-residue emulsion per 100 gal. of water). The spray acts as a repellent. The period of effectiveness was 3 to 4 days. Bags do not fall off the trees, but larvae cease feeding and do not increase in size.

Psychidae (unidentified sp.)

The Institute of Physical and Chemical Research (214) Tokyo, Japan, in 1927 reported that Neoton, 1 pound in 60 imperial gallons of water, warded off an attack by larvae of the pear bagworm for 7 days. Upon invading the field sprayed as above with Neoton, 20 percent of the larvae were killed by the internal action of the drug.

Bagworm larvae, not more than two-thirds grown, were controlled, apparently by repellent action, by derris or cube powder in water to which rosin-residue emulsion had been added. -- New Jersey Agricultural Experiment Station (294) in 1938.

Pterophoridae

Pterophorus periscelidactylus Fitch, the grape plume moth

(Oxyptilus) Pterophorus periscelidactylus readily controlled by spraying with 3 pounds of ground derris or cube (4 percent rotenone) and 1 pound of powdered skim-milk in 100 gallons of water. -- Haude, in advertising literature published by John Powell and Co., New York, N. Y., in 1939.

Pyralididae

Acrobasis caryae Grote, the pecan nut casebearer

Moznette (285) in 1935 reported that sprays containing pyrethrum and derris extracts produced very unsatisfactory results against this species in the Southeast in 1932 and 1933.

Homalopalpia dalera Dyar

Wolfe and Lynch (497) in 1940 reported that spraying for control of the papaya webworm is difficult because the web soon fills with excreta. A strong pyrethrum spray, or a rotenone spray, gives fair control if applied with enough pressure to drive away the web. The webbing may be removed with a feather to give the spray free access to the stem and fruit.

Pyraustidae

Crocidolomia binotalis Zell.

Van der Vecht (454) in 1936 reported tests of derris against this species, which is a serious pest of cabbage in Java. Tests in the field with derris dusts containing 0.5 percent and 1.0 percent of rotenone gave excellent results. The dust was applied once a week from a small tin, closed with a piece of cheesecloth, or by means of a hand duster. The dusted plots yielded about three times as much as the untreated plots and twice as much as a plot where the caterpillars had been regularly destroyed by hand-picking. About 5 to 6 pounds of dust are required for 100 cabbages during the entire growth period, but where infestation is less severe, the number of applications may perhaps be reduced. Spraying with derris powder in water (rotenone 1: 2,860 to 1:10,000) was less satisfactory than dusting.

Merino and Otanes (273) in 1938 recommended derris powder for the control of these cabbage caterpillars in the Philippines.

Desmia funeralis (Hbn.), the grape leaf folder

Dickey and Loucks (98) in 1938 recommended derris spray for control in Florida.

Diaphania hyalinata (L.), the melon worm

D. nitidalis (Stoll), the pickleworm

Reid (343) in 1933 reported that in tests made in Charleston, S. C., derris dust, mixed with tobacco dust to give a 1.5 percent rotenone content, is particularly effective against the melon worm and the pickleworm. In a series of plots in which derris, cryolite, pyrethrum, paris green, lead arsenate, and calcium arsenate were used, effective control was obtained in the order given. The derris plot produced 765.5 pounds of sound fruit, as compared with 86.5 pounds of sound fruit produced on the calcium arsenate plot. The derris plot produced over 100 pounds more of sound fruit than did the cryolite plot, which was next in effectiveness. The check plot produced no sound fruit.

The United States Department of Agriculture, Bureau of Entomology and Plant Quarantine (435) in 1934 issued the following recommendations for the control of some important truck-crop insects:

> The indications are that the melon- and pickleworms may be satisfactorily controlled by dusting with a derris-powder mixture containing from 0.5 to 1.5 percent of rotenone. In light infestations the 0.5 percent dust should be sufficient if applied early and regularly. Where the infestation is heavy the 1 percent or the 1.5 percent dusts should be used. Sulfur seems to be the most effective diluent for melon worms and pickleworms, possibly because of some action against young larvae. The addition of from 10 to 25 percent of talc, clay, or wheat flour or finely ground tobacco dust to the derris-sulfur mixture will improve its dusting qualities.
>
> The treatments should begin when the worms first appear on the leaf buds of the squash plant, which may be within a week or 10 days after the plants appear above ground, and should be continued at 7- to 10-day intervals as long as the worms are present or the crop is being harvested. The rate of application will depend on the size of the plants, and should range from 15 to 25 pounds per acre. Extreme care should be exercised to see that the growing tips of the plants are well covered with the dust as the worms feed extensively on the young leaf buds before tunneling into the fruit, stem, and vines.
>
> There are several leaf-feeding forms which may attack lettuce and spinach, and on occasions cause considerable damage. Pyrethrum or derris is recommended as a substitute for the arsenicals in order to safeguard the health of the consumer.

The Alabama Polytechnic Institute, Agricultural Experiment Station (10) in 1935 issued information on the use of derris in controlling garden insects. Derris-sulfur dust (at least 1.0 percent rotenone) gave fair results in controlling pickleworms and melon worms in squash, cucumbers, and cantaloups. As a spray, 4 pounds of derris (4 percent rotenone) should be used per 100 gallons. Directions are given for applying derris dust to squash, cucumbers, and cantaloups (15 to 25 pounds per acre per application.

White (480) in 1935 recommended derris-sulfur dust (1 to 1.5 percent rotenone) for combating the pickleworm and the melon worm. In 1936 and again in 1937 he (482) wrote that the indications are that the melon worm and the pickleworm may be controlled satisfactorily on squash in the coastal areas of North Carolina and South Carolina, and probably elsewhere, by dusting with a derris-sulfur mixture containing from 1.0 to 1.5 percent of rotenone.

Haude in advertising literature published by John Powell and Co., New York, N. Y., in 1939 recommended to dust with cube or derris plus sulfur (rotenone 1.0 to 1.5 percent) at 15 to 25 pounds per acre.

Nettles (291) in 1939 referred to results obtained by the Bureau of Entomology and Plant Quarantine, which reported promising control of these worms on late squash with a derris-sulfur mixture. The mixture contained from 1.0 to 1.5 percent of rotenone. From 10 to 25 pounds per acre of the mixture were applied at 7-day intervals, beginning about 1 week after the plants came up and continuing as long as worms were present.

Arant (14) in 1940 reported that derris-talc dusts containing 1 percent of rotenone were effective in controlling the pickleworm and the melon worm on small field plots; the control in cantaloups ranged from 83 to 100 percent and in squash from 89 to 100 percent. A derris dust containing 25 percent of sulfur was effective against the insects but caused such severe burning to cantaloup foliage that an average of one-third fewer edible fruits were produced than on the untreated checks; plants treated with derris-talc mixtures produced 10 times as many fruits as the checks. Derris mixtures containing 0.5 percent of rotenone were less effective than dusts containing 1 percent of rotenone. Cube appeared to be inferior to timbo and derris. Heavy applications of dusts were made, approximately 15 to 30 pounds to the acre, and no attempt was made to determine the minimum effective rate of application.

Evergestis rimosalis (Guen.), the cross-striped cabbage worm

The Division of Control Investigations, of the Bureau of Entomology and Plant Quarantine, United States Department of Agriculture (444) in May 1938 reported results of tests with derris and cube on the cross-striped cabbage worm as follows:

Material	Instar	Dosage per cm.^{2}	Mortality in 48 hours
		Micrograms	Percent
Derris (rotenone 5.4 percent; total extractives 15.5 percent) as a dust	First	110	100
	Fourth	110	100
Derris (rotenone 4.5 percent; total extractives 19 percent) as a dust	First	120	100
	First	120	100 (72 h
Derris-talc dust (rotenone 1 percent)	Fourth	170	83
	First	170	100
Derris-talc dust (rotenone 0.5 percent)	Fourth	185	23
	First	185	100
Cube (rotenone 4.4 percent; total extractives 20.7 percent) as a dust	Fourth	125	100
	First	125	100

M. l. d. of derris and cube powders in 48 hours

Instar				
Fifth	Fourth	Third	Second	First
---	110(5)	---	---	185(0.5)

The same Division (445) in August 1938 issued its third report of tests on the insecticidal value of various compounds. Derris (rotenone 5.4 percent, total extractives 15.5 percent) at 230 micrograms per cm.^{2} gave 100-percent mortality of fourth instars in 48 hours.

Hymenia fascialis (Cram.), the Hawaiian beet webworm

The Bermuda Department of Agriculture (33) in 1934 reported that derris spray (Katakilla) adequately controlled a mild attack of the beet fireworm in the field.

Fenton (129) in 1936 quoted the following from a letter dated December 10, 1935, from Roney, of the Texas Truck Crop Experiment Station, Dickinson, Tex.:

> "Our experiments seem to bear out the fact that early applications of the three-way dust (10 percent cube, 15 percent 'A' dust, 75 percent sulfur) are very beneficial in controlling the insect. Due to the fact that it has such a web, also because of the number of larvae on each plant, we find it very difficult to control."

Haudo in advertising literature published by John Powell and Co., New York, N. Y., in 1939 referred to the successful control of this species in Texas with a dust containing 10 parts of cube, 15 parts of Stimtox "A", and 75 parts of sulfur.

Walker and Anderson (470) in 1940 reported that several tests had been conducted with dusts containing calcium arsenate and hydrated lime and with rotenone-bearing dusts at Norfolk, Va., in the preceding 5 years. In these tests, even though the spinach leaves appeared to be well covered with the dusts, none of the materials gave satisfactory control. Occasionally the worms disappeared without seriously damaging the spinach, which probably accounts for many of the reports that the calcium arsenate dusts gave good control of this pest.

Hellula undalis (F.), the cabbage webworm

Watanabe (474) in 1927 recommended spraying the young growth of cruciferous vegetables with derris to combat this species in Japan.

At the 1934 meeting of the American Association of Economic Entomologists, as reported by the United States Department of Agriculture, Bureau of Entomology and Plant Quarantine (437), Cory led a discussion of field results with arsenical substitutes for the control of vegetable insects. White reported derris to be effective against the cabbage webworm. In general, dusts gave better results than sprays. The Bureau (435) in 1934 stated that the preferred dust for the control of the webworm on cabbage is derris or other rotenone dust and that the preferred spray is combined pyrethrum-derris extract.

Veitch (457) in 1935, reporting on tests made in Queensland, stated that derris was effective against the larva, which tunnels in the stem of cabbage.

White (481) in 1935 summarized the results obtained by the Bureau of Entomology and Plant Quarantine at Chadbourn, N. C., Charleston, S. C., Baton Rouge, La., and Columbus, Ohio, with nonarsenical insecticides for the control of the cabbage webworm. Derris gave the best results. Applications were begun when the worms first appeared on the plants. White (482) in 1937 reported that results of experiments in 1936 indicated that the cabbage webworm can be controlled by applications of dust containing 0.5 percent of rotenone, provided applications are made during the early stages in the growth of both insects and plants, and the plants are covered thoroughly with the dust.

Walker and Anderson (467) in 1936 reported tests made in 1932. A derris extract containing 5 gm. of rotenone per 100 cc. of solution, used at the rate of 1 part by volume to 200 and to 400 parts of water containing 0.5 percent of Red A soap, gave only 11 and 9 percent control, respectively. Dusts containing 50 percent by weight of calcium arsenate, 25 percent of cryolite, 25 percent of Dutox, 5 percent of paris green, and 0.4 percent of rotenone gave from 10 to 21 percent control.

C. E. Smith (373) in 1937 reported tests made at Baton Rouge, La. In field experiments involving several species of cabbage worms, principally Autographa brassicae (Riley), Hellula undalis (F.), and Pieris rapae (L.), a dust mixture of peat moss containing 2 percent of nicotine was distinctly inferior in insecticidal efficiency to derris-dust mixtures containing 0.5 and 1.0 percent of rotenone, and also to an undiluted tri-calcium arsenate.

There was practically no difference between the efficiency of the derris dust containing 0.5 percent of rotenone and that of calcium arsenate, but a derris-dust mixture containing 1.0 percent of rotenone, applied at intervals of 2 weeks, was distinctly superior to the other 3 materials tested.

Haude in advertising literature published by John Powell and Co., New York, N. Y., in 1939 recommended cube or derris dust (0.75 percent rotenone) at the rate of 15 to 20 pounds per acre for the control of the cabbage webworm in South Carolina.

Lineodes integra Zell.

Compton (77) in 1937 reported on this species, a potential pest of greenhouse tomatoes. Greenhouse tests were made with a 0.5 percent rotenone dust composed of 10 pounds of ground derris root having a rotenone content of 5 percent and 90 pounds of talc. This dust was effective in holding the insect in check, but did not give so complete control as did the 85:15 sulfur-lead dust.

Loxostege commixtalis (Walk.), the alfalfa webworm
L. sticticalis (L.), the sugarbeet webworm

McCampbell (259) in 1934 recommended derris dusts for the control of these species on cabbage in Colorado.

Maruca testulalis (Geyer), a bean pod borer

See United States Department of Agriculture, Puerto Rico Experiment Station (450) under Etiella zinckenella (Treit.), on page 101.

The United States Department of Agriculture, Bureau of Entomology and Plant Quarantine (442) in 1936 reported that derris was tested on three species of pod borers attacking beans in Puerto Rico, but was less effective than fluorine compounds and none of the insecticides tested to date could be recommended.

Nymphula depunctalis (Guen.)

The Federated Malay States Department of Agriculture (120) in 1922 reported that for dealing with the rice case-worm in the padi nurseries spraying was being carried out with a decoction of tuba root.

Sison (371) in 1938 recorded laboratory tests as follows: Larvae with their cases were collected from the field and placed in 3 separate containers each with water having a volume of about 200 cc. and a surface area of about 0.11 square meter. Grass was also placed in each container. Twenty-two larvae were placed in the first container and 25 each in the second and third. The first container was dusted with 0.2 gm. of derris powder (rotenone, 3.09 percent); the second with 0.13 gm.; and the third with 0.1 gm. The dust covered the surface of the water. With the 0.2 gm. all the larvae died after about 5 hours, whereas in the last two treatments it was about 22 hours before all died. In another trial the derris powder was put in the water, then the whole was stirred well before the larvae were placed, so as to get readily the soluble substance from the powder.

The strengths used were 0.1 gm. and 0.05 gm. per liter of water. Twenty larvae were used in each test. In the first all the larvae died after about 4 hours; and in the second, after about 5 hours. Dusting the infested plants with calcium arsenate, draining the water from the infested paddies, and applying a thin film of kerosene over the water to control the larvae gave encouraging results. Preliminary trials, under laboratory conditions, with derris powder also gave encouraging results, warranting further trials in the laboratory and in the field.

Pachyzancla licarsisalis (Walk.)

The Federated Malay States Department of Agriculture (125) in 1937 reported that the caterpillars inflicted severe damage to Bermuda, Blue Couch, and other grasses in experimental plots. A derris spray was effective in controlling them.

Phlyctaenia rubigalis (Guen.), greenhouse leaf tier, or celery leaf tier

Howard (194) in 1933 reported tests to control this insect on celery in storage houses near Sandusky, Ohio. Dipping the celery in various concentrations of pyrethrum and derris extract was not feasible, because of demands that the celery be kept dry. It was decided that shaking was probably the most satisfactory control.

Stahl (390) in 1934 reported derris dust not toxic to the leaf tier. A single test yielded the following results:

Rotenone in dust	Larvae killed in 6 days --		
	Quarter-grown	Half-grown	Mature
Percent	Percent	Percent	Percent
0.1	8.7	0	0
0.5	6.7	0	0
1.0	16.6	1.8	0
3.0	41.3	7.2	0

No noticeable effects resulted from the use of any of the dilutions against the larger larvae, and even the 3-percent dust gave unsatisfactory results against the small larvae.

The United States Department of Agriculture, Bureau of Entomology (436) in 1934 reported that additional tests have shown rather definitely that rotenone compounds are not effective, and that pyrethrum is apparently a specific poison for the pest.

In 1935 the United States Department of Agriculture, Bureau of Entomology and Plant Quarantine (441) reported that toxicity tests in the laboratory showed that this insect is not affected by derris powder.

Derris is ineffective against this insect. -- Hutson (208, 209) in 1936 and 1937.

The United States Department of Agriculture on January 13, 1936, published a press release which called attention to certain disadvantages that bar the use of rotenone insecticides for some types of insects. Derris is not effective against all insects, e.g., the celery leaf tier.

Howard and Mason (196) in 1937 reported that derris or cube was ineffective against this insect.

The Massachusetts Agricultural Experiment Station (270) in 1937 reported that derris and pyrethrum were tested for control of the greenhouse leaf tier on snapdragons in two separate experiments on greenhouse grown plants. Commercial pyrethrum sprays diluted 1:200 and 1:400 and applied at approximately 10-day intervals gave good control. A derris extract containing 1.5 percent of rotenone was also satisfactory. Derris-powder washes (2 lb. and 3 lb. in 50 gal.) permitted 66 percent of moderate or severe injury and were surprisingly unsatisfactory. Derris and pyrethrum clay dust diluted with inert clay were less effective than the liquid spray and left a very objectionable residue on the plants, which generally eliminates these dusts from commercial use on snapdragons.

Parks and Pierstorff (324) in 1938 wrote as follows: "Apply two pyrethrum or rotenone sprays within 30 minutes. The first brings them out of heart leaves and the second kills them."

Pionea forficalis (L.)

Miles (277) in 1931 wrote on the garden pebble moth, which is a pest of cabbage, cauliflower, and allied cruciferous plants in England. A spray can be used for controlling the larvae of the pest in plants so long as the center or heart of the plant is loose and open; soap and nicotine spray or a spray containing derris extract, forced well into the plants and played on the undersurfaces of the leaves, should be satisfactory.

Pyrausta aurata meridionalis (Stgr.)

Bremond and Rungs (49) in 1938 reported that in Morocco experiments using sweetened-bait traps gave poor results. A commercial insecticide containing rotenone 3 percent, powdered soap 67 percent, and inert matter 30 percent, applied as a 2-percent spray 4 days after the beginning of adult flight and again 8 days later, gave good control. Equally good results were obtained with a commercial rotenone-containing dust.

Pyrausta nubilalis (Hbn.), the European corn borer

Worthley (501) in 1929 reported that derris powder was ineffective against eggs of the European corn borer laid on potted corn plants, but would be given further trial as a larvicide.

The United States Department of Agriculture (425) in 1930 stated that rotenone was being tested against the European corn borer. According to a press release of the Department, dated March 11, 1938, derris spray is a promising insecticide for control of the European corn borer on early market sweet corn. It must be applied during the comparatively brief period the caterpillar spends on the outside of the plant. The Department on April 23, 1938, announced in a press release that several new insecticides recently developed by the Department gave effective and practical borer control for early crops. These insecticides--nicotine tannate spray, derris spray, phenothiazine spray, and a nicotine dust--mixed with suitable spreaders, must be applied to plants as soon as the borer eggs begin to hatch, before the young caterpillars have had time to find shelter beneath leaf sheaths and inside corn husks or stalks.

Campbell (60) in 1932 reviewed previous work on rotenone. Worthley tested rotenone as a dust (with talc as a carrier) against the European corn borer. A certain number of eggs (from 598 to 679) were seeded into each of four plots of sweet corn, which were then dusted as follows: (1) with 5 percent of rotenone, (2) with 1 percent of rotenone, (3) with 0.33 percent of rotenone, and (4) with pure talc. On the check plots 2,450 eggs were placed. Six larvae, or 0.88 percent of the number of eggs, were found in (1); 44, or 7.12 percent, in (2); 52, or 8.55 percent, in (3); and 50, or 8.36 percent, in (4). In the check plots 305, or 12.51 percent, were recovered. Only the 5-percent rotenone dust was markedly effective.

Ficht (132) in 1933 reported that in Indiana, two applications of a proprietary pyrethrum soap (pyrethrum = 1.82 gm. per 100 cc.) at a concentration of 1:400, together with rotenone at 1:40,000, reduced the number of larvae 53.6 percent. Lead arsenate (3 applications each at the rate of 4 lb. per 100 gal.) reduced the number 47.8 percent. A proprietary derris extract [Derrisol?] when added to an oil emulsion only slightly increased its effectiveness in reducing larval infestation.

Batchelder, in a typewritten report to the Division of Cereal and Forage Insects, Bureau of Entomology and Plant Quarantine, United States Department of Agriculture, in 1936, reported that derris spray (4 lb. of 4-percent powder per 100 gal. plus butyl phenyl phenol sodium sulfonate at 1:2,500) and derris dust (1 percent rotenone) were tested against second-generation borers infesting dahlias at Milford, Conn., in August 1936. The derris spray reduced the population 82.1 percent; the dust 72 percent. Phenothiazine and nicotine preparations were equally good. In November 1936 he reported tests against European corn borer in seed sweet corn at Milford. Derris dust (1 percent rotenone) reduced the population 56.3 percent, being somewhat less effective than dual-fixed nicotine as a dust (66.1 percent) or as a spray (64.1 percent reduction). Batchelder in 1937 reported that the corn borer population in ears of early market sweet corn in Connecticut, when treated with derris spray (4 lb. of 5-percent powder per 100 gal.) under commercial conditions, was reduced 78 percent. Batchelder (25) in 1938 reported that in 1937 at New Haven derris spray reduced the corn borer population in ears of early market sweet corn 77 percent. Cube dust reduced the population infesting dahlias in experimental plots about 90 percent. In August 1939 he (26) reported that derris spray (rotenone 0.023 percent; made by adding 4 lb. of derris powder to 100 gal. of water) containing Ultrawet 0.062 percent reduced infestation 82.2 percent in the plants and 80.6 percent in the ears of early market sweet corn, infested with the first generation at New Haven in 1937.

Batchelder and Questel (27) in 1937 described experiments with insecticides at Berkley, Mass., and at New Haven, Conn., for control of the borer in early market sweet corn. Derris (2 lb. of powder containing 4 percent rotenone to 50 gal. of water) plus a suitable spreader (e.g., sodium lauryl sulfate 3 oz. per 50 gal.) was recommended. Other suitable spreaders are ammonium-sulpho soap, sodium-sulpho soap (4 oz. per 50 gal.), or sulfonated alkylated diphenyl, dry powder (3 oz. per 50 gal. of spray). In 1938 these authors (29) recommended derris, phenothiazine, and nicotine tannate for the control of the European corn borer in dahlias. Derris powder (4 percent rotenone) should be used at the rate of 4 pounds per 100 gallons, to which may be added 32 ounces of liquid measure of a spreader such as Areskap, Ultrawet, and SS-3. They also stated (28) that, in controlling the borer in dahlias, derris powder (4 percent rotenone) may be used as a mixture in spray water to which has been added a spreader as described in 1937. For 50 gallons of spray, 2 pounds of ground derris-root powder was stirred with a small quantity of spray water until the powder was thoroughly wetted and in the form of a thin paste. This paste was then added to the spray water, and the mixture agitated to obtain complete dispersion of the derris.

Questal in a typewritten report to the Division of Cereal and Forage Insect Investigations, Bureau of Entomology and Plant Quarantine, United States Department of Agriculture, in 1937 reported on the effect of nicotine- and derris-treated surfaces on newly hatched larvae. Sheets of paraffined paper 9 inches by 11 inches were covered lightly with the following materials, using Bancroft clay as a carrier: (1) Dual-fixed nicotine (4 percent nicotine), and (2) ground derris (0.6 percent rotenone). Two sheets dusted with these materials were left dry while two more were sprayed with water to dampen the dust, and allowed to dry. A dry sheet was dusted with Bancroft clay, and a sheet on which there were no materials served as a check. Approximately 160 eggs of the European corn borer, in the black-head stage, were placed in the center of each sheet and allowed to hatch in a room of constant temperature (75° F.) and high relative humidity (80-90 percent). After 40 hours in the incubator room the sheets were examined. The results are shown in the following table.

Material	Eggs		Dead larvae	Greatest distance traveled from hatching point by any one larva
	Placed on paper	Not hatched		
	Number	Number	Number	
Dual-fixed nicotine	169	31	138	Not more than 1 inch.
Dual-fixed nicotine dampened and dried	171	1	10	Many had completely gone; the remainder were scattered all over the sheet.
Ground derris	153	1	153	Not more than 1 inch.
Ground derris dampened and dried	155	1	49	Many had completely gone; the remainder were scattered all over the sheet.
Bancroft clay	156	2	143	Not more than 3 inches.
No treatment	158	1	0	All had left the sheet.

The mechanical effect of the clay dust on the larvae was fatal, although it allowed them to travel farther than the dual-fixed nicotine or the derris dusts. The dual-fixed nicotine apparently acted as an egg destroyer, but in this particular case the egg mass had been placed face downward on the dusted surface. In a season when rainfall is not excessive a dust such as dual-fixed nicotine, applied just before hatching and kept on the plant during the hatching period, should give good results.

Questal in September 1937, in a typewritten report to the Division of Cereal and Forage Insect Investigations, stated that early market sweet corn was completely tolerant to derris spray and derris dust. In another typewritten report to the Division, he said that derris spray (4 lb. per 100 gal.), containing 0.0235 percent of rotenone, gave high control on Golden Cross Bantam corn at Maumee, Ohio, in 1937. Derris dust (0.98 percent rotenone) plus sodium butyl hydroxy phenylbenzenesulfonate 1:3,000 was equal to a dust of dual-fixed nicotine but inferior to derris spray. The plants were completely tolerant to both derris sprays and dusts. In 1937 Questel stated in a similar report that various fluorine compounds compared favorably with derris as a spray on early sweet corn in the vicinity of Toledo, Ohio. In a similar report in 1938, he said that ground derris was outstanding among the sprays used at Toledo. Very good control was obtained, as well as complete freedom from spray injury to the sweet corn plant. When applied by hand with a single nozzle, this spray appeared to be satisfactory for use in the Lake States. The labor cost of application by this method is high, however, and types of booms tested, although reducing the labor cost, did not allow sufficient quantities of the spray to enter the whorl of the corn plant, therefore the control was lessened. The derris powder was used at the rate of 4 pounds per 100 gallons of water and contained 4 percent of rotenone. Derris dust (1 percent rotenone) was less effective. Ground derris (four applications at 5-day intervals starting with first hatching) was outstanding among the sprays tested in 1938 and provided a very satisfactory control when applied with a hand nozzle.

Questel (341) in 1938 again reported that ground derris (4 lb. per 100 gal. of water) was the outstanding spray used in the Lake States. With this spray, 97.8 percent of the No. 1 ears in the treated plots were borer-free, as compared with 68.4 percent in the nontreated plots, and the borer population in the treated plots was reduced 89.3 percent from that in the nontreated plots. A report on Questel's (342) experiments of 1938 in the Lake States was published in 1940, giving the results stated above. Sprays and dusts of two fluorine compounds and phenothiazine spray also gave good control and were about equal in their effectiveness. The fluorine compounds, however, caused severe burning of the corn plants. Both standard nicotine tannate (0.0625 percent nicotine) and Quebracho nicotine tannate (0.0625 percent nicotine) sprays were low in insecticidal performance in the Ohio tests.

Batchelder, Questel, and Turner (30) in 1937 reported good control with derris spray, but derris dust was unsatisfactory. As a spray finely powdered derris (rotenone 4 percent) was used at the rate of 4 pounds per 100 gallons of water, with ammonium-sulpho soap 0.075 percent and butyl phenyl-phenol sodium sulfonate 0.03 percent as spreading agents. In dust form, 1 part of derris to 8 parts of talc was used to obtain a content of approximately 0.4 percent rotenone. In 1936 cube was diluted with talc to a rotenone content of 0.8 percent and applied as a dust. In the dusts, butyl phenyl-phenol sodium sulfonate 0.03 or 0.1 percent was used as an adhesive. In sprays ground derris (rotenone 0.02 percent) was more effective than an acetone extract of derris of the same rotenone content. Ground derris applied to corn in a dust (talc) carrier in 1935 was less effective (63 percent) than when applied in adjacent plots as a spray (88 percent). The results obtained in 1936 indicated that (A) the effectiveness of derris dust, when the rotenone content was 0.4, 0.6, or 0.8 percent, did not increase consistently with the rotenone content; and (B) all of these derris dusts gave a reduction in the borer population infesting the plants approximating the results obtained with the dual-fixed nicotine (4 percent) dust tested in adjacent plots. In another experiment conducted in adjacent plots, a dust preparation of ground cube containing 0.8 percent of rotenone was less effective than dual-fixed nicotine dust (4 percent nicotine). In comparing the performance of dust preparations tested in 1936, however, the frequency and the extent of the rainfall during the critical period of residue effectiveness should be considered carefully. It is believed that the effectiveness of all materials was greatly reduced by these rains and that inconsistent results are attributable to residue losses occasioned by them.

Turner (420) in 1936 reported that in tests in Connecticut, two of the materials tested proved to be outstanding and a third only slightly less effective. Pure ground derris root (4 percent rotenone) and phenothiazine used in suspension at the rate of 2 pounds in 50 gallons of water, with a suitable spreader, were very effective. Sprayed plots produced 85 percent of borer-free ears, while adjoining unsprayed plots produced only 36 percent The formula recommended for derris is: Water, 25 gal.; pure ground derris root, 1 lb.; and a spreader, IN 181 (sodium lauryl sulfate) 1.5 oz. (avoirdupois), or Areskap (monosodium sulfonate of butyl phenylphenol) 1.5 oz., or SS-3 (a sulfated alcohol combined with a resinous sticker) 2.5 liquid oz. The only practical sprayer used to date has been a hand sprayer either a knapsack-type or a small compressed-air sprayer. The spray mixture is prepared in a barrel and poured through a fine screen into the hand sprayers. Turner (421) in 1937 stated that both pure ground derris root and pure ground cube root (each 4 percent rotenone) had proved highly satisfactory in sprays on early market corn, and were the most practical materials for borer control. To obtain the best results in corn borer sprays, it was necessary to use a spreader. Three available materials had proved satisfactory and had not injured corn plants in the quantities used. These were Areskap, a phenyl-phenol preparation (dry powder); Ultrawet, a dry powder made from petroleum sulfonates; and SS-3, a self-emulsifying liquid containing a sulfated alcohol combined with a rosinous sticker. To 25 gallons of water one of the following spreaders is added: Areskap, 1.5 oz. (avoirdupois); Ultrawet, 2.0 oz.(avoirdupois); or SS-3, 1.5 liquid oz. One pound of derris was mixed with a small quantity of this spreader solution to form

a thin paste and then added to the 25 gallons of water. It was very important that the exact quantities of spreader be used, since larger quantities may injure the corn and smaller ones may fail to ensure adequate spreading.

Turner (422) in 1939 recommended sprays or dusts of derris or cube for control of this insect on dahlias, stating that they should be directed at the tips of all growing shoots. The first application should be made about August 5, with weekly applications until the middle of September. Applications made at intervals of 5 days rather than 1 week are somewhat more effective. The spray was prepared as follows: To 1 lb. of pure ground derris or cube root (4 percent rotenone) was added one of the following spreaders: Areskap, 1.5 oz. (avoirdupois); Ultrawet, 2.0 oz.; or Grasselli Spreader-Sticker, 1.5 liquid oz. The derris or cube and spreader are mixed thoroughly and enough water is added to make a thin paste. One pound of derris or cube is sufficient for 25 gallons of water. For small amounts 2 level tablespoonfuls may be diluted in 1 gallon of water. Rotenone dust (derris, cube, or timbo roots diluted with talc or clay) containing 1 percent of rotenone is available ready for use. This dust has been very satisfactory on dahlias but has not been effective in controlling the corn borer in sweet corn.

Zappe, Turner, and Schread (504) in 1937 referred to their work reported in Connecticut Agricultural Experiment Station Circulars 114 and 118, which showed that nicotine tannate, phenothiazine, and pure ground derris root were highly effective against the European corn borer when applied in sprays on early sweet corn and that a spreader was necessary for best results.

Britton, Turner, and Zappe (51) in 1938 reported on the control of the European corn borer in Connecticut in 1937, referring to former reports in Connecticut Experiment Station Bulletin 395 and Circular 118. The spray, which contained 1 pound of pure ground derris or cube root (4 percent rotenone) in 25 gallons of water, with a suitable spreader, was slightly more effective than the dual-fixed nicotine dust (4 percent nicotine). Application of dust with hand dusters was more effective than with a 4-row vegetable duster. Late sweet corn was successfully treated by applications on August 5, 9, 14, 20, and 27. Reduction in borers was well over 80 percent, with a high increase in the percentage of borer-free ears. The materials, method of application, and time of application were highly satisfactory. Dahlias were treated with the following sprays: (1) Pure ground cube root (4 percent rotenone), 1 lb. in 25 gal. of water with a suitable spreader; (2) nicotine tannate and dusts (A) dual-fixed nicotine dust (4 percent nicotine) and (B) cube dust (1 percent rotenone). Applications were made August 2, 9, and 16, and September 1, 8, and 15. All treatments were satisfactory, but the cube spray was somewhat less effective than the other treatments.

Dunlap and Turner (102) in 1938 recommended a spray of cube powder (4 percent rotenone) at the rate of 4 pounds per 100 gallons per acre per application. Ultrawet or Areskap should be added as a spreader.

The United States Department of Agriculture, Bureau of Entomology and Plant Quarantine, in a typewritten report for January 1937 submitted by the Division of Cereal and Forage Insect Investigations, stated that powdered derris diluted with Bancroft clay to a rotenone content of 0.6 percent was dusted lightly over sheets of paraffined paper 9 x 11 inches. About 160 eggs in the black-head stage were placed in the center of each sheet and allowed to hatch at 75° F. and a relative humidity of 80 to 90 percent. Dual-fixed nicotine killed some eggs but derris killed larvae only. Bancroft clay alone killed most of the larvae and did not permit them to travel more than 3 inches from the hatching point.

Walker (463) in 1937 reported that bordeaux (4-4-50) plus cube (4 lb. per 100 gal.) was increased in effectiveness, from 59.5 to 92.3 percent, in potatoes by the addition of Ultrawet 1:1,600. Cube alone (4 lb. per 100 gal.) gave 63.5 percent control; the same with Ultrawet 1:1,600 gave 85 percent control.

Bourne and Boyd (42) in 1937 recommended the use of 2 pounds of derris powder (4 percent rotenone) and about 2.5 ounces of Areskap or similar material as a wetting agent to 50 gallons of water. Apply four times at 5-day intervals beginning as soon as first larvae hatch. Fill central whorl of leaves and cover base of lower leaves and of young forming ears.

Hervey (187) in 1937 stated that spraying or dusting sweet corn for control may become feasible where the value of the crop is high. Insecticides showing the most promise include derris or cube, phenothiazine, and nicotine.

Insecticides were tried for the control of this insect on sweet corn according to the Massachusetts Agricultural Experiment Station (270, 271, 272), in 1937, 1938, and 1939. Such use is based on the habit of the young larvae of feeding externally during the early period of their growth. In cooperation with the Federal European corn borer laboratory at New Haven, Conn., the department ran field tests with three contact sprays in 1/2-acre plots of sweet corn on two farms in Hampden County, Mass. Each material was run in quadruplicate, with a corresponding number of unsprayed areas. The sprays were applied at 5-day intervals beginning with the first appearance of larvae in each field. Four applications were made between June 19 and July 3 on each farm. A fifth application was made on July 8 on one farm because the corn there had developed more slowly than in the other field, although the insect first appeared on approximately the same date in both fields. The materials tested were ground derris (4 percent rotenone), phenothiazine (thio-diphenylamine), and tank-mix nicotine tannate. Each material was used at the rate of 12.5 gallons for the first application, 15 gallons for the second and third, and 25 gallons for the fourth and fifth sprays. The results were based on the total yield from both fields, approximately 20,000 ears being examined. Nicotine tannate and derris were effective in reducing damage. Phenothiazine gave fair control. Its failure to measure up to the other materials is believed to be due to its poor suspension, which prevented uniform coverage and protection. None of the materials caused any injury to the corn nor did they render it unsafe as fodder. The yield record from one of the farms is as follows:

Treatment 1/	Total ears	Conditions of ears --			
		Clean	Grades 1 and 2	Infested	Infested but salable
	Number	Percent	Percent	Percent	Percent
Derris	2,124	95.1	90.0	4.9	57.2
Nicotine tannate	2,447	92.1	88.4	7.9	53.0
Phenothiazine	2,232	89.9	78.8	10.1	48.4
Check	1,993	77.7	70.4	22.3	45.7

1/ Four plots totaling 1/8 acre for each treatment.

On each farm Span Cross 2, the earliest variety of yellow sweet corn to mature was tested. The crop was harvested as rapidly as possible, which allowed a comparatively short time for the infestation of the ears and enabled the check plots to show a much better record than the relative infestation warranted. Practically every stalk in the check plots was infested and many contained 6 to 8 borers and were seriously weakened, while comparatively few stalks in the sprayed plots showed the presence of borers. In January 1937 Questel reported that derris spray (4 lb. per 100 gal., 0.0192 percent rotenone) and derris dust (1 percent rotenone) were effective in reducing the population of second-generation borers infesting dahlias at Milford, Conn. The station in 1938 reported the results with derris spray, as follows: In the derris plot, 5 percent of the sprayed plots and 12 percent of the checks were damaged by borers. In the treated plots the infested stalks were not often seriously damaged and for the most part, contained only one and two small, young-stage larvae, whereas in the checks the stalks were badly riddled often contained from five to eight mature borers, and many stalks had broken down before the ears had fully matured. The loss of vitality to the plants caused by even a light or moderate infestation is clearly reflected in the yield records as shown by the following table:

Material	Infestation	Increase on treated over untreated plots	
		Total ears per acre	Uninfested ears per acre
	Percent	Number	Number
Dual-fixed nicotine (dust)	30	225	1,562
Derris (spray)	5	1,692	2,052

In every case the treated plots showed an increased total yield over the checks. On the basis of uninfested ears, the difference was even more pronounced. Even in comparatively light infestations, as in the derris plots, an advantage of more than 2,000 ears per acre represented a considerable profit to the grower. A more significant index of the value of the treatments is the relative proportion of Grade 1 corn harvested from the experimental plots as shown in the following table:

Material	Total yield			
	Uninfested plots		Grade 1 ears in plots	
	Dusted	Check	Dusted	Check
	Percent	Percent	Percent	Percent
Dual-fixed nicotine	92.8	70.0	76	48
Nicotine tannate	97.6	94.4	72	60
Derris	98.3	94.9	88	81

The field containing the derris plots was heavily fertilized. The corn made excessive stalk growth and many of the ears did not fully develop and were graded as culls. Since the total yield in this field, however, was at the rate of 24,000 ears per acre, even the small difference of 7 percent represented an increase of 1,680 ears. Derris spray increased the uninfested ears per acre by 2,052, and the grade-1 ears by 1,680.

The same station in 1939 reported the results of field tests with three dusts--dual-fixed nicotine, cube-vatsol, and a commercial rotenone--conducted in a commercial planting in Hampden County, and with four sprays, including ground derris, cube, and two of commercial rotenone. The sprays and dusts were applied at 5-day intervals from June 10 to June 25, the first application being based on the general appearance of the young larvae. The sprays gave satisfactory protection and the dusts fair commercial control on the basis of the borer-free ears harvested. The real value of the insecticidal treatments, however, is indicated by the relative proportion of the total yield that was of marketable grade. In the dusted plots from 62 to 65 percent of the crop was borer-free and 50 to 56 percent of marketable grade; in the sprayed plots from 75 to 80 percent of the total yield was borer -free and from 57 to 60 percent was marketable; while in the unsprayed plots only 16 percent of the crop was borer-free and less than 12 percent of the ears fit for market.

The Connecticut Agricultural Experiment Station (78) in 1938 reported that trials of sprays devised by the United States Department of Agriculture for control of the European corn borer in Connecticut were again successful. One spray contained pure ground cube root at the rate of 2 pounds in 50 gallons of water with and without spreaders. It was applied four times, on June 9, 15, 22, and 26 for the first generation, and resulted in 75 percent of the ears being borer free. Untreated plants produced 37 percent of borer-free ears. Dual-fixed-nicotine dust applied on the same dates was not so effective as the sprays. Second-generation sprays were applied on August 5, 9, 14, 20, and 27. A spreader increased the percentage of borer-free ears (64.8) as compared with cube without a spreader (57.3), and the untreated check (9.7). A pyrethrum spray was not effective.

Dual-fixed-nicotine dust applied on the same dates resulted in 75 percent of borer-free ears in contrast to 40 percent on the untreated check. The same station (79) in 1939 reported that further trials using pure ground cube root (4 percent rotenone) at the rate of 1 pound in 25 gallons of water with a suitable spreader, indicated the effectiveness of this material against the corn borer, especially when used in August against the second generation. Three applications on early corn at weekly intervals were almost as effective as four at 5-day intervals. Five applications at 5-day intervals were more effective on late corn than four at weekly intervals. Seven weekly applications of rotenone dust (1 percent rotenone in pure ground cube) or of pure ground cube root (4 percent rotenone) 1 pound in 25 gallons with a suitable spreader protected dahlias against the corn borer, but the cube spray was somewhat less effective than the dust.

Parks and Pierstorff (324) in 1938 recommended derris spray (4 lb. per 100 gal. of water plus 3 oz. of sulfated alcohol spreader) to control borer on sweet corn.

Pepper (328) in 1938 reported that nicotine bentonite dust and ground derris or cube-root dust have proved more satisfactory than other dust materials tested in reducing damage. Nicotine bentonite dust gave slightly better protection than derris -root or cube-root dust. Derris-root or cube-root dust was made by mixing 19 pounds of finely ground derris root or cube root (4 percent of rotenone and 16 percent or more of total extractives), 1.6 ounces (by weight) of wetting agent, and 81 pounds of talc. If desired, 25 pounds of dusting sulfur may be substituted for 25 pounds of talc. The derris-root or cube-root dust is easier to mix at home than the nicotine bentonite dust, as the nicotine bentonite dust tends to pack when mixed in a ball mixer. Each application of dust should be made at the rate of 25 to 30 pounds per acre. In experimental plots of the New Jersey Agricultural Experiment Station nicotine bentonite, derris-root sprays, and cube-root sprays consistently gave good results. Derris or cube (4 percent rotenone) spray at 4 pounds per 100 gallons of water plus 5 ounces of wetting agent is also recommended.

O'Kane (319) in 1939 reported that derris powder plus Ultrawet made a safe and effective spray.

According to Haude in advertising literature published by John Powell and Co., New York, N. Y., in 1939, the Connecticut Experiment Station reports good control of this insect by a spray of finely powdered derris (4 percent rotenone) at the rate of 4 pounds per 100 gallons of water.

Hervey and Carruth (188) in 1939 reported that powdered derris root (5 percent rotenone), used at the rate of 4 pounds to 100 gallons of water with a suitable spreader, gave very good control at Albany, N. Y. Four to 5 treatments were necessary to protect the rapidly growing corn plants during the egg-laying season. The treatments were begun when the first eggs started to hatch and continued until shortly after egg laying reached a peak. Certain fixed-nicotine dusts and sprays also reduced borer population but were less efficient than the derris spray. In order to reach the newly hatched borers, which feed between the leaves in the crown of the plant, one of the newer wetting or spreading agents should be used to reduce the surface tension and cause the mixture to penetrate the spaces where the insects are feeding.

Baker and Questel (21) in 1939 reported that at Toledo, Ohio, derris powder (rotenone 4 percent) at 4 pounds per 100 gallons of water plus Areskap at 1:2,000 reduced the borers as follows: In 1937, 94.4 percent on ears, 91.9 percent on plants; in 1938, 92.8 percent on ears, 89.3 percent on plants. Derris dusts were tried with the following results:

Year	Material	Reduction of borers in -- Ears	Plants
		Percent	Percent
1937	Bancroft clay + derris (rotenone 0.8 percent) + Areskap 1:3000	69.7	63.0
1938	Bentonite + derris (rotenone 1 percent)	61.0	59.4

The authors concluded that, in general, the sprays were more effective than the dusts. Derris and the fluorine compounds gave excellent protection when used as sprays in a standard-treatment schedule of four applications at 5-day intervals, starting immediately after the first hatching of eggs. The fluorine compounds injured the plants, however, which makes their use undesirable unless some means can be devised to eliminate burning.

Pyrausta salentialis (Snell.)

The Federated Malay States Department of Agriculture (122) in 1933 stated that experiments for the control of the larvae, which bore into corn stalks, have been laid down, consisting essentially of a varying number of applications of the extract of tuba root.

Saturniidae

Cricula trifenestrata (Helfer)

Dusts containing as little as 0.25 percent of rotenone killed all larvae within 3 to 4 days. -- Van der Vecht (454) in 1936.

Schoenobiidae

Schoenobius bipunctiferus (Walk.)

The Federated Malay States Department of Agriculture (119) in 1920 sprayed derris extract for the control of this species, with uncertain results.

Jack (216) in 1923 wrote that the juice extracted from Derris elliptica was most effective in combating this species attacking rice.

Schoenobius incertulus (Walk.)

Otanes (320) in 1925 wrote that in certain parts of the Visayan Islands, as in Cebu, it is said that farmers sometimes use the roots of derris for combating the rice borer by scattering chips of the roots and stem. The juice mixes in solution with the water, and when the caterpillars come in contact with the water, as when they transfer from stalk to stalk or after hatching, they are poisoned and soon die. Just how effective this remedy is has not been scientifically determined.

Sphingidae

Celerio lineata (F.), the white-lined sphinx

Finch et al. (133) in 1939 recommended derris preparations for the control of this species on grapes in Arizona.

Ceratomia catalpae (Bdv.), the catalpa sphinx

Hamilton (180) in 1938 reported that the caterpillars on catalpa trees were controlled satisfactorily by cube or derris spray (4 lb. of powder containing 4 percent of rotenone plus 4 lb. of rosin-residue emulsion per 100 gal. of water). The spray acts as a contact poison. Within a few hours there was 100-percent kill of all sizes of caterpillars. These results were referred to by the New Jersey Agricultural Experiment Station (294) in 1938, and Haude in 1939 recommended this spray, in advertising literature published by John Powell and Co., New York, N. Y.

Herse convolvuli (L.)

In the laboratory dusts containing 0.5 percent of rotenone killed all larvae. -- Van der Vecht (454) in 1936.

Pholus achemon (Drury), the achemon sphinx

Finch et al. (133) in 1939 recommended derris preparations for control on grapes in Arizona.

Protoparce quinquemaculata (Haw.), the tomato hornworm (on tobacco)

Neither pyrethrum nor derris, even at the heaviest doses, gave satisfactory control on tobacco, but the larvae, after feeding on derris, stopped feeding for a time. -- Gilmore (160) in 1933.

Stanley and Marcovitch (391) in 1935 reported that in 1934 derris and pyrethrum were used in preliminary field tests against this insect on tobacco, and some of the applications showed a temporary reduction in number of insects. Hornworms were not much affected by either derris or pyrethrum, even with heavy applications. Results are shown in the following table. Cage tests indicated that derris was not toxic to hornworms. Some repellent action was shown, however, as the worms would not eat dusted leaves until they had been exposed for 4 days.

Material	Dust used per acre	Worms found -- Before dusting	On June 16	On June 19
	Pounds	Number	Number	Number
Pyrethrum, 0.20 percent	25.7	9	8	16
Pyrethrum, 0.50 percent, diluted with talc	26.1	6	5	24
Derris (0.75 percent rotenone)	10.3	2	7	4

White (480) in 1935 stated that derris was ineffective against this insect.

Chamberlin and Morrill (68) in 1936 called attention to the necessity of devising a new method of evaluating insecticides tested against this insect. The fifth instar consumes 300 square inches of shade-grown tobacco leaf, or about 12 times as much as the fourth instar, which in turn consumes 5 times as much as the third instar. Chamberlin and Morrill proposed that the value of the insecticide applied be determined by the ratio of the third, fourth, and fifth instars to the total of all instars, rather than by the usual method of percentage of kill. According to this method, the lower this ratio the more efficient the treatment. Different insecticides yielded the following results:

Insecticide	Ratio
5 parts lead arsenate + 3 parts lime	0.091
1 part paris green + 4 parts lime	.071
1 part paris green + 6 parts lime	.079
1 part derris + 1 part sulfur + 2 parts clay	.381
Phenothiazine diluted 1:10	.552

Gunderson (173) in 1938 recommended derris with or without sulfur for the control of Protoparce quinquemaculata (Haw.) and P. sexta (Johan.), with flour, sulfur, pearl dust, gypsum, or other carrier as diluents for derris dust. He said that a 1-percent-rotenone dust was generally strong enough for all needs and that derris spray, 5 pounds per 100 gallons, gave satisfactory control of the tomato hornworms.

This insect on tomato may be killed by dusting the plants rather heavily with a dust containing 0.75 percent of rotenone, although the larger worms are rather difficult to poison. -- Crosby, Chupp, and Leiby (87) in 1939.

Haude in 1939, in advertising literature published by the John Powell Co., New York, N. Y., recommended a dust containing 0.5 percent of rotenone at the rate of 20 to 25 pounds per acre, applying it when the worms are young and repeating every 7 to 10 days. For severe infestation, the New York State Experiment Station recommended a 0.75- or 1.0-percent-rotenone dust. A 0.5-percent-rotenone dust was recommended to control young tomato hornworms on eggplant.

Protoparce sexta (Johan.), the tobacco hornworm

See Gunderson (173) and Haude under Protoparce quinquemaculata (Haw.).

Campbell (60) in 1932 critically reviewed the work of Chamberlin, who tried rotenone against this species on tobacco. The preparation contained 0.5 percent of rotenone in an inert carrier. The effectiveness of a 1-percent suspension of this preparation was compared with that of a 1-percent suspension of lead arsenate, each applied as a spray on growing tobacco plants. The third and fourth instars were allowed to feed on the sprayed plants until they died, or until the end of 5 days. Lead arsenate killed all the larvae in the first 24 hours. The rotenone preparation killed only 26 percent of the larvae in 5 days. Similar results were obtained when the rotenone preparation was used as a dust at 8 to 9 pounds per acre. The failure of rotenone to cause a greater mortality may have been due, not only to decomposition and weathering, but to the small quantity of rotenone applied per unit area of leaf surface.

At the 1934 meeting of the American Association of Economic Entomologists, as reported by the United States Department of Agriculture, Bureau of Entomology and Plant Quarantine (437) Cory led a discussion of field results with arsenical substitutes for the control of vegetable insects. Headlee of New Jersey stated that derris dust had given excellent control of this hornworm. This statement was published by Headlee (186) in 1935.

The Alabama Polytechnic Institute (10) in 1935 reported that derris dust was effective in control.

Protoparce spp.

Cube exerts only a very limited control of the tobacco hornworms, Protoparce spp. -- Chamberlin and Madden (67) in 1937.

Parks and Pierstorff (324) in 1938 recommended rotenone spray to control hornworms on tomato.

Tineidae

Gracilaria azaleella Brants, the azalea leaf miner

This pest on azalea was mitigated by a product containing 12 percent of powdered Lonchocarpus nicou root (6 percent rotenone) and 88 percent of talcum, according to Etablissements Rotenia in a letter to R. C. Roark in 1938.

Kakivoria flavorasciata Nagano

Nozu (311) in 1936 reported that, in experiments against this tineid on persimmon in Japan, sprays of Neoton (a derris insecticide), nicotine sulfate, or lead arsenate and calcium caseinate were effective for control, Neoton being the most successful.

Tinea pellionella L., the casemaking clothes moth

See Back (16) under Tineola bisselliella (Hüm.), on page 152.

Tinea sp.

A swarm of almost-grown Tinea moths on an oak in Korea were killed within an hour by the application of a commercial derris spray [probably Neoton. -- R.C.R.]. -- Anonymous (1) in 1927.

Tineola bisselliella (Hüm.), the webbing clothes moth

Back, Cotton, and Roark (18) in 1930 reported that acetone containing only 0.05 percent of rotenone gave excellent protection against this species to woolen goods thoroughly impregnated with the solution. Rotenone appears to equal any proprietary moth-proofing solution now offered the public in imparting moth resistance to fabrics.

The United States Department of Agriculture, Bureau of Entomology (432) in 1930 mentioned the work of Back, Cotton, and Roark in mothproofing woolens with an acetone solution of rotenone.

Campbell (60) in 1932 critically reviewed the work of Back, Cotton, and Roark, who in 1930 published the results of moth-proofing fabrics by treating them with an acetone solution of rotenone. According to Campbell, Moore repeated the tests of those authors, using a solution of rotenone in a mixture of acetone and naphtha, and obtained the same results; however, he found that when treated fabric was exposed to sunlight or ultraviolet light it lost some of its resistance.

Turner and Townsend (423) in 1934 reported that an infested upright piano was vacuum cleaned and the felts treated with rotenone in carbon tetrachloride at 1:500, applied with a camel's-hair brush. The piano was treated in June 1932, and two subsequent examinations, the latter made in January 1934, disclosed no additional damage to the felts. Clothes moths were still present in the house but had not established an infestation in the piano. Rotenone is particularly suitable for this purpose because it is soluble in carbon tetrachloride.

Turner (419) in 1935 reported on tests in moth-proofing materials. Wool flannel was exposed to the larvae. Three materials were tested, including rotenone in carbon tetrachloride at the rate of 1:1,000. The rotenone solution was not satisfactory. The two proprietary compounds, the one containing a fluoride, the other cinchona alkaloids, were very effective in half-disc and whole-disc tests in petri dishes.

DeBussy et al. (57) in 1936 reported that larvae are somewhat sensitive to derris powder and rotenone.

Back (16) in 1938 recommended spraying as one of the methods for control of the webbing and the casebearing clothes moths. Available trade-name sprays usually consist largely of a high-grade, odorless, stainless kerosene oil plus pyrethrum or derris extracts. Directions for making a spray of this type were issued by the United States Department of Agriculture. These sprays are contact sprays and do not render the sprayed objects immune to moth attack. They are used to destroy moths on clothing and furniture, in floor cracks, about baseboards, and elsewhere. They can be applied with hand sprayers, but are best applied with power sprayers.

Craufurd-Benson (85) in 1938 reported that a derris insecticide had a very slight effect on the larvae dipped in it.

Tineidae (unidentified sp.)

Kelsall et al. (233) in 1926 reported that a trunk of woolen goods swarming with adult clotes moths was given a liberal application of a 50-50 mixture of derris and hydrated lime. Four days later all moths were dead. The trunk was examined a month later and no living larvae and no moths were found.

The Canada Experimental Farms (64) in 1927 stated that derris has been found "very effective as a moth preventative".

Back and Cotton (17) in 1931 stated that the most effective of the mothproofing solutions for the control of moths in upholstered furniture are the fluoride, cinchona alkaloid, and rotenone solutions.

Schmitt (362) in 1931 reported that experimental impregnation of woolens with rotenone in alcohol, ether, ether and alcohol, chloroform, and combinations of these extracts was effective in mothproofing the material.

Vizetelly (459) in the 1931 edition of the New Standard Encyclopedia wrote:

> "Some species of insects (clothes moths and fabric pests) may best be destroyed by rotenone (from derris root) dissolved in acetone."

Back (15) in 1932 stated that when rotenone dissolved in acetone is applied to fabrics in laboratory tests it imparts a real moth resistance. A number of mothproofing solutions now on the market contain rotenone.

Campbell (60) in 1932 critically reviewed the tests of rotenone as a mothproofing agent by Back and Cotton and by Moore. These tests gave the clearest evidence of a repellent or deterrent effect. When the larvae were placed in a petri dish containing a half circle of cloth treated with rotenone and an untreated half circle, they at first distributed themselves over both pieces. Later most of them were found on the untreated piece. Back does not consider rotenone repellent, because the initial distribution of the larvae was uniform. Moore writes that rotenone has a very strong repellent effect, because all the larvae fed on the untreated side. He says thereis some doubt about its toxicity to the larvae. Whether the effect is repellent or deterrent, it is certain that rotenone drives the larvae away to the untreated cloth, where they feed normally. With the exception of the case just mentioned, Campbell does not believe that a repellent or deterrent effect of rotenone has been convincingly demonstrated.

Musser (286) in 1936 included rotenone solutions among the most effective mothproofing solutions available.

McTavish (265) discussing mothproofing problems in New York in 1937, said that frequently vegetable insecticides are dissolved in hydrocarbons, the favorites being pyrethrum extract, cube, and derris root. These tend to prolong the larvicidal action after the solvent has evaporated. Unfortunately deterioration of these natural insecticides under ordinary atmospheric conditions is relatively rapid.

Takei and Tada (399) in 1937 in discussing the use of insecticides against insect pests of woolen goods, said that pyrethrum and rotenone are both effective, but the latter at the rate of 3 parts to 1,000 by weight of material is preferable for preventing infestation because the former evaporates more quickly.

Tortricidae

Adoxophyes privatana (Walk.)

Nawa (289) in 1936 reported that the eggs of this species on tea in Japan can be destroyed by spraying with derris and soap.

Archips fosteriana (F.)

An anonymous writer (5) in 1937, discussing the control of insects in the Netherlands with derris, stated that a concentration of 0.75 percent of rotenone suffices for control of (Tortrix) Archips fosteriana.

Archips xylosteana (L.)

Yago (502) in 1933 wrote that (Tortrix)(Cacoecia) Archips xylosteana, which was formerly abundant in pear orchards in Shizuoka, Japan, had become scarce, probably owing to the use of insecticides, including derris.

Nakayama (288) in 1937 reported that this species was widely distributed on apple and pear in Korea. Sprays containing nicotine sulfate or derris were effective against the young larvae and lead arsenate was effective against the older ones.

Argyrotaenia citrana (Fern.), the orange tortrix

Basinger and Boyce (24) in 1936 reported that cryolite and barium fluosilicate may be combined with derris compounds for citrus aphid control. Organic compounds used alone were ineffective. The following results with a derris containing 5 percent of rotenone were obtained at Corona, Calif., in 1934 against orange worms, principally the larvae of this species, though Holcocera iceryaeella (Riley) and Platynota stultana (Wlsm.) were also involved.

Material and concentration	Fruits with live larvae under buttons prior to treatment	Recently damaged fruits observed per hour approximately 130 days after treatment
	Percent	Number
Derris (rotenone 5 percent) 1:800	31.2	69
Derris (rotenone 5 percent) 1:800 + synthetic cryolite 3 lb./100 gal.	14.8	2
Check (no treatment)	30.3	116

Argyrotaenia mariana (Fern.), the gray-banded leaf roller

Kelsall and Stultz (234) in 1937 reported laboratory tests of derris (3.95 percent rotenone) and pyrethrum (0.94 percent pyrethrins) as dusts, with gypsum as the diluent. Results with derris were as follows:

Concentration of derris	Mortality	
Percent	Percent	Days
5.0	20	8
12.5	10	8
25.0	40	5
100.00	40	5

Feeding was reduced when caterpillars were treated with more concentrated dosages.

Derris powder (2 lb. per 100 imp. gal.) gave poor control on apple trees in Nova Scotia. -- Kelsall (232) in 1938.

Argyrotaenia velutinana (Walk.), the red-banded leaf roller

Hough (191) in 1927 reported that in an insectary Derrisol applied to the red-banded leaf roller with an atomizer at a strength of 1:800 did not give promising results.

Garman (151) in 1936 reported the following results of tests against the red-banded leaf roller on apples in Connecticut:

Treatment	Apples		
	Without external insect injury	Marked by this species	Conspicuous spray russet
	Percent	Percent	Percent
Lead arsenate (3 lb./100 gal.) plus flotation sulfur	91.5	0.1	----
Cryolite (4 lb./100 gal.) plus flotation sulfur	65.4	2.1	----
Cryolite plus Goposil	48.3	4.3	35.8
Derris spray (4 lb./100 gal., ground root, 4 percent rotenone, combined with skim-milk powder. One extra spray in August)	32.0	1.5	----
Check--pink spray only	24.4	2.6	1.3

Haude, in advertising literature published by John Powell and Co., New York, N. Y., in 1939 recommended cube or derris dust (0.75 percent rotenone).

Argyrotoxa semipurpurana (Kearf.)

Felt and Bromley (127) in 1938 reported comparative tests of derris (4 percent rotenone and 15 to 16 percent total ether extractives) at the rate of 4 pounds to 100 gallons plus rosin-residue emulsion, 2 quarts to 100 gallons, cryolite, and lead arsenate. In the case of the pin-oak leaf rollers, derris, apparently most effective as a contact spray, gave little control, most of the larvae being protected by the roll of the leaf. Cryolite gave much better control, while lead arsenate gave complete protection.

Hamilton (180) in 1938 reported that oak leaf rollers on pin oak trees were controlled satisfactorily (50- to 100-percent kill) in one test out of three by cube or derris spray (4 lb. powder of 4-percent rotenone content plus 4 lb. rosin-residue emulsion per 100 gal. water). The spray acts as a contact poison. The effective period was 3 to 4 days.

Cacoecia podana (Scop.)

The East Malling Research Station Kent, England (106), in 1935 stated that tests of derris dusts and sprays against the apple surface-eating fruit tortricid showed sufficient promise to justify further trials. F. J. D. Thomas (409) of that station, reported in 1935 on the control of apple surface-eating tortricid larvae with derris dust and derris spray. The object of the dusting trial was to apply a protective dust to the fruit before tortrix attack began. Moths, both codling and Cacoecia podana, were beaten from the trees available for this trial during the latter part of June. On July 17 two dusts were applied, one of derris and the other of barium fluosilicate. Subsequent observations and counts on both windfalls and crop showed very little tortrix damage to the fruit on any of the trees, including the undusted controls. Derris (crude rotenone, 3.63 percent), 2 pounds, plus soft soap 5 pounds per 100 imperial gallons, reduced the damage 50 percent when applied approximately 9 weeks after petal fall.

Cacoecia pronubana (Hbn.)

Miles and Miles (278) in 1935 discussed the use of derris for combating greenhouse pests. For control of the carnation tortrix moth, spraying with lead arsenate and nicotine washes and the more recently introduced derris and pyrethrum sprays is most likely to give satisfactory results when carried out before the larvae spin themselves up in their feeding shelters.

This pest on carnations was killed by a product containing 12 percent of powdered Lonchocarpus nicou root (6 percent rotenone) and 88 percent of talcum, according to Etablissements Rotenia in a letter to R. C. Roark in 1938.

The Experimental and Research Station of the Nursery and Market Garden Industries' Development Society Ltd., of Cheshunt, England (113), in 1939 stated that a concentrated derris insecticide failed to control caterpillars of the carnation tortrix moth on cyclamen.

For the control of the carnation tortrix moth, poison sprays such as lead arsenate, nicotine, derris, and pyrethrum are effective in killing the caterpillars before they become enclosed in their protective webs. The foliage of the plants should be thoroughly wetted above and below, and the spray should penetrate the flowers and leaves at the ends of the shoots. -- Cameron (59) in 1939.

Archips rosaceana (Harr.), the oblique-banded leaf roller

In the Netherlands derris at a dilution of 1:5,000 was used with good results against (Cacoecia) Archips rosaceana. -- Anonymous (5) in 1937.

Carposina sasakii Mats.

Toyoshima (415) in 1934 reported that spraying apples with nicotine sulfate, or derris, killed many of the eggs.

Sprays of lead arsenate, derris, or nicotine sulfate have not proved effective for control. -- Yago and Ishikawa (503) in 1936.

Platynota stultana (Wlsm.)

See Basinger and Boyce (24) under Argyrotaenia citrana (Fern.), on page 154.

Sparganothis sulfureana (Clem.)

Beckwith (31) reported in 1938 on the control of this species, commonly known as the false yellowhead or sulfur leaf roller. Cage tests carried on in the Doehlert apparatus indicated that the adults could be killed by an application of 30 pounds of pyrethrum dust (0.9 percent pyrethrins) to the acre but, because of the irregularity of emergence, this treatment was not considered practical under ordinary conditions. An airplane application of 15 pounds of derris dust (4 percent rotenone) to the acre was not effective in killing larvae in a single field experiment.

The New Jersey Agricultural Experiment Station (294) in 1938 stated derris dust (4 percent rotenone), applied at the rate of 15 pounds per acre from an airplane, was not effective in killing this insect.

Acleris contaminana (Hbn.)

A product containing 12 percent of powdered Lonchocarpus nicou root (6 percent rotenone) and 88 percent of talcum killed "Terras contaminata" on rose and pear, according to Etablissements Rotenia in a letter to R. C. Roark in 1938.

Tortrix viridana (L.)

See Tragårdh (416) under Panolis griseovariegata, on page 92.

Tortrix sp.

Derris with sulfite-lye failed to wet and spread well on the foliage but the addition of lime-sulfur improved the mixture in this respect. Neither nicotine nor derris greatly reduced the proportion of fruits bitten by caterpillars of Tortrix sp. -- East Malling Research Station (105) in 1934.

Steer (394) in 1936 published a summary of the use of derris as an insecticide in England. Promising results were obtained in 1934 with derris and soap against larvae of the apple tortrix.

This pest on carnations was killed by a product containing 12 percent of powdered Lonchocarpus nicou root (6 percent rotenone content) and 88 percent of talcum, according to Etablissements Rotenia in a letter to R. C. Roark in 1938.

Zygaenidae

Artona catoxantha (Hmps.)

Van der Vecht (454) of Buitenzorg, Java, in 1936 reported that the well-known coconut pest (Brachartona) Artona catoxantha was readily killed in the laboratory by dusts containing from 0.5 to 1.0 percent of rotenone. In the field a derris dust containing 1 part of ground derris (11 percent rotenone) and 10 parts of talc, and applied by a motor duster, compared favorably with the pyrethrum product "Dusturan". In another field experiment derris dusts containing 0.5 percent or 1.0 percent of rotenone killed about 90 percent of the caterpillars. In 1938 van der Vecht (455) reported that the addition of 1 to 2 percent of talc to spray suspensions used against this species helped to fix the particles of derris on the smooth lower surface of coconut leaves and also served to indicate the thoroughness of application of the spray. In 1939 van der Vecht (456) reported that laboratory experiments showed that aqueous suspensions of derris powder containing 0.005 percent of rotenone caused a 100-percent kill of fourth instars, whereas a total mortality of full-grown larvae was obtained after spraying with suspensions containing 0.01 percent of rotenone. Furthermore, it was observed that the residue of the suspensions kept its toxicity to Artona larvae for a considerable period, especially when talc was added, which apparently improved the sticking power of the derris and rendered the residue more easily visible. In field experiments in West Java 2 infested localities with 800 and 4,000 trees, respectively, were sprayed with derris- and cube-talc suspensions, containing 0.015 to 0.03 percent of rotenone; in both localities large numbers of caterpillars were killed and in the next generation the remains of the population were destroyed by parasites. From the results of these experiments, it may be concluded that spraying with derris-talc suspensions is more effective and cheaper than dusting, and that the various difficulties connected with the latter method can be avoided by the use of sprays. Some advantages of spraying over dusting are that the treatment of the highest trees offers no special difficulties, the disturbing effect of strong winds is much less pronounced, the sprayers are more easily transported, and the work can be better controlled. For these reasons, the spraying method was applied in a number of outbreaks in central Java in 1938.

Harrisina americana (Guer.), the grape leaf skeletonizer

Dickey and Loucks (98) in 1938 recommended derris spray for control in Florida.

Haude in advertising literature published by John Powell and Co., New York, N. Y., in 1939 stated that this insect may be controlled with a 0.75-percent dust or a liquid-rotenone spray.

Harrisina brillians B. and McD., the western grape skeletonizer

Finch et al. (133) in 1939 recommended derris preparations for the control of the western grape skeletonizer.

Illiberis pruni Dyar

The Institute of Physical and Chemical Research (214) Tokyo, Japan, in 1927 reported that Neoton, 1 pound in 60 imperial gallons of water, warded off an attack of the larvae for 5 days, and that in a field sprayed with Neoton 25 percent of the larvae were killed by the internal action of the drug. A pound of Neoton in 32 imperial gallons of water exterminated the larvae of this species completely. One pound of Neoton in 40 imperial gallons of water killed 15.1 percent of the eggs, which were sprayed soon after they were laid and were kept from the rain.

Pryeria sinica Moore

Takai (398) in 1928 reported that derris spray may be used for the control of this species but arsenicals are more effective.

Lepidoptera, unidentified sp.

Daniels (89) in 1905 mentioned the successful use of derris against lepidopterous larvae in British Malaya.

Schneider (363) in 1907 reported that the use of a strong milky suspension of derris destroyed caterpillars on tobacco in Sumatra.

McDougall et al. (261) in 1912 stated that derris extractives at the rate of 12 ounces per 100 imperial gallons of water would destroy the more hardy and vigorous caterpillars.

Ridley (348) in 1912 wrote of derris as follows:

> "Tuba root is one of the best insecticides and is the one most regularly used by the Chinese in the Malay Peninsula for treating their vegetables and other crops. The roots are pounded up in water and the decoction poured or sprayed over the crop, where it will kill all caterpillars, grasshoppers, and other insects. It is perfectly harmless to any plants."

Wood (498) in 1912 described the use of derris for the control of three undetermined species of small caterpillars on cabbage in the Federated Malay States. Two pounds of crushed root was added to 2 imperial gallons of boiling water, allowed to soak for a few hours, and then diluted 1:8 for spraying.

Gimlette (162) in 1923 referred to tests by Durham who, in 1903, found that caterpillars were easily poisoned by derris.

Lewin (250) in 1923 wrote that in Sumatra diluted derris-root sap was used to kill caterpillars on young tobacco plants, but too great a quantity killed the tobacco.

Tattersfield and Roach (403) in 1923 referred to work carried out between 1902 and 1907 by Durham, who reported that larvae of Lepidoptera were very susceptible to derris.

The preparation of derris for use as an insecticide was described by the Federated Malay States Department of Agriculture (121) in 1924, as follows:

> For small caterpillars and sucking insects, where a simple wash is required, the derris spray can be made on the spot. Use the following proportions: Derris root 4 to 5 pounds, soap 2 pounds, water 50 imperial gallons.
>
> Cut the derris root into small pieces and pound to a pulp in a mortar with a little water. Inclose the pulp in a cloth and squeeze well in a larger quantity of water. To the extract obtained by this process add the soap, which has been dissolved in a little hot water. Then dilute to 50 gallons.

Alcoholic extracts of cube and derris plus soap were ineffective against first-instar webworms, as was also derris used as a fumigant. -- McIndoo and Sievers (263) in 1924.

Caterpillars can be easily exterminated by the application of insecticides containing derris or its products. -- Carlos (65) in 1926.

Tattersfield, Gimingham, and Morris (402) in 1926 reported that preliminary experiments indicated that the haiaris and Tephrosia vogelii and T. toxicaria, as stomach poisons are both repellent and toxic to caterpillars.

The application of a commercial derris spray killed cabbage worms within a half-hour. Cabbage butterflies flew away. -- Anonymous (1) in 1927.

The Institute of Physical and Chemical Research (214) Tokyo, Japan, in 1927 reported that Neoton gave 100-percent mortality of caterpillar and green caterpillar at the rates of 1/2 pound and 1 pound of Neoton per 40 imperial gallons of water.

Leefmans (248) in 1927 reported that on the Sumatra East Coast cabbage growers are mixing lead arsenate with the usual derris solution. A derris suspension in water gave unfavorable results against cabbage caterpillars but excellent results were obtained when finely pulverized derris was extracted with alcohol. The addition of a water suspension of derris or derris roots to a solution of lead arsenate seemed useless, because the latter, with the addition of soap, was satisfactory.

According to an anonymous (2) writer in 1930, the milky colloidal solution of resins and other compounds obtained by extracting the roots and stems of Derris elliptica with water is exceedingly toxic to insects. A 0.8-percent solution constitutes an effective stomach poison. Derris does not injure blossoms and foliage, and leaves sprayed with derris solution remain toxic to insects for many days. The dust is equally effective. The dry root may be powdered, worked up in water with soap or other emulsifying agents, and applied as an insecticide. Extracts of the root, made with petroleum ether and ethyl alcohol and mixed with water, are used as sprays. There is no record of injurious effect on those handling the materials.

Schmitt (361) in 1930 reported that spraying with derris extract gave good results against caterpillars.

Hendren in 1931, in a typewritten report to the United States Department of Commerce, stated that tuba-root extract was used to combat caterpillars on cabbage in Sumatra, sprinkled on the plants by means of a little brush of coconut fiber. Later lead arsenate was added to the tuba extract, but this left poisonous residue on the cabbage. The use of an alcoholic extract of derris was also recommended.

Andries (13) in 1932 recommended both tuba and derris extracts for use against caterpillars.

Corbett (81) in 1932 reported that an unidentified caterpillar was found damaging golf greens in British Malaya. A tuba spray was recommended but, possibly owing to prevailing wet weather, it was not effective in controlling the caterpillar.

Been (32) in 1933 suggested to the cauliflower growers in Suffolk County, N. Y., the use of rotenone and pyrethrum in place of the arsenicals. Reference was made to the work of Huckett in controlling worms on early cabbage and early cauliflower, using various rotenone dusts and sprays, and combination rotenone-pyrethrum dusts and sprays. The dusts contained 0.5 percent of either rotenone or pyrethrins or 0.25 percent of each where a combination was used. Either finely ground talc or clay was suggested as a diluent. Dusts were effective when applied at the rate of 25 to 30 pounds per acre. Sprays used at a dilution of 2 quarts to 100 gallons of water gave good control where three nozzles per row were used and coverage was good. Rotenone, pyrethrum, and a combination of the two were equally effective. On July 17, 1935, Been warned cauliflower growers to avoid arsenical or fluorine residues on cauliflower, brussels sprouts, and other crops, by dusting or spraying with one of the new rotenone or pyrethrum insecticides.

Huckett (198) in 1933 discussed the various pyrethrum and rotenone insecticides proposed as substitutes for arsenicals for use on cabbage, cauliflower, and lima beans on Long Island. In the dust mixtures the percentage of active ingredients necessary to kill cabbage and cauliflower worms, for example, was taken at some point between 0.5 and 1.0 percent. With liquid extracts from 1 to 2 quarts of extract per 100 gallons of spray per acre was commonly recommended.

The Suffolk County [N. Y.] Farm Bureau (395) in 1933 reported that on Long Island all the rotenone products were effective against cabbage worms. The dusts contained 0.5 percent of rotenone, and the sprays were used at the rate of 2 quarts of extract to 100 gallons of water. Proprietary products tested included Derox, Cubor dust, Cubor spray, and Hellthspra No. 1.

In discussing White's (479) paper presented in 1933, Ginsburg commented that recent investigations have shown that rotenone is not the main toxic principle of derris so far as chewing insects are concerned. Derris from which all rotenone had been extracted proved to be just as toxic to cabbage worms as derris containing 1.5 percent or more of rotenone. [It is practically certain that Ginsburg did not extract all the rotenone by the procedure used. -- R.C.R.]

Bock (38) in 1934 reported the results of tests with Derris elliptica, which was tried as a spray material in the following mixture: 125 gm. of soft soap plus 100 gm. of derris tincture (percolation with fuel alcohol in proportion 1:5) plus 7 liters of water. Experiments were made against caterpillars on fruit trees, berry bushes, ornamental shrubs, roses, and vegetables. In all cases, the derris preparation proved equal to the "Nosprasit" and arsenical mixture used for comparison. The soap could be replaced by soap bark without detriment.

At the 1934 meeting of the American Association of Economic Entomologists, as reported by the United States Department of Agriculture, Bureau of Entomology and Plant Quarantine, (437), Cory led a discussion of field results with arsenical substitutes for the control of vegetable insects. Watson, of Florida, reported successful control of cabbage worms with some of the commercial rotenone preparations including Cubor. Robinson, of Alabama, reported derris-talc and derris-sulfur dusts (0.5 percent rotenone) effective in the control of various cabbage worms. Hutson, of Michigan, reported trying various combinations of derris and pyrethrum against caterpillars on celery and cole crops with strikingly successful results. Satisfactory diluents were flour, talc, bentonite, china clay, 300-mesh dusting sulfur, tobacco dust, silicated infusorial earth, and finely ground gypsum.

Currie (88) in 1934 reported that in the Salinas, Calif., area derris dust gave good results against cabbage worms.

Garman and Turner (153) in 1934 recommended a dust containing 0.6 percent of rotenone for the control of cabbage worms.

Hamilton and Gemmell (181) in 1934 compared the effectiveness of derris, pyrethrum, and hellebore powders against the cabbage worm. The derris-clay dusts (rotenone 0.5 and 1.0 percent) were best, hellebore next best, and pyrethrum (1.16 percent pyrethrins) the poorest. A dust containing both derris and pyrethrum gave good results.

Huckett (199) in 1934 reported that dusts containing 0.5 to 1.0 percent of rotenone were used in 1933 to protect 4,000 acres of late cauliflower on Long Island against worms. About 275,000 crates of cauliflower were sold by the Long Island Cauliflower Association and about 150 tons of derris dusts were sold by dealers on Long Island at a price of from 12 to 14 cents per pound, as substitutes for calcium and lead arsenates. He (200) also reported in 1934 that against insects attacking vegetables, derris dusts have usually been slightly superior to derris sprays. For cabbage worms effective control may be obtained by the use of a derris-clay, kaolin, or talc-dust mixture containing not less than 0.5 percent of rotenone, applied much in the same manner as recommended for arsenical dusts. Hydrated lime or a mixture of hydrated lime and monohydrated copper sulfate effects rotenone adversely, hence their use as a diluent for derris dust is not recommended. During the summer months, it will usually be found necessary to apply sprays or dusts once every 10 days to 2 weeks, but with the shorter, cooler days of autumn once every 2 to 3 weeks may be satisfactory. If derris powder is applied in a spray mixture, a strength comparable to 10 pounds of a derris-clay dust (1 percent rotenone) should be used in 100 gallons of water, or 2 pounds of an undiluted powdered derris root of 5-percent-rotenone content in 100 gallons of water, plus in either case 4 pounds of a spreader, such as dry skim-milk powder, or a miscible sulfonated oil or neutral coconut-oil soap, 2 quarts. Both derris powder and skim-milk powder should be made into a paste before being added to the tank. Hydrated lime, bordeaux mixture, and ordinary laundry soap are considered undesirable in a derris spray, owing to their adverse effect on rotenone. Although the cost of ingredients for spraying may be a little cheaper than for dusting, it will generally be necessary to spray at slightly shorter intervals to obtain results similar to those obtained with the dust.

Huckett, in a letter dated May 3, 1934, to W. H. White, submitted the following results of tests of proprietary rotenone dusts against cabbage worms:

Treatment	Plant Injury		
	None	Slight	Moderate to severe
	Percent	Percent	Percent
Derox (0.55 percent rotenone)	83.1	15.1	1.8
Cubor and clay (50-50)	65.4	28.5	6.1
Hellthicide No. 1 (1 percent rotenone)	86.0	12.0	2.0
Hellthicide No. 2 (1 percent rotenone)	92.4	5.7	1.9
Kubatox (0.44 percent rotenone)	73.6	22.7	3.7
Drimac	82.0	14.0	4.0
Florote	62.3	26.4	11.3
Check	27.5	43.1	29.4

Hutson (206) in 1934 reported that pyrethrum and derris dusts (1 percent rotenone) were very efficient in the control of cabbage worms in Michigan. Hutson (208) in 1936 stated that cabbage worms and many other insects on plants from which residues are difficult to remove are readily controlled by derris or pyrethrum sprays or dusts. Derris and pyrethrum work best when finely ground if used as dusts; and when the proper spreader is present, if used as sprays. Tobacco dust, talc, bentonite, clay, chalk, sulfur, and flour are good mixing materials; soap, emulsified oils, and sulfated alcohols are good spreaders for sprays. A good insecticidal dust contains 0.5 to 0.75 percent of rotenone. Applied at the rate of 15 to 25 pounds per acre the dust will control cabbage worms and most caterpillars. Five pounds of ground derris with 1 pound of powdered skim milk or 2 gallons of skim milk, or 3 pounds of thoroughly dissolved soap or 3 to 6 ounces of one of the sulfated alcohols makes 100 gallons of effective spray. Hutson (209) in 1937 recommended derris dust (0.5 to 0.75 percent rotenone) for the control of most caterpillars.

The New York State Agricultural Experiment Station (300) in 1935 reported that derris dusts controlled worms on cabbage and cauliflower on Long Island. Dust mixtures containing not less than 0.5 percent rotenone, applied at about 14-day intervals, gave satisfactory protection from worms. Talc, Georgia clay, and tobacco dust made the most satisfactory diluents. Spray mixtures of rotenone were not so effective as derris dusts.

Stahl (390) in 1934 reported that in all of his derris tests with the celery leaf tier the repellent effect of the dust was much less than with several species of cabbage worms. The amount of feeding of the cabbage worms decreased as the concentration of rotenone in the dust increased from 0.1 to 3.0 percent, but there was some feeding in all cages.

The Wisconsin Agricultural Experiment Station (486) in 1934 reported the results of tests of rotenone dust against cabbage worms in Wisconsin. A 2-percent-rotenone dust proved more effective than any of 13 sprays and dusts, arsenical and other, used in comparative trials. Each of the spray materials was applied to 20 heads of cabbage in 1 row. Three rows, 60 heads of cabbage per row, were used to test each dust. A similar number of heads of cabbage were used as checks. Counts were taken 48 hours after the materials had been applied. The check lot showed 4.4 worms per head. All the materials except lead arsenate-hydrated lime dust (1:1) and 2 percent of rotenone showed an average of 1 worm more per head. The lead arsenate-hydrated lime dust showed 0.9, while the 2 percent rotenone dust showed 0.6 percent. Neither of these latter sprays discolored the foliage or resulted in other injury, as did several of the other materials tried. Further tests were made to compare the toxicity to insects of the rotenone dust with that of the lead arsenate-hydrated lime dust (1:1), and a calcium arsenate-hydrated lime dust (1:1). The dusts were applied to 1-1/2 acres of cabbage at about 20 pounds per acre. Results clearly showed that the rotenone dust was at least as efficient as either of the arsenical dusts. Since the surface of the cabbage leaf has a waxy coating, it was necessary to employ stickers such as blood albumen, fish-oil soap, or hydrated lime-ferric oxide, when arsenicals are used. Such carriers are not needed with prepared rotenone dust.

The Alabama Polytechnic Institute (10) in 1935 reported that derris dust was effective in controlling cabbage worms.

Elmore, Campbell, and Guy (111) in 1935 described a precision duster for use in cage tests of insecticides. One gm. of dust (derris diluted with talc) deposited an average of 1.3 mg. of dust per square inch, with a range of 1.2 to 1.33 mg. in four different applications. Tests showed a consistent increase in mortality of cabbage worms with an increase in the percentage of rotenone.

Ginsburg and Granett (166) in 1935 discussed arsenical substitutes. Derris mixtures were cited as examples of internal poisons that have proved a valuable adjunct in the control of beetles and caterpillars infesting vegetables, ornamental plants, and house insects.

Huckett and Hervey (204) and the United States Department of Agriculture, Bureau of Entomology and Plant Quarantine (437), in 1935 reported results of tests with derris and cube in western New York and on Long Island in 1934. The derris contained 5.3 percent of rotenone and 21 percent of total extractives. The cube contained 5.1 percent of rotenone and 20 percent of total extractives. Dust mixtures containing either powdered derris or cube root, prepared from roots having nearly the same average content of rotenone and total extractives compared favorably in effectiveness with one another when used against cabbage worms. The differences in results obtained with mixtures containing 0.5 to 1 percent of rotenone were small and variable, indicating that the weaker strength is satisfactory for practical purposes and, for reasons of economy, would be preferable to the 1-percent mixture. All were superior in effectiveness to dusts containing 0.33 percent of rotenone. Talc, clay, finely ground gypsum, and sulfur-clay were satisfactory diluents or carriers. Spray mixtures containing derris powder were slightly more effective than those containing cube powder. The sprays were not quite so effective as derris or cube in dust mixtures.

Two applications of a proprietary dust containing 0.75 percent of rotenone at the rate of 10 pounds per acre gave commercial control of cabbage worms in Aroostook County. -- Maine Agricultural Experiment Station (266) in 1935.

Polvosol was advertised in England, according to Miles and Miles (278) in 1935, for the control of caterpillars. A highly concentrated liquid-derris preparation, Polvosol kills at 1:400 and is particularly suitable for oedema-susceptible plants. Sprays containing derris are valuable alternatives to nicotine sprays and have a much wider range of use because they are effective against caterpillars. Generally used at the rate of 2 pounds of finely ground derris root to 100 gallons of water, with 6 to 10 pounds of soft soap or 1/2 to 1 pound of a suitable wetting and spreading agent.

R. J. Prentiss & Company, Inc., in advertising literature in 1935 stated that for the evaluation of insecticidal dusts less emphasis should be placed on rotenone content and more on total ether extractives. Dusts were prepared from derris containing 5 percent of rotenone and 18 percent of total ether extractives, and also from another lot of derris testing 1 percent of rotenone and 18 percent of extractives. Dusts were made from the case containing in each 15 pounds of powderod derris and 85 pounds of clay.

The first dust tested 0.75 percent of rotenone and the second only 0.15 percent of rotenone, yet both gave substantially the same satisfactory results when used in the field on cabbage worms. The total active ingredients of each dust was 2.70 percent of ether extractives.

Schotte and Gornitz (364) in 1935 stated that a ground mixture of 2.5 parts of Derris elliptica root, 7.5 parts of sabadilla seed, and 90 parts of talcum proved useful in exterminating many kinds of caterpillars. Instead of the drugs, their effective extracts or the alkaloids recovered therefrom may be used by mixing 0.2 percent of rotenone, 0.3 percent of veratrine, and 99.5 percent of kaolin.

Walker and Anderson (466) in 1935 reported tests to determine the tolerance of cabbage seedlings to insecticide dips used for the control of aphids and cabbage worms. Cabbage plants were taken from seedbeds, dipped for 30 seconds in various insecticidal baths, and planted in the field, and the percentage of plants surviving was determined. In a test conducted in the spring of 1933, under favorable weather conditions, over 94 percent of the plants dipped in Super Agricultural Spray (a derris product) survived without injury. In November 1933 tests were made with dips including the commercial derris products, Super Agricultural Spray and Pysol, and also Red Arrow, which was believed to contain some derris in addition to pyrethrum. A severe freeze occurred the night following these treatments. For plants whose tops alone were dipped, the percentages surviving the above-mentioned treatments were 43, 29, and 60, respectively. For plants whose tops and roots were dipped, the percentages surviving were 6, 5, and 14. In a repetition of this test in December, under more favorable weather conditions, the percentages were 93, 96, and 96 for plants with tops dipped and 81, 74, and 95 for plants with tops and roots dipped. In all these tests the derris mixtures were used at dilutions strong enough (1:100) to control cabbage worms and aphids.

Brown (52) in 1936 referred to the use of derris dust (0.6 percent rotenone) for the control of cabbage worms. Twenty-five to 30 pounds per acre applied once or twice is usually sufficient.

The East Malling Research Station, England (107), in 1936 reported that a proprietary derris powder was used in the routine spraying program in 1935 against caterpillars on pears (2.5 lb. + 3-1/3 gal. lime sulfur per 100 imp. gal.), and for caterpillars on walnuts (2 lb. + 8 lb. bluestone + 36 lb. hydrated lime).

The Koloniaal Instituut of Amsterdam (239) in 1936 reported that many insects, including caterpillars of butterflies and moths, can be destroyed with the help of derris.

The New York State Agricultural Experiment Station (301) in 1936 reported that extensive experiments were conducted in western New York in 1934 on the control of cabbage worms, which were unusually prevalent and caused serious damage on Danish cabbage. Derris dust (0.5 percent rotenone) proved more satisfactory than lead arsenate or calcium arsenate. On such crops as broccoli, cauliflower, brussels sprouts, and early or loose-headed cabbage, a derris dust was recommended to avoid arsenical residues.

Comparative tests were made of derris and cube roots in powdered form and as extractives containing the toxic ingredients for the control of cabbage worms. Field tests indicated that extractives were inferior to powdered root for sprays, and that sprays were not so effective as dusts. For spray purposes the most satisfactory results were obtained with a mixture containing 4 pounds of powdered derris root to 100 gallons of water in addition to neutral coconut-oil soap, penetrol, or skim-milk powder as a sticker. For dusting, equally satisfactory results were obtained with derris and cube mixtures (0.5 to 1.0 percent rotenone) containing talc, clay, or air-floated gypsum as the diluent.

The Texas Agricultural Experiment Station (404) in 1936 reported that derris mixed with sulfur gave better control of cabbage worms at Weslaco than when mixed with a finely ground clay or with hydrated lime.

The United States Department of Agriculture (426, 427) in 1936 and 1937 reported as follows:

> "Laboratory and field tests with organic insecticides, particularly derris and cube, have brought many modifications in the recommendations for the control of certain insect pests. It has been demonstrated that these insecticides, which do not leave residues objectionable from the standpoint of human health, can be effectively used against a number of different truck-crop pests, such as certain cabbage worms."

White in 1936 and again (482) in 1937 recommended derris for the control of several insects attacking certain vegetables, small fruits, and tobacco, and implied that cube may be used in place of derris. Cube is specifically mentioned as follows:

> "Preliminary experiments in California have shown that derris, or cube, or pyrethrum-dust mixtures, at the dilutions mentioned for cabbage, gave as satisfactory results in the control of the three more common species of cabbage worms on cauliflower as they did on cabbage."

The Wisconsin Agricultural Experiment Station (487) in 1937 reported that alkaline diluents (e.g., hydrated lime, pH 12.5) reduce the effectiveness of derris and timbo for cabbage worms, but the more acid samples retain their effectiveness in storage.

Bourne and Boyd (42) in 1937 gave directions for the control of cabbage worms. When caterpillars first appear apply a fresh pyrethrum-dust mixture containing at least 30 percent of pyrethrum or a rotenone mixture containing 0.5 to 0.75 percent of rotenone, using about 30 pounds to the acre. Commercial rotenone sprays or dusts may also be used. They should be diluted as recommended by the manufacturer. Usually it is advisable to treat the entire planting, but in cases of light or "spotty" infestations only the infested plants need to be treated.

Consumers Research (80) in 1937 recommended the following rotenone products for use against cabbage worms: Derox, D. P. T. Dust, Kubatox Dust, Kubatox Liquid, Red Arrow Insect Spray, Rotecide, and Rotecide Dust.

Derrisol controls cabbage worms, according to Wm. Cooper and Nephews, Inc., in a letter to R. C. Roark, dated November 16, 1937.

The Louisiana Agricultural Experiment Station (257) in 1937 recommended derris dust (1 percent rotenone) for the control of cabbage worms.

Derris dust (1 percent rotenone) was worthless against the European red moth. A spray of 1-1/4 to 2 pounds of derris powder (4 percent rotenone) plus 5/8 pound of Aresket per 100 gallons of water killed 99 percent. -- Manschke (268) in 1937.

The Rotenone Chemical Company, Inc., Los Angeles, Calif., in advertising literature in 1937 recommended [derris] Barfoot No. 1 and Barfoot No. 2 diluted 1:800 for the control of leaf rollers.

C. E. Smith (372) in 1937 reported that field tests at Baton Rouge, La., showed that derris-dust mixtures containing 1 or 0.5 percent of rotenone were superior to nicotine-peat dust in controlling the more common species of cabbage worms.

Stanco, Inc., in advertising literature in 1937 recommended [derris] Garden Flit for use against cabbage worms and tomato worms.

Dibble (97) in 1938 recommended derris or pyrethrum dust or spray for the control of cabbage worms. Early control keeps the population low and prevents much difficulty later. Sprays do not stick well on cabbage and dusts are often given first choice. In large patches spraying is cheaper if good equipment is available.

Dunlap and Turner (102) in 1938 recommended dust (0.75 percent rotenone) for the control of cabbage worms on cabbage, cauliflower, broccoli, and brussels sprouts. It should be applied when larvae first hatch and again 10 days later at about 20 pounds per acre.

The Idaho Agricultural Experiment Station (210) in 1939 reported that the season's work showed rotenone dust to be effective against cabbage worms.

G. D. Jones (224), of the University of Missouri Agricultural Extension Service, in 1938 recommended a dust containing 0.5 to 1.0 percent of rotenone to control cabbage worms.

The New Jersey Agricultural Experiment Station (294) in 1938 reported that caterpillars protected by rolled leaves were not controlled satisfactorily by derris or cube powder in water to which rosin-residue emulsion had been added.

The New York State Agricultural Experiment Station (304) in 1939 reported that for cabbage worms arsenical dusts are the most economical and are recommended for use on cabbage that is to be trimmed close; but on market cabbage, broccoli, and cauliflower, where arsenical residue must be avoided, the use of rotenone dusts or sprays is recommended.

Parks and Pierstorff (324) in 1938 recommended derris spray to control leaf roller on rose and strawberry.

Roark (357) in 1938 reviewed the comparative action of derris and cube of equal rotenone content on cabbage worms. He referred to Howard and Davidson (195), who found derris and cube dusts and sprays equally effective, and to Huckett and Hervey (204), who reported the dusts to be equally effective but spray mixtures containing derris slightly more effective than those containing cube.

Derris products may be used very effectively against smooth-bodied caterpillars. -- Warwick (471) in 1938.

The Wisconsin Agricultural Experiment Station (488) in 1938 reported that trials carried on in the Racine-Kenosha truck-crop area since 1933 showed that rotenone dust (0.75 percent rotenone) is one of the most effective insecticides for cabbage worms, being more effective than sprays of the same material.

According to Faloon (116) in 1939 the addition of 15 parts of lithopone zinc sulfide pigment to a mixture of 15 parts of derris or cube powder (5 percent rotenone) and 70 parts of kaolin increased the time during which the dust was toxic to cabbage worms.

Haude in 1939, in advertising literature published by John Powell and Co., New York, N. Y., stated that the United States Department of Agriculture recommended a dust containing 0.75 percent of rotenone for use against leaf-eating caterpillars on "greens" such as spinach, lettuce, and turnip, but should be used prior to harvest to avoid excess arsenical residues. Rotenone dusts are effective in controlling numerous leaf-feeding caterpillars but their use has not been extensive because of their cost.

An anonymous (7) writer in 1940 said it is believed that derris and pyrethrum compounds should give the same results on cauliflower, broccoli, kale, or collards, as when used on cabbage, provided the affected parts of the plant can be well covered. Preliminary experiments in California have shown that derris, or cube, or pyrethrum-dust mixtures, at the same dilutions as have been mentioned for cabbage (4 percent derris 1 part, 3 parts diluent) gave as satisfactory results in the control of the three more common species of cabbage caterpillars on cauliflower as they did on cabbage. It was found to be especially important to start the treatments early, while the plants were small, since it was not possible to obtain a good coverage over the heavy foliage of nearly mature plants. Good results were also obtained against cabbage caterpillars on cauliflower with sprays of derris-root powder containing from 0.02 to 0.025 percent of rotenone (viz, 2 to 2-1/2 pounds of derris-root powder containing 4 percent of rotenone per 50 gallons of water).

In 1940 the Experimental Research Station, Turner's Hill, Cheshunt, Herts, England (114), reported that sprays containing derris or Lonchocarpus powders have been found of great value in preventing autumn- and winter-feeding caterpillars from causing injury to vegetable crops in the glass-house.

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