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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 I: COLLEMBOLA, ORTHOPTERA, DERMAPTERA, ODONATA, ISOPTERA, CORRODENTIA, AND MALLOPHAGA

By R. C. Roark, Division of Insecticide Investigations1/

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1/ The manuscript of this publication was read by the following leaders of research divisions of the Bureau, who contributed helpful suggestions: D. L. Van Dine, Fruit Insect Investigations; W. H. White, Truck Crop and Garden Insect Investigations; R. W. Harned, Cotton Insect Investigations; F. C. Bishopp, assistant chief of Bureau, formerly in charge of Investigations of Insects Affecting Man and Animals; C. F. W. Muesebeck, Insect Identification; C. M. Packard, Cereal and Forage Insect Investigations; and L. A. Hawkins, Control Investigations.

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INTRODUCTION

In the past decade a voluminous literature describing the insecticidal uses of derris, cube, and rotenone has grown up. In an effort to collect and classify the information on this subject the writer has compiled a number of reviews which treat separately of Derris, Lonchocarpus, and Tephrosia. These publications (Misc. Pub. 120 and mimeographed circulars E-367, E-402, E-453, and E-468) deal with the data on a chronological basis. Inasmuch as the rotenone and the rotenoids (levodeguelin, toxicarol precursor, etc.) of the various leguminous fish-poison plants are identical, irrespective of botanical origin, it seems logical to treat them together, and not separately according to the plant in which they are found.

In this compilation the writer has endeavored to bring together all the information on the insecticidal uses of Derris, Lonchocarpus, Tephrosia, and Mundulea, and the products that have been isolated from them. The information is arranged according to the orders, families, and genera of insects upon which rotenone and the rotenoids have been tested. The present publication, called Part I, describes all tests that have been made upon members of the Collembola, Orthoptera, Dermaptera, Odonata, Isoptera, Corrodentia, and Mallophaga. (See Insect Index at the end of this circular.)

COLLEMBOLA

Entomobryidae

Lepidocyrtus cyaneus Tull.

Lepidocyrtus lanuginosus (Gmel.)

Thomas (69) in 1934 tested derris against mushroom insects. Powdered derris and rotenone dusts were only partially or slowly effective against these species of springtails and cannot compare with the nicotine compounds for this purpose.

Isotomidae

Isotomurus palustris var. maculata Schäffer

De Bussy, Van der Laan, and Diakonoff (8) in 1936 reported that this insect was controlled by a spray of derris powder in water.

Proisotoma sp. (close to P. thermophila Axels.)

Dusts containing rotenone were only partially or slowly effective.--Thomas (69) in 1934.

Poduridae

Achorutes armatus (Nic.)

Dusts containing rotenone were only partially or slowly effective.--Thomas (69) in 1934.

Unidentified species of Collembola

Epp (22) in 1851 stated that in Banka (an island lying east of Sumatra) derris is used for destroying the tree lice, springtails, and "all kinds of vermin pernicious to vegetables." For this purpose the root is cut into pieces, soaked for some days in water, and sprinkled on the plants.

Jancke (42) in 1931 mentioned Polvo (powdered derris root) as a preparation for control of ground fleas, and in the same year the Deutsche Pflanzenschutzdienst (21) approved it for this purpose, recommending that it be dusted at the rate of 2 to 3 gm. per square meter of ground surface.

Trappmann (72), in his book on insect control published in 1932, referred to the presence of derris in European products used successfully for the control of springtails.

Bock (5) in 1934 controlled ground fleas with a spray made by percolating derris root with fuel alcohol in the proportion of 1 to 5 and adding 100 gm. of this tincture and 125 gm. of soft soap to 7 liters of water.

Miles and Miles (54) in 1935 stated that the application of derris powder to the surface soil in glass houses is effective against springtails.

ORTHOPTERA

Acrididae

Melanoplus differentialis (Thos.), the differential grasshopper

Melanoplus femur-rubrum (Deg.), the red-legged grasshopper

Campbell (12) in 1932, in a review of both unpublished information and published articles on the insecticidal value of rotenone, referred to C. H. Richardson and also Davidson, who found that rotenone is ineffective against grasshoppers. Richardson fed rotenone in bran-molasses baits to the differential grasshopper and the red-legged grasshopper. One grasshopper took a dose of 3.9 mg. of rotenone per gram of body weight, yet lived more than 4 days. Low toxicity was also indicated by experiments with rotenone in corn-leaf sandwiches. Richardson concluded that rotenone has little if any toxicity to grasshoppers.

Richardson and Haas (64) in 1932 reported on the evaluation of stomach poisons for grasshopper baits. The median lethal dose of rotenone (94.6 percent pure) to the red-legged grasshopper is more than 2 mg. per gram of body weight. The median lethal doses of other substances are as follows: Monosodium arsenite, trisodium arsenite, paris green, and sodium fluosilicate, 0.16 mg.; arsenious oxide, 0.36 mg.; and acid lead arsenate, more than 3 mg. per gram. These results were obtained by feeding the insects determined quantities of a bran-molasses-water bait containing known concentrations of the poisons. The possibility that certain ingredients of the bran bait might react with rotenone to reduce its toxicity led to some tests by a leaf-sandwich method previously described. Corn-leaf sandwiches containing rotenone in starch paste were fed immediately after preparation to adults of M. femur-rubrum. Doses of about 4.5 to 7.0 mg. per gram were fatal in 30 to 73 hours. Recovery occurred from doses of 0.7 to about 1.3 mg. per gram.

Schistocerca gregaria (Forsk.), a desert locust

Regnier (63) in 1931 reported the following percentage mortalities resulting from tests of derris and rotenone baits on third instars of the desert locust: (1) Wheat bran, 100; derris as an impalpable powder in suspension in water, 0.4; and (2) rotenone as a 4-percent solution in acetone, 0.02; molasses, 8; water, q. s. The percentage mortalities with the derris bait were: After 24 hours, 10 to 15; after 48 hours, 30 to 40; after 72 hours, 40 to 50. With the rotenone bait the percentage mortalities were: After 24 hours, none; after 48 hours, 5; and after 72 hours, 10.

(Stenobothrus) Chorthippus sp.

De Bussy, Van der Laan, and Diakonoff (8) in 1936 reported the results of tests made in Holland with derris dusts and sprays. Both the mature and immature forms of Stenobothrus sp. are sensitive to derris. Dusting, as well as spraying with a suspension of the powder in water, is successful. The effect is slow in becoming apparent.

Table 1.--Effect of derris sprays and dusts on Stenobothrus sp.

Manner of application	Agent used	Concentration: Rotenone	Concentration: Ether extract	Percentage dead
Spraying - - - -	Rotenone	1:5000	---	75
Do - - - -	Derris powder	1:7000	---	100
Dusting - - - -	Derris dusting mixture	0.8 pct.	2.1 pct.	80
Do - - - -	do	trace	2.0 pct.	15
Do - - - -	Kieselguhr	---	---	12

The percentages of dead insects are the averages of several tests, with 20 insects per test. The counts were made every 3 days. For the spraying liquids, 0.1 percent of Agral (an alkyl cyclic petroleum sulfonate) was used as a spreader.

Van der Laan (47) in 1936 included Stenobothrus sp. in a list of insects sensitive to derris.

Valanga nigricornis (Burm.), a Javanese grasshopper

This insect was used by the Federated Malay States Department of Agriculture (27) in 1935 and in 1936 (28) to test the manner in which derris affects insects, but no results were reported.

Grasshopper (species undetermined)

Ridley (65) in 1912 wrote that the Chinese in the Malay Peninsula killed grasshoppers on vegetables and other crops by spraying with water in which derris roots had been pounded.

The Institute of Physical and Chemical Research (41) of Tokyo, Japan, in 1927 stated that Neoton (a preparation of derris extract in fish oil) killed 70 percent of grasshoppers when applied at the rate of 1 pound plus 1 pound of soap per 40 imperial gallons of water.

The Philippine Sugar Association Research Bureau (59, 60) in 1932 reported tests of Philippine-grown derris of unspecified rotenone content against grasshoppers. Derris powder was tested, both as a spray suspended in water and as a dust, upon third instars, which were given food 5 hours after treatment. To determine whether derris acts as a stomach poison or as a contact poison some of the fourth instars were dusted and put on untreated food, others were put on sugarcane leaves that had been dusted with derris, and in another test both leaves and insects were dusted. The results of these tests are shown in table 2.

Table 2.--Effect of derris sprays and dusts on Philippine grasshoppers

Treatment	Percentage killed	
	First series	Second series
Spray: 15 gm. per liter- - - - -	48.58	57.00
Spray: 30 gm. per liter- - - - -	74.87	74.02
Control - - - - - - - - - - - - - -	26.89	34.78
Dust: 15 gm.- - - - - - - - - - -	87.75	90.18
Dust: 30 gm.- - - - - - - - - - -	98.58	90.33
Control - - - - - - - - - - - - - -	78.71	70.38
Fine dust - - - - - - - - - - - - -	95.19	91.93
Coarse dust - - - - - - - - - - - -	74.45	69.51
Control - - - - - - - - - - - - - -	40.09	76.35
Insects dusted - - - - - - - - - -	24.40	25.09
Food dusted - - - - - - - - - - - -	40.28	32.27
Both insects and food dusted - - -	84.82	72.69
Control - - - - - - - - - - - - - -	14.00	20.73

The Philippine Sugar Association Research Bureau (61) in 1933 reported further tests of insecticides against grasshoppers in the Philippines. Grasshoppers and food were dusted before they were placed in the corrals. Sodium fluoride dust gave 100-percent kill after 30 hours. Fine derris was rather slow in its effect, although at the end of 60 hours two series of tests averaged 93.51-percent kill, coarse derris averaged 71.98 percent, and untreated grasshoppers in controls, 58.07 percent. Fine derris containing 5 percent of lubricating oil gave an increased kill over derris alone by about 30 percent; however, this mixture lost its buoyancy because the dust particles were cemented by the oil. In another experiment lubricating oil was replaced by kerosene, but on account of the high mortality in the control plots no definite conclusion could be drawn.

Later this association (62) reported that laboratory experiments with derris gave satisfactory kills against grasshoppers, but field trials were a failure. Derris acts slowly on grasshoppers, and in places where there are frequent rains it is easily washed away and is, therefore, too unreliable to use.

Tischler (71) in 1935 reported the results of studies on how derris kills insects. Derris must penetrate into the insect body to produce its toxic effects. Derris spray or dust has low toxicity to grasshoppers, which, however, are susceptible to derris when a water extract is injected into the blood stream.

Chamberlin and Madden (15) in 1937 reported that cube is not toxic to grasshoppers.

The Bureau of Foreign and Domestic Commerce, of the United States Department of Commerce (75), in 1937 reported that the Government of the Union of South Africa was conducting researches to discover a cheap, efficient locust killer less poisonous than sodium arsenite. Some preliminary investigations undertaken with powders containing rotenone and with liquid sprays did not yield very favorable results.

Blattidae

Blatta orientalis L., the oriental cockroach

Hockenyos (37) in 1933 reported on the effect of dusts on the oriental roach. It was found that particles of pure magnesium carbonate from 1 to 10 microns in size do not enter the tracheae of this roach when the roaches are submerged in the dust or suspended in a dust-charged atmosphere. Ten roaches were similarly treated in the dusting machine, but a clay dust containing 10 percent of derris resin was used and the time of dusting reduced to 20 minutes, after which the roaches were individually freed from as much dust as possible by means of an air blast and soft brush, to prevent the possibility of their ingesting enough derris from the antennae or legs to cause death. These insects seemed unaffected at the end of 2 days and the experiment was discontinued.

De Lapparent (48) in 1934 reported that a powder made by mixing 10 parts of derris (5 percent rotenone) and 90 parts of potato starch eradicated roaches, B. orientalis, from a hotel in France.

Blattella germanica (L.), the German cockroach

McIndoo, Sievers, and Abbott (52) in 1919 reported the results of laboratory tests with powdered derris root. Six small cages were thoroughly dusted, and 20 roaches were placed in each cage. At the end of 1 week the average mortality was 57.5 percent.

Gilmer (33) in 1923 reported the results of tests of a mixture of 20 percent of commercial derris powder and 80 percent of tobacco dust on cockroaches, both B. germanica and Periplaneta americana (L.). The dust mixture was effective but slow in action against roaches. Roaches forced to run through the powder and then confined in cages or small glass jars all died within 24 hours. These roaches were forced to run over a considerable depth of the powder and were thoroughly coated with it. The powder was also mixed with flour and a little sugar, and roaches were allowed to feed on it. It proved an effective stomach poison, killing all the roaches experimented on.

Davidson (18) in 1930 reported that dust containing 1 or 2 percent of rotenone (made by adding pure rotenone to diatomaceous earth) controlled German roaches, probably through internal rather than contact action. When the roaches were dipped for 30 seconds in a suspension of rotenone made by adding an acetone solution to water, none of the roaches were killed at a concentration of 1 part of rotenone to 250 parts of water.

Woodbury (80) in 1938 reported on methods of testing liquid insecticides on the German cockroach. On the basis of concentration by weight of toxicant in Deo-Base (an odorless kerosene) required to kill a given percentage of second instars, rotenone and pyrethrins were about equally toxic, whereas normal butyl carbitol thiocyanate was much less toxic but pcssessed striking paralytic properties. There was no difficulty, however, in making a concentration of the thiocyanate that would give a high kill. A 50-50 combination of rotenone and pyrethrins was not more toxic to second instars than an equivalent concentration of either alone. Adult males were about 2 1/2 times and adult females about 4 1/2 times as resistant to the Official Test Insecticide as were second instars. Pyrethrum sprays caused female roaches to drop their egg capsules, some of which later hatched. Normal butyl carbitol thiocyanate produced the same effect to a lesser degree, whereas rotenone did not cause the females to drop their capsules.

Anisole was used to aid the solution of rotenone in Deo-Base, the solution containing 15 percent of anisole by volume. A solution containing 100 mg. of rotenone per 100 cc. killed an average of 59 percent of second instars of the German cockroach.

Periplaneta americana (L.), the American cockroach

The Ceylon Department of Agriculture (13, 14) in 1932 treated bookbinding cloth with various substances in an effort to find something that would protect it against this roach. Eleven poison solutions were prepared for this purpose. Alcoholic extracts of the roots of Derris malaccensis and D. elliptica and of the leaves of Tephrosia vogelii proved of little value. Best results were obtained with solutions of mercuric chloride and ammonium arsenite.

The Federated Malay States Department of Agriculture (24) in 1933 reported that adult P. americana had been used in laboratory tests to determine the value of dusts and sprays containing derris extracts, but no results are given. Again in 1934 this department (26) referred to the use of this species as a test insect to determine the insecticidal value of Derris elliptica and D. malaccensis, and in 1935 (27) it stated that large numbers of this insect were being kept for experimental work to ascertain the manner in which derris affects insects.

The Monsanto Chemical Company (56) in 1934 reported that a mixture of 1 part of dry derris extract, 3 parts of dry Aresco (a sulfonated biphenyl), and 96 parts of talc killed P. americana almost as quickly as did a mixture of 4 parts of dry derris extract and 96 parts of talc, and interpreted this to mean that Aresco has an activating effect. In 1935 the Rubber Service Laboratories Company, Inc., a subsidiary of the Monsanto Chemical Company, reported the same findings with another proprietary wetting agent, namely, Areskap (sodium monosulfonate of butylphenylphenol), also made by this company.

Tests made by using derris in 4.0-, 2.0-, 1.0-, 0.5-, and 0.25-percent solutions, with and without Areskap, indicated that it has an

activating effect. Fine talc was used as a filler, and the roaches were tested in jars, five to eight roaches in each jar. Areskap itself has practically no effect on roaches.

Tischler (71) in 1935 observed that the rate of pulsation of the heart of the American roach was markedly decreased after treatment with derris Tests on this insect 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.

Miller (28, 55) in 1935 reported on the toxic value of different species of Derris. Rotenone was ineffective as a stomach poison to the American cockroach, and derris incorporated in baits had a repellent action on this species. Cockroaches were fed for a long period, without ill effect, on mixtures of tapioca flour and derris powder or rotenone. An analysis was made of the excreta from cockroaches that had fed on rotenone baits. Some rotenone was recovered by direct extraction with carbon tetrachloride. After treatment of the residue with dilute sulfuric acid an additional amount of rotenone was obtained. It was suggested that part of the rotenone may be converted in the metabolic processes to a derivative insoluble in carbon tetrachloride. [This is open to question. It seems more likely that the original treatment of the excreta with carbon tetrachloride was not sufficient to extract the rotenone completely.--R.C.R.]

The Federated Malay States Department of Agriculture (25) in its annual report for 1934 referred to Miller's work.

Van der Laan (47) in 1936 reported that P. americana was sensitive to derris.

The American cockroach is very sensitive to dusting with derris. Treatment with a dusting mixture containing 1 percent of rotenone and 2.4 percent of ether extract kills the full-grown insects in half a day. The powder containing 0.5 percent of rotenone and 1.2 percent of ether extract kills the insects in 1 or 2 days.--De Bussy et al. (8) in 1936.

The Federated Malay States Department of Agriculture (29, 39, 40) in 1938 reported that rotenone, deguelin, and toxicarol in tapioca flour are nontoxic as stomach poisons to P. americana. The insects refused to feed on cocoa powder mixed with toxicarol precursor and died of starvation.

Johnson and Vallee (43) in July 1938 reported on tests at the Naval Medical School which showed that, when American cockroaches were exposed to either sodium fluoride or derris, a period of about 24 hours was required for lethal effect; but the lethal effect was certain with either material. Derris is therefore slower in action than pyrethrum, but it is undoubtedly effective in ultimate kill of insect pests. [According to a private communication from L. B. Kilgore, who cooperated in these tests, the species experimented with was P. americana.--R.C.R.]

In the tests conducted at the Naval Medical School 100 cockroaches were dusted with sodium fluoride, sulfur, powdered derris, and pyrethrum powder, and with combinations of derris and pyrethrum. Clay and sulfur were used as diluents with derris and pyrethrum. Upon the appearance of symptoms, insects were removed to wire cages away from the insecticide. Insects exposed to rotenone in the absence of pyrethrum were removed to cages 5 minutes after the beginning of the exposure.

The derris assayed 5 percent of rotenone and the pyrethrum assayed 2 percent of pyrethrins, except one sample, which assayed 0.9 percent of pyrethrins. The authors concluded that a mixture of 0.4 percent of pyrethrins and 1 percent of rotenone with alkaline-free sulfur or nonalkaline clay is a safe insecticide and is more active than sodium fluoride, and that stabilized derris or cube powder (assaying 3 to 5 percent rotenone), used in the percentage proportion required to yield 1 percent of rotenone, adds to the ultimate toxicity of a powder.

Periplaneta australasiae (F.)

Neostylopyga rhombifolia (Stoll)

These species, like P. americana (q. v.), were not prevented from attacking bookbinding cloth when it was treated with alcoholic extracts of the roots of Derris malaccensis and D. elliptica and the leaves of Tephrosia vogelii.--Ceylon Department of Agriculture (13) in 1932.

Roaches (species undetermined)

Geoffroy (32) in 1895 described tests on certain insects with rotenone extracted from Lonchocarpus nicou. Flies were placed under a bell jar with a piece of sugar dried in an oven after being dipped into an alcoholic solution saturated with nicouline (rotenone). The flies that came to the sugar soon fell and manifested their vitality only by an intermittent trembling of the feet and wings. The same results were obtained with wasps and cockroaches.

Schmitt (66) in 1930 reported that dusting with finely pulverized derris was ineffective against cockroaches.

Peyer (58) in 1930 recommended a mixture of derris powder with flour and sugar as a stomach poison for cockroaches.

Worsley (81) in 1934 extracted the seeds of Tephrosia vogelii with paraffin oil and sprayed the extract upon cockroaches. He concluded that this spray was about half as toxic as a similar pyrethrum spray, and furthermore acted more slowly.

An anonymous (1) writer in 1935 stated that the inclusion of from 5 to 25 percent of derris or cube powder with pyrethrum had recently been noted in roach powders.

Worsley (82) in 1936 reported tests with derris (5.4 percent rotenone) and with the bark of Mundulea suberosa Benth. (0.9 percent rotenone). Powdered pyrethrum (Kenya-grown) required 17 hours to kill 98 percent of the roaches dusted with it, whereas powdered derris, Mundulea bark, and Mundulea seed killed 100 percent in 18 hours. Mundulea bark and derris are almost identical in action; the first effect is to cause the insects to become very agitated and dash rapidly about the dish for about 10 to 15 minutes, after which they become quiet with occasional violent movements; after several hours they fall on their backs (but recover again) during each period of activity, until after about 10 hours they are permanently on their backs. During the first few hours the cockroaches appear to be trying to clean themselves, especially the leg joints, with their mouths. Further trials were carried out in which the cockroaches, after being dusted with the powders, were removed to clean dishes, in which they were merely made to walk through the insecticide by putting a ring of powder around the inside edge of the dish and placing the cockroaches in the center. In every case the results were similar to those given above.

Cockroaches were sprayed with paraffin-oil extracts of the three substances, prepared by shaking the finely ground powder with the paraffin in the correct quantity to produce 10-percent extracts. They were sprayed for 2 seconds from a distance of 2 feet under the usual standard conditions. The cockroaches were examined after 24 and 48 hours. All three extracts have identical toxicities at the higher concentrations, but pyrethrum is slightly more toxic at the 2.5-percent strength, although most of the roaches that were seriously affected after 24 hours had recovered in 48 hours. The results are shown in table 3.

Table 3.--Mortality of cockroaches sprayed with paraffin oil extracts of pyrethrum, Mundulea, and Derris

Spray	Concentration	Mortality in-- 24 hours	48 hours
	Percent	Percent	Percent
Paraffin oil only	---	---	---
Pyrethrum	10	100	100
Do	5	90	90
Do	2.5	65	35
Mundulea	10	100	100
Do	5	90	90
Do	2.5	20	20
Derris	10	100	100
Do	5	90	90
Do	2.5	35	20

Boyd (6) in 1937, in a discussion of the use of rotenone for the control of household insects, referred to its application in sprays for roaches.

An anonymous writer (2) in 1937 described the use of derris against insects in Holland. A dust containing 3 percent of rotenone placed in the running and hiding places of cockroaches proved to be effective for weeks against young nymphs and adults, but did not affect the eggs.

Jones (44) of the Extension Service, United States Department of Agriculture, in 1939 recommended derris or cube for the control of cockroaches.

Gryllidae

Gryllotalpa sp., a mole cricket

In 1920 the Federated Malay States Department of Agriculture (23) sprayed extract of tuba root (Derris sp.) upon mole crickets, but the results were uncertain.

Gryllus assimilis (F.), the field cricket

Thomas and Reed (70) in 1937 reported that G. assimilis caused much damage to strawberries in the Chadbourn area of North Carolina. Three series of toxicity tests were conducted in the laboratory in cylindrical cages, each containing 20 active crickets. Checks containing baits with molasses solution but no poison were employed in all tests. Examinations were made at 24-hour intervals for 2 days in the first test and for 3 days in the second and third tests. The following materials were tested as poisons for bait: Sodium fluosilicate, sodium fluoride, barium fluosilicate, calcium arsenate, white arsenic, derris, and paris green. They were mixed with corn meal, wheat middlings, a mixture of equal parts of wheat middlings and cottonseed meal, chick mash and cottonseed meal, 10 pounds of the poison being used to 90 pounds of the feed, and enough molasses solution (1:9) to moisten the mass. Derris and paris green gave the poorest results and sodium fluosilicate the best. In one series of tests the mortality from derris was only 53 percent at the end of 3 days, whereas for sodium fluosilicate it was 76 percent at the end of 1 day and 100 percent 2 days after treatment.

Gryllus domesticus L., the house cricket

Caesar and Dustan (10) in 1939 described tests against G. domesticus. Crickets collected late in October were placed in large jars partially filled with old rags and bits of paper, and kept supplied with water and food. Several tests with a number of foods indicated that dry rolled oats was as attractive as any. The insecticides were applied in four ways: (1) Layer method. The crickets were allowed to run over a layer of poison about 1/32 inch thick for from 1 to 2 minutes, and were then transferred to

a cage with unpoisoned food. (2) Ring method. A teaspoonful of unpoisoned food was placed in the center of the cage, and around this, at a distance of about 3 inches, a ring of poison about 3/4 inch wide and 1/8 inch deep was poured. (3) Spot method. Unpoisoned food was put at one or two places on the floor of the cage, then a little of the poison was put in one spot at another place on the floor, the purpose being to see whether the crickets avoided the poison. The results showed that, under cage conditions at least, crickets did not seem to be repelled by either sodium fluoride or pyrethrum, but walked over the poison and were killed. (4) Bait method. The poison was mixed with the food (usually rolled oats) and placed in the cages with the crickets. Derris powder by the layer and bait methods killed 16 percent in 7 days. Pyrethrum by the ring and spot methods killed 100 percent in 1 day and by the layer method 100 percent in 7 days.

Phasmatidae

Carausius morosus Brunn., a walkingstick

Klinger (46) in 1936 reported that when pure rotenone was allowed to stand for several days in physiological salt solution and was then injected into C. morosus no injury was caused in most cases.

Tettigoniidae

Sexava sp., a coconut treehopper

Froggatt (30) in 1938 reported tests of insecticides against Sexava sp. Cages were made of copra-bed wire about 3 feet high and 2 feet in diameter, in which fresh coconut foliage was suspended and a number of Sexava, collected at night, were placed. The dust was then applied by means of a hand-dusting machine, and the number of deaths recorded over a period of 3 days. In each series one cage was untreated, to serve as a check. The nonarsenicals comprised various preparations of derris (as pure powder, and total extractives, diluted with an inert filler) and pyrethrum; both proprietary and experimental preparations were used. The nonarsenicals gave variable results, even with the same preparation, ranging from 48 to 59 percent under the same conditions.

Tachycines asynamorus Adel., the greenhouse stone cricket; a green grasshopper

Schotte and Görnitz (67) stated that a ground mixture of 2.5 parts of Derris elliptica roots, 7.5 parts of sabadilla seeds, and 90 parts of talcum successfully controlled T. asynamorus. Instead of the drugs, their active principles may be used; for example, a suitable mixture contains 0.2 percent of rotenone, 0.3 percent of veratrin, and 99.5 percent of kaolin.

Klinger (46) in 1936 reported that rotenone and derris powder produced no symptoms of poisoning when applied to the head organs of Tachycines asynamorus.

DERMAPTERA

Forficulidae

Forficula auricularia L., the European earwig

Van der Laan (47) and de Bussy et al. (8) in 1936 reported that the European earwig is not affected by derris.

ODONATA

Aeshnidae

Aeshna sp.

Danneel (17) in 1933 reported that Aeshna larvae were uninjured after 24 hours in a solution of rotenone of 0.001-percent concentration.

Unidentified species of Odonata

Daniels (16) in 1905 reported that the larvae of dragonflies are only temporarily injured by the application of fresh derris root macerated in water.

ISOPTERA

Unidentified species

Daniels (16) in 1905 reported that in British Malaya derris had been used, mainly unsuccessfully, to deal with termites.

Hoover (38) in 1910 stated that a rubber plantation had been freed from white ants with tuba, prepared by beating the root and mixing it with water. This mixture, whether strong or weak, did not affect the trees or other vegetation. If the infestation was light, the mixture was poured around the infested tree; in heavy infestations a little earth was first taken away from the roots. In reply to this article, the editor, H. N. Ridley, stated that tuba root had often been tried against termites, with more or less success. It would eject them temporarily but, like other liquid insecticides, was too easily washed out by rain.

Miller (55) in 1935 made spraying, dusting, and immersion tests with three types of derris root grown in British Malaya against species of Isoptera, but no results are recorded.

CORRODENTIA

Psocidae

Liposcelis divinatorius (Müll.)

Trogium pulsatorium (L.)

Back (4) in 1939 wrote that pyrethrum or derris powder will kill these psocids if it is blown into cracks and crevices about baseboards, door and window trim, cupboards, and other places.

MALLOPHAGA

Gyropidae

Gliricola porcelli L.

Gyropus ovalis Nitz.

The California Agricultural Experiment Station (11) in 1923 and De Ong and White (20) in 1924 reported that a dust made by mixing 20 parts of ground derris root with 80 parts of calcium carbonate gave perfect control of Gliricola porcelli and Gyropus ovalis on the guinea pig.

Menoponidae

Eomenacanthus stramineus (Nitz.) (syn., Menopon biseriatum Piaget), the chicken body louse; a large body louse of poultry

Menopon gallinae L. (syn., M. pallidum Nitz.), common chicken louse

Gilmer (33) in 1923 reported that derris powder alone, and also when mixed with tobacco dust, was effective against M. biseriatum.

A dust containing 20 parts of derris powder and 80 parts of calcium carbonate gave perfect control of M. biseriatum, according to California Agricultural Experiment Station (11) in 1923 and De Ong and White (20) in 1924.

Davidson (18) in 1930 reported that a dust of 1 part of rotenone and 99 parts of diatomaceous earth killed 100 percent of Menopon stramineus and M. pallidum on chickens.

M. pallidum and M. biseriatum can be controlled with derris powder containing from 2 to 7 percent of rotenone. Poultry can be freed from these lice in 2 or 3 days if the powder is dusted between the feathers.--De Bussy et al. (8) in 1936.

Philopteridae

Goniocotes gigas Tasch., the large chicken louse

Goniocotes hologaster Nitz., the fluff louse

Lipeurus heterographus Nitz., the chicken head louse

A dust containing 20 parts of derris powder and 80 parts of calcium carbonate gave perfect control of G. gigas, according to California Agricultural Experiment Station (11) in 1923, and De Ong and White (20) in 1924.

Little (49) in 1931 reported that the powdered root of Tephrosia virginiana was 100 percent effective against all lice experimented with. Six hens and two roosters infested with G. hologaster and G. gigas were dusted and put in a coop. A day later one live louse was found and it was paralyzed. At the end of the second day no live lice were found.

Derris powder alone and also mixed with tobacco dust was effective against L. heterographus.--Gilmer (33) in 1923.

Brittain (7) in 1925 reported that the following derris treatments gave perfect results in the control of L. heterographus on young chicks: (a) Derris 1 part plus 3 parts vaseline, 11 drams per 100 chicks; (b) derris powder, 16 drams per 100 chicks; (c) derris 1 ounce, calcium caseinate 1 gram, and water 8 imperial gallons. The birds were rapidly immersed in the fluid and the feathers ruffled.

Trichodectidae

Bovicola bovis (L.) (syn., Trichodectes scalaris Nitz.), the cattle biting-louse

Bovicola pilosus (Gieb.) (syn., T. pilosus Gieb.), a biting-louse of horses

Trichodectes canis Deg. (syn., T. latus Nitz.), a biting-louse of dogs

Trichodectes subrostratus Nitz.

Trichodectes sp.

Derris proved effective against B. bovis. Derris powder, 1 ounce per animal, applied with a dust gun killed all lice and their eggs. A mixture of derris with an equal quantity of flour, applied at the rate of 1 or 1.5 ounces per animal, also killed all lice and their eggs. A mixture of equal parts of derris and sodium fluoride dusted on calves at the rate of 1 3/16 ounces per animal killed all lice. A mixture of equal parts of derris and tobacco dust, the latter containing about 0.1 percent of nicotine, killed all adult lice, but some of the eggs escaped destruction. Mixtures of derris, 1 part, and tobacco dust, 10 parts; and of derris, 1 part, and flour 3, 5, 10, or 20 parts, killed most but not all the lice.--Wells, Bishopp, and Laake (78) in 1922.

The Bureau of Animal Industry of The United States Department of Agriculture (73) in 1935 reported that a mixture of 1 part of derris powder (5 percent rotenone) and 99 parts of kaolin in a single application was found to be effective for the destruction of B. bovis and B. pilosus. When the content of derris in the powder was reduced to 1/2 part per 100, two applications killed all lice.

Schroeder (68), of the Bureau of Entomology and Plant Quarantine, in 1937 reported that a derris-tripoli-earth mixture containing 1/8 of 1 percent of rotenone controlled both B. bovis and B. pilosus. Tephrosia virginiana root was as effective as derris when the rotenone concentration was the same. These dusts had no effect on the eggs. From 1 to 4 ounces of dust, depending on the size of the animal, is sufficient to give good coverage.

Babcock (3) in 1938 recommended a dust containing not less than 1/8 of 1 percent of rotenone for the control of cattle lice in Texas, including B. bovis. From 1 to 4 ounces of this dust should be worked into the hair of each animal, depending on its size. A suitable rotenone dust is made by diluting derris or cube with kaolin or talc.

A second treatment 11 days after the first is necessary in order to kill the lice hatched from eggs presumably present at the time of the first application.

Little (49) in 1931 dusted with powdered root of Tephrosia virginiana a puppy infested with Trichodectes canis. An examination 1 day later failed to reveal any live lice.

De Bussy, Van der Laan, and Jacobi (9) in 1935 reported derris powder to be excellent against T. canis.

De Bussy, Van der Laan, and Diakonoff (8) in 1936 reported that a cat infested with T. subrostratus was freed of this vermin by treatment with a derris dusting powder containing 0.35 percent of rotenone.

Van der Laan (47) in 1936 reported that one of the principal uses of derris in Holland was to control vermin (e. g., Trichodectes spp.) on cats and dogs.

Unidentified species of Mallophaga

McIndoo, Sievers, and Abbott (52) in 1919 reported that derris dust was effective against chicken lice. Twelve hens badly infested with several species of Mallophaga were thoroughly treated with the powder, which was well rubbed in through the feathers. When the hens were examined 2 or 3 days later they were free from lice.

Wells, Bishopp, and Laake (78) in 1922 reported the results of tests of powdered derris root against certain external parasites of animals. When chickens infested with seven species of lice (Mallophaga) were thoroughly dusted with derris the lice were very quickly destroyed, practically all of them being dead the day following treatment. Subsequent examinations extending over a period of 6 weeks showed no live lice present, indicating that the eggs were killed or the young lice destroyed upon hatching. All lice were dead 3 days after the fowls were dipped in a bath of 1/4 ounce of powdered derris in 1 gallon of water.

The Bureau of Entomology (78) in 1922 reported derris dust to be very effective against lice of cattle and other domestic animals.

The Ohio Agricultural Experiment station (57) in 1922 reported that Derrisene (a liquid extract of derris) seemed to kill all the lice on hens without perceptible injury to the hens, but its action was considerably slower than that of sodium fluoride.

Wardle and Buckle (76) in 1923, in reviewing information on derris, mentioned that it had been used successfully as a dust, mixed with an equal weight of cornstarch, against Mallophaga on domestic animals.

McIndoo and Sievers (51) in 1924 reported that cube powder, dusted into the hair of three cats badly infested with Mallophaga, was efficient.

Kelsall et al. (45) in 1926 reported that derris powder, undiluted and also 1 part of derris to 3 parts of dry cement powder, was very effective against lice on cattle and horses.

According to tests made at the Animal Husbandry Experimental Station, Chiba, Japan, and reported in 1927 by the Institute of Physical and Chemical Research (41) of Tokyo, Japan, Neoton (derris extract in fish oil), applied at the rate of 1 pound plus 2 pounds of soap in 40 imperial gallons of water, killed all lice on 36 full-grown chickens, whether applied by spraying, painting, or bathing. No directly injurious action of Neoton on the chickens was noticed.

Haseman (34) in 1929 mentioned that derris had proved satisfactory for the control of some of the pests of livestock and poultry.

Schmitt (66) in 1930 reported derris dust to be effective against chicken lice.

Peyer (58) in 1930 recommended the following dusts for use against ectoparasites of vertebrate animals: (A) 8 parts of derris powder, 67 parts of tobacco dust, 25 parts of sulfur; (B) 20 parts of derris powder and 80 parts of tobacco dust.

Fulmer (31) in 1930 stated that many insects, particularly lice, are amenable to control by derris.

Little (50) in 1931 reported that the root of Tephrosia virginiana gave almost perfect results on various species of lice.

Davis (19) in 1932 stated that derris seemed to have special usefulness as a control for lice on domestic animals.

Herrarte (36) reported in 1933 that Derris grandifolia is used in Guatemala to kill lice on livestock. [This plant is properly called Piscidia grandifolia (Donn. Sm.) I. M. Johnston.]

Meads (53) in 1933 reported on control measures for external parasites of poultry in Malaya. Parasitized birds may be dipped in a solution of tuba root (1 lb. to 10 imp. gal. water), the feathers being manipulated by hand to enable the solution to reach the skin. A hot day should be chosen for the carrying out of this treatment so that the birds will dry quickly.

Whittaker and Whittaker (79) in 1935 found derris powder to be an effective treatment for body lice. Several badly infested cocks were dusted by the pinch method with small amounts of a ground derris powder having a 1-percent-rotenone content. In 18 hours no signs of any live lice could be found.

Hearle (35) in 1938 stated that derris powder in dilutions of up to 10 parts of an inert carrier, such as cornstarch, is fairly effective against both types of lice on all classes of livestock.

Wells (77) in 1938 reported that derris powder diluted with tripoli earth to 1/16 of 1-percent-rotenone content kills some but not all cattle lice and, because of the small difference in cost of rotenone content, 1/4 of 1 percent is judged to be the proper dilution for general recommendation. Such a content would compensate for lack of thoroughness in application.

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