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EFFECT OF ARSENICAL AND COPPER INSECTICIDES ON THE NATURAL CONTROL OF WHITEFLIES AND SCALE INSECTS BY FUNGI ON ORANGE TREES IN FLORIDA

By
S. B. HILL, JR., W. W. YOTHERS, and RALPH L. MILLER
U. S. Department of Agriculture
Bureau of Entomology

One of the most important considerations in the choice of an insecticide for use on living plants is the effect it may have on the tree or plant on which the application is made. In killing insects on citrus trees one of the important requirements is that the insecticide shall not destroy the great abundance of beneficial entomogenous fungi present on the trees. When new materials were being tried as insecticides against the Mediterranean fruit fly in 1930, it was always important to know just what effect these would have on the entomogenous fungi on the citrus trees. Copper and arsenical insecticides having been found to be the most promising, as reported in a paper by Miller and McBride[1], these materials, with a few others, were used in the toxicity work on entomogenous fungi. The effect of these materials on citrus trees and fruit has been investigated by Miller and Bassett[2]. The present paper is concerned mainly with the effect of arsenical and copper insecticides on scale fungi and whitefly fungi on citrus trees.

Method of Investigation.—Three citrus groves at Orlando, Fla., were used for the experimental spraying in 1930. One was of Valencia orange trees that were only about 7 years old, another was of seedling trees some 30 or more years old, and the third was of mixed seedling and budded trees. The spraying was done with hand sprayers, and only small parts of the trees were sprayed, following the method used during the Mediterranean fruit fly campaign. A record of fungi present was made

[1] Miller, Ralph L., and McBride, O. C. Experiments with Copper Carbonate, Lead Arsenate, and Other Compounds Against the Mediterranean Fruit Fly in Florida. Journ. Econ. Ent., vol. 24, no. 6, pp. 1119-1131. 1931.

[2] Miller, R. L., Bassett, Ione P., and Yothers, W. W. Effect of Lead Arsenate Insecticides on Orange Trees in Florida. U. S. Dept. Agr. Tech. Bul. 350, 20 pp. 1933.

six to eight months after the first application. An accurate record was kept of meteorological conditions, but only those data that seem necessary or significant are given in this paper.

In both the Valencia and the seedling orange groves seven trees were used in each plot. Three were left as checks and four were sprayed. In some cases only half of a tree was sprayed and this was checked against the unsprayed half.

Rainfall.—The rainfall during the period covered by the experiment, June 1930 to April 1931, was 47.68 inches in the Valencia grove, 43.13 inches in the seedling grove, and 65.36 inches in the mixed grove.

Effect on Whitefly Fungi.—Some 7 or 8 months after the first spray application, 50 leaves on each of the treated and untreated parts of the 78 plots were inspected to determine the abundance of the citrus whitefly (*Dialeurodes citri* (Ashm.)), the cloudy-winged whitefly (*Dialeurodes citrifolii* (Morgan)), and the fungi attacking them. The fungi considered were the red Aschersonia (*Aschersonia aleyrodis* Webber), the yellow Aschersonia (*Aschersonia goldiana* Sacc. et Ellis), and the brown whitefly fungus (*Aegerita webberi* Fawcett); these were found to have been destroyed in approximately the same ratio, judging from the numbers of parasitized whiteflies found on leaves that had received different spray treatments. As a matter of convenience, only the percentages of live whitefly pupae are given in table 1.

All the insecticides used in the Valencia and seedling groves allowed an increase in the percentages of live whitefly pupae found 8 months after spraying. On leaves sprayed with lead arsenate, cryolite, and potassium aluminum fluoride there was only a small increase, ranging from 1½ to 5 times as many live pupae as were found on the unsprayed parts of the trees. On foliage sprayed with copper compounds there was a greater increase, with from 5 to 10 times as many live whitefly pupae in the sprayed plots as in the checks. Syrup and sugar did not seem to have any influence on the fungus control of the whitefly. The results secured in the Valencia and seedling groves were fundamentally similar. The percentages in the last two columns of the table show very clearly that the mixed grove had different treatment. On investigation it was found that this grove had been thoroughly sprayed with Bordeaux-oil mixture, and consequently the data cannot be compared with those for the other two groves; however, they may indicate what will happen when Bordeaux-oil mixture is used.

TABLE 1.—PERCENTAGES OF LIVE CITRUS WHITEFLY AND CLOUDY-WINGED WHITEFLY PUPAE ON FIFTY CITRUS LEAVES EIGHT MONTHS AFTER SPRAYING; ORLANDO, FLA., APRIL 1931.

Kind of spray[1]	No. of plots	Valencia		Seedling		No. of plots	Mixed grove[2]	
		Sprayed	Check	Sprayed	Check		Sprayed	Check
		%	%	%	%		%	%
Lead arsenate, 8 pounds	7	11.4	7.0	13.2	7.2	4	64.3	80.5
Bordeaux mixture, 4-4-50)	5	56.5	6.8	77.0	4.7	8	85.0	71.0
Copper acetate, 4 pounds						4	64.0	46.5
Copper carbonate, 8 pounds	6	36.4	14.5	14.8	2.6	4	28.1	35.1
Copper cyanide, 8 pounds	2	50.5	3.1	67.0	12.4			
Cryolite, 8 pounds	3	19.2	3.4	5.0	2.6			
Potassium aluminum fluoride, 8 pounds	3	9.0	5.4	4.6	2.8			
Syrup and sugar solution	1	.3	7.7	3.2	.7	4	60.5	36.4

[1] For each spray (except Bordeaux mixture, which was of the formula 4-4-50) the given quantity of the chemical was used in 200 gallons of a syrup and sugar solution made of 10 gallons of syrup and 50 pounds of sugar in 190 gallons of water.

[2] This entire grove had been sprayed with Bordeaux-oil mixture before the counts were made, so the checks had been sprayed also.

From the preceding table it is evident that citrus growers, at least in the vicinity of Orlando, Fla., can expect up to 90 percent control of the whiteflies by fungi. When they spray with any mixture containing a copper compound they may expect an increase of from 5 to 10 times as many live whiteflies on the trees, or only about 40 or 50 percent natural control.

Effect on Purple Scale Fungi.—Ten leaves on each plot were very carefully examined under a binocular microscope some 6 to 8 months after the first spraying, and a record of the live and fungus-killed purple scales was made. The fungi considered in this examination were the pink scale-fungus (*Nectria diploa* B. and C.), the red-headed scale-fungus (*Sphaerostilbe aurantiicola* (B. et Br.) Petch), and the white-headed scale-fungus (*Podonectria coccicola* (E. and E.) Petch). The effects of the various materials on the scale populations are shown in table 2.

Lead arsenate, cryolite, potassium aluminum fluoride, and syrup and sugar did not have any appreciable effect on the action of scale fungi. All the copper compounds allowed the scale to increase to nearly twice the normal population. Bordeaux mixture was the most serious in this respect and copper carbonate followed closely.

TABLE 2.—PERCENTAGES OF LIVE PURPLE SCALES ON TEN CITRUS LEAVES EIGHT MONTHS AFTER SPRAYING; ORLANDO, FLA., APRIL 1931.

Kind of spray[1]	No. of plots	Valencia		Seedling		No. of plots	Mixed grove[2]	
		Sprayed	Check	Sprayed	Check		Sprayed	Check
		%	%	%	%		%	%
Lead arsenate, 8 pounds	7	66.	67.	36.8	36.0	4	81.5	69.
Bordeaux mixture, (4-4-50)	5	88.	42.7	90.0	43.5	8	83.0	73.
Copper acetate, 4 pounds	....	....	....	....	....	4	87.0	85.
Copper carbonate, 8 pounds	6	77.6	40.3	68.5	53.0	4	84.5	83.
Copper cyanide, 8 pounds	2	43.0	59.5	93.0	43.6	....	....	....
Potassium aluminum fluoride, 8 pounds	3	50.7	59.4	49.0	53.2	....	....	....
Cryolite, 8 pounds	3	62.6	52.0	60.6	40.4	....	....	....
Syrup and sugar solution	1	3.4	58.5	49.5	52.7	4	89.5	81.5

Citrus growers in the vicinity of Orlando, Fla., can expect a natural control of about 60 percent on unsprayed trees, but when Bordeaux mixture is used only about 20 percent control can be expected.

The data for the mixed grove, as in the case of the whitefly counts, serve only to show what an application of Bordeaux-oil mixture will do to the live scale population.

Summary.—Lead arsenate, cryolite, and potassium aluminum fluoride allowed whiteflies to increase on orange trees at Orlando, Fla., so that after 8 months the infestation was from 1½ to 5 times as great as on untreated checks, while copper compounds allowed whiteflies to increase to an infestation from 5 to 10 times as great as on the checks. Unsprayed groves at Orlando may have a natural fungus control of the whitefly as high as 90 percent, but when groves are sprayed with any mixture containing a copper compound, such as Bordeaux mixture, only about 40 or 50 percent of natural control can be expected.

Copper compounds used on orange trees at Orlando, Fla., allowed the purple scale to increase to a population nearly twice as great as that on untreated checks. Lead arsenate, cryolite, and potassium aluminum fluoride had no measurable effect on the amount of scale fungus or on the live scale population. Bordeaux mixture was the most serious in allowing scale to increase and copper carbonate followed closely. A natural control of about 60 percent in unsprayed groves can be expected, but when the groves are sprayed with Bordeaux mixture only about 20 percent control can be expected.

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NON-ARSENICAL STOMACH POISONS FOR GRASSHOPPER CONTROL

W. L. THOMPSON

Grasshoppers, as a rule, are not a serious pest of citrus trees over three or four years old. During the fall of 1931, they did severe damage in some orange groves in the central part of the State. Due to recent legislation prohibiting the use of arsenicals in citrus groves, except under special permission, it was necessary to make some tests of non-arsenical stomach poisons to control these pests.

The grasshopper doing the most damage was the "Bird Grasshopper", *Schistocerca americana.* It is one of our largest grasshoppers, long and slender, a powerful flier, and very active, especially on sunny days. It is evidently a sun-loving insect, as the trees were most severely damaged on the sunny side.

The grasshoppers used for the following experiments were collected from one of the infested groves. Wire screen cages, 12″x14″x18″, were used in the dusting, spraying, and a few of the bait tests. The majority of bait tests were made in cages of the above size but having no bottoms. In each test, potted citrus plants were put into the cage, or the bottomless cages were placed over young citrus trees in the nursery. In almost every case the tests were started the day after the grasshoppers were collected.

Kalo, a material made up of 96 percent sodium silicofluoride, gave very good results when used in a bran mash. Kalo used at the rate of 3 pounds to 50 pounds of bran, 1 gallon of syrup and approximately 10 grapefruit, gave a 100 percent kill in two to three days. A wire screen cage six feet square and six feet high was placed over a three year old orange tree and the above bait applied on the tree and ground. There were 80 grasshoppers used in this experiment. In three days, 79 of the grasshoppers were dead. The results of this experiment seemed to justify a field test.

In the field test, the following formula was used.

TEST 52—*Field Test.*

Kalo, 3 pounds, Bran, 50 pounds, 1 gallon syrup, grapefruit, 15, water enough to make a stiff mash. This material was applied to four acres of Temple oranges about eight years old. Approximately two large handfuls of bait was applied on and around the east and south sides of each tree, since the most damage was being done there. Most of the grass and weeds had been killed by cultivation. This bait was applied between six and seven o'clock in the evening.

Before application of the bait, an approximate average of thirteen grasshoppers would fly from each tree when the foliage was disturbed. After four and one-half days, observations were made to determine the effect of the bait. An approximate average of two grasshoppers per tree was observed, or about an eighty-four percent kill. Many trees had no grasshoppers on them, the number ranging from zero to five per tree. A few dead hoppers were found under the trees but due to the fact that so much dead grass was on the ground, it was difficult to find them.

The far side of the same grove, ten rows removed from the treated section, was used as a check. There was no decrease in the number of grasshoppers in this section of the grove during four and one-half days.

The above observations were made from one to two-thirty o'clock in the afternoon when the grasshoppers were very active.

Sodium fluoride, used at the rate of 1 pound to 20 pounds of bran and 2 quarts of syrup, gave a 100 percent kill in three to four days. The combination gave better results than using 2 pounds of sodium fluoride to 20 pounds of bran, since a kill of only 90 percent was obtained after six days. It is quite probable that 2 pounds of sodium fluoride per 20 pounds of bran is distasteful to the grasshoppers.

Sodium fluoride, mixed with oat-meal and syrup, gave only a 40 percent kill in six days. Sodium fluoride, as well as the Kalo, should be sifted through a fine screen before it is mixed with the bran as both of these materials are more or less lumpy.

Kalite, a dust containing 18 percent sodium silicofluoride, gave a kill of 100 percent in six days when the plants *and grasshoppers* were both dusted; but when only the plants were dusted, the kill was but 55 percent in six and one-half days and ninety-nine percent of the leaves were eaten off the plant. Kalite did not stick well on the citrus leaves, but when a mixture of 3 parts of Kalite to 1 part talc was applied, the adhesive qualities seemed to be improved. Two different tests were made where five grasshoppers were placed under a small wire screen and the Kalite dusted over them and on the boards where they had to crawl. No food was under these screens. After 48 hours all the grasshoppers were dead and in the checks none. Whether the grasshoppers died from the poison eaten when cleaning themselves or whether it passed into the body through other channels, was not determined.

Kaolith, made up of 94.26 percent sodium aluminum fluoride, applied as a spray, gave only a 20 percent kill in six days, and approximately ninety-nine percent of the leaves of the plant were eaten. The adhesive qualities of this material is very poor on citrus. By adding 1 percent of Penetrol, a sulfonated oil, a kill of 70 percent was obtained in five and one-half days and 80 percent in eight and one-half days.

Copper carbonate baits and sprays gave only fair results. Copper carbonate at the rate of 16 pounds per 200 gallons of water, 50 pounds of sugar and 10 gallons of syrup, gave only a 36 percent kill in seven days. When the amount of copper carbonate was raised to 25 pounds with the same amount of the above ingredients, a kill of 80 percent was obtained in five days and 100 percent in seven days. After six and one-half days, approximately fifty percent of the leaves of the plants had been eaten and on the checks, ninety-nine percent. Copper carbonate in a bran mash was tested in amounts from 2 pounds to 9 pounds to 50 pounds of bran with syrup and grapefruit. The syrup was increased from four quarts to six quarts to make the bait more attractive, but the kill was not increased. In one test, copper carbonate, used at the rate of 5 pounds to 20 pounds of bran and 2½ quarts of syrup, gave a 100 percent kill in five days.

A 5-5-50 Bordeaux mixture gave a 60 percent kill in five days and 80 percent in ten days. A combination of a 5-5-50 Bordeaux mixture and arsenate of lead at the rate of 4 pounds to 100 gallons of water gave only a 64 percent kill in seven days.

Neither bichloride of mercury nor strychnine gave any results as a poison for grasshoppers.

ARTIFICIAL CONTROL OF GRASSHOPPERS (SCHISTOCERCA AMERICANA)

Test No.	Applications	No. Specimens	% Dead	Days	% Dead	Days	% Dead	Days	% Dead	Days
	Dusts									
1.	Kalite—Plants and grasshoppers dusted	20	80	2½	84	3½	84.6	4½	100	6½
2.	Kalite—Plants and grasshoppers dusted	15	86	2½	86.6	3½	86.6	5½	100	6
3.	Kalite—Plants and grasshoppers dusted	20	60	2½	80	3½	100	4½		
4.	Kalite—Plants dusted only	20	5	2½	20	3½	40	4½	55	6½
5.	Kalite 3 parts, Talc 1 part—Plants and grasshoppers dusted	19	84.6	2½	84.6	3½	90	4½	90	6½
6.	Kalite 3 parts, Talc 1 part—Plants and grasshoppers dusted	20	85	2½	95	3½	100	5½		
7.	Check for tests 1, 2 and 5	20	5	2½	5	3½	10	4½	60	6½
8.	Check for tests 3, 4 and 6	20	5	2½	25	4½			35	6½
	Sprays									
9.	Kaolith—4 lbs. per 100 gallons	20	10	2	20	4			20	6
10.	Kaolith—4 lbs. per 100 gallons plus Penetrol 4%	20	60	2½	65	3½	70	5½	80	8½
11.	Arsenate of Lead—2 lbs. per 100 gal.	20	10	2½	30	4½	65	5½	85	10
*12.	Arsenate of Lead—2 lbs. per 100 gal.	80	13.7	2½	22.5	4½	27.5	5½	37.5	12
13.	Arsenate of Lead—2 lbs. per 100 gal. plus Bordeaux 5-5-50	25	16	2			52	5	64	7
14.	Bordeaux Mixture 5-5-50	20	15	2½	60	4½	60.5	5½	80	10
15.	Copper Carbonate 16 lbs., Sugar 50 lbs., Syrup 10 gal., Water 200 gal.	25	4	2½	1		24	5	36	7
16.	Copper Carbonate 25 lbs., Sugar 50 lbs., Syrup 10 gal., Water 200 gal.	25	36	2½			80	5	100	7
17.	Check for test 9	20	5	2½	5	3½	10	4½	60	6½
18.	Check for test 10, 11, 12, and 14	20	5	2½	25	4½	35	6½	85	10
19.	Check for test 13, 15, and 16	25	0	2	4	3½	8	4½	32	7
	Baits									
20.	Sodium fluoride 2 lbs., Oatmeal 20 lbs., Lemons 4	20	5	2	5	3	10	4	40	6
21.	Sodium fluoride 2 lbs., Bran 20 lbs., Syrup 2 qts., Lemons 4	20	35	2½	85	3½	85	4½	90	6½
22.	Sodium fluoride 1 lb., Bran 20 lbs., Syrup 2 qts., Grapefruit 5	20	85	2½	95	3½	100	4½		
23.	Sodium fluoride 2 lbs., Bran 50 lbs., Syrup 1 gal., Grapefruit 15	25	92	2	100	3				
24.	Paris Green 1 lb., Bran 20 lbs., Syrup 2 qts., Lemons 4	15	80.9	2	95	3	100	4		
25.	Kalite 1 part, Bran 9 parts, Syrup 2 qts., Lemons 4	20	0	2½	0	3½	10	4½	25	6½

* Screen cage, 6 ft. x 6 ft. x 6 ft. over three year old tree.

ARTIFICIAL CONTROL OF GRASSHOPPERS (SCHISTOCERCA AMERICANA)—Continued

Test No.	Applications	No. Speci-mens	% Dead	Days	% Dead	Days	% Dead	Days	% Dead	Days
	Baits (Continued)									
26.	Kalo 2 lbs., Bran 50 lbs., Syrup 1 gal., Grapefruit 10	25	96	2	100	3	....	....	....	....
27.	Kalo 3 lbs., Bran 50 lbs., Syrup 1 gal., Grapefruit 10	25	100	2	....	....	....	....	....	....
28.	Kalo 4 lbs., Bran 50 lbs., Syrup 1 gal., Grapefruit 10	25	96	2	96	3	100	4	....	....
29.	Kalo 3 lbs., Bran 50 lbs., Syrup 1 gal., Grapefruit 10	25	100	2½	....	....	....	....	....	....
30.	Kalo 3 lbs., Bran 50 lbs., Syrup 1 gal., Grapefruit 15	25	96	2	100	3	....	....	....	....
31.	Kalo 3 lbs., Bran 50 lbs., Syrup 1 gal., Grapefruit 15	80	25	1	50	2	97.5	3	....	....
32.	Strychnine 10 gr., Bran 20 lbs., Syrup 2½ qts., Lemons 4	25	0	1½	8	4½	12	5½	....	....
33.	Bichloride of Mercury 1-200, Bran 20 lbs., Syrup 2½ qts., Lemons 4	25	4	2	8	5	24	7	....	....
34.	Copper Carbonate 5 lbs., Bran 20 lbs., Syrup 2½ qts., Lemons 4	25	80	3	100	5	....	....	....	....
35.	Copper Carbonate 3 lbs., Bran 50 lbs., Syrup 4 qts., Lemons 10	25	20	1½	68	3½	72	4½	76	5½
36.	Copper Carbonate 4 lbs., Bran 50 lbs., Syrup 4 qts., Lemons 10	25	24	1½	52	3½	76	4½	96	5½
37.	Copper Carbonate 5 lbs., Bran 50 lbs., Syrup 4 qts., Lemons 10	25	20	1½	64	3½	80	4½	88	5½
38.	Copper Carbonate 6 lbs., Bran 50 lbs., Syrup 5½ lbs., Lemons 10	15	46.6	2	53.3	3	73.3	4	86.6	6
39.	Copper Carbonate 7 lbs., Bran 50 lbs., Syrup 5½ qts., Lemons 10	15	53.3	2	66.6	3	66.6	4	86.6	6
40.	Copper Carbonate 8 lbs., Bran 50 lbs., Syrup 5½ qts., Lemons 10	15	53.3	2	86.7	3	86.6	4	93.3	6
41.	Copper Carbonate 9 lbs., Bran 50 lbs., Syrup 5½ qts., Lemons 10	15	33.3	2	60.6	3	86.6	4	86.6	6
42.	Copper Carbonate 6 lbs., Bran 50 lbs., Syrup 6 qts., Grapefruit 15	15	33.33	2	53.33	3	80	4	86.6	7
43.	Copper Carbonate 7 lbs., Bran 50 lbs., Syrup 6 qts., Grapefruit 15	15	46.66	2	66.66	3	80	4	80	7
44.	Copper Carbonate 8 lbs., Bran 50 lbs., Syrup 6 qts., Grapefruit 15	15	40	2	66.66	3	73.33	4	93.33	7
45.	Checks for tests 42, 43, and 44	15	6.66	2	13.33	3	20	4	26.66	7
46.	Checks for tests 20, 21, 24, and 25	20	5	2½	5	3½	10	4½	60	6½
47.	Checks for test 22	20	5	2½	25	4½	35	6½	85	10
48.	Checks for tests 23, 26, 27, and 28	25	0	2	4	3	....	....	....	....
49.	Checks for tests 29, 33, and 34	25	0	2½	4	3½	8	4½	32	7
50.	Checks for tests 30, 31, 32, 35, 36, and 37	25	0	2½	4	3½	8	4½	12	5½
51.	Checks for tests 38, 39, 40, and 41	30	3.3	2	9	3	15.1	4	24.2	6

INGREDIENTS OF MATERIALS USED

Kalite	Sodium silicofluoride	18.0%
	Sulfur	19.0%
	Inert ingredients	62.0%
Kaolith	Sodium aluminum fluoride	94.26%
	Inert ingredients	5.24%
Kalo	Sodium silicofluoride	96.0%
	Inert ingredients	4.0%
Sodium fluoride—active ingredients		90-95%
Arsenate of lead—active ingredients		98%
Copper—active ingredients—Metallic copper		18%

OBSERVATIONS OF TREATED PLANTS EXPOSED TO GRASSHOPPERS

	Leaves eaten			
Kalite ¾, Talc ¼, dusted on plants and grasshoppers	5%	after	6½	days
Kalite dusted on plants and grasshoppers	1%	"	6½	"
Kalite dusted on plants only	99%	"	6½	"
Kaolith, sprayed on plants only	99%	"	6½	"
Lead arsenate, 2 lbs	90%	"	6½	"
Check	99%	"	6½	"
Strychnine Bran Bait	99%	"	6½	"
Kalo Bran Bait	1%	"	6½	"
Sodium fluoride bran bait	1%	"	6½	"
Copper carbonate spray	50%	"	6½	"

Out of 200 grasshoppers that were not exposed to poison, only six parasites were observed. The parasites were tachinid flies.

Sodium fluoride and Kalo gave the best results and were the most economical. Both of these materials compare with the kill obtained by using Paris green bran bait in like amounts. No burning of foliage was observed when sodium fluoride or Kalo were used in the bran bait, which was thrown on the plants. Copper carbonate gave only fair results, unless used in rather large amounts.

The table on page 9 gives in detail the results of the various experiments.

DR. HERBERT OSBORN ADDRESSES ENTOMOLOGICAL SOCIETY

On April 2 the members of the Florida Entomological Society and visitors were treated to an illustrated lecture on the "History of Entomology in the U. S. and Canada." Dr. Osborn showed lantern slides of most of the early entomologists and spoke briefly of the work of each.

The speaker was introduced by Dr. P. H. Rolfs who has recently returned from Brazil. Three other former students of Dr. Osborn were present, Drs. E. W. Berger, Wilmon Newell, and A. N. Tissot.

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THE EFFECT OF COOL TEMPERATURES ON SOME STAGES OF THE CIGARETTE BEETLE

S. E. CRUMB and F. S. CHAMBERLIN
U. S. Department of Agriculture
Bureau of Entomology

The use of cool chambers for the storage of surplus stocks of cigars has made it important to determine the effect of these moderately cool temperatures on the cigarette beetle (*Lasioderma serricorne* Fab.). The temperatures employed range from 50° to 65° Fahrenheit. Pook[1], Jones[2] and Runner[3] have shown that with exposure to temperatures below 32° F. for a sufficient period all stages of the beetle can be killed, but the only recorded experiments with temperatures such as are in use for cigars in the storage chamber are those of Jones[2], who carried out a short series of tests on each of the stages of the cigarette beetle at temperatures ranging from 46° to 57° F.

In these experiments by Jones it was found that some of the eggs hatched after an exposure of 20 days, but that none of the small and half-grown larvae lived more than 30 days. The large larvae, pupae, and adults, however, were found to be very much more resistant. Large larvae lived for as much as 157 days, the pupae transformed to adults, and the adults lived for 111 days.

Jones did not establish an exposure which would destroy the viability of all eggs, and, since stages of the beetle other than the egg and the small larvae are very rarely found in fresh cigars, the writers carried out a series of experiments at Tampa, Fla., and Clarksville, Tenn., during 1927 and 1928 in an effort to establish the proper periods of exposure for eggs and small larvae at several temperatures. A few experiments also have been carried out with large larvae and pupae.

These experiments were conducted under conditions of commercial storage and the temperatures and humidities used were those actually occurring in commercial practice. Humidity ranges in the storage rooms were such that it is unlikely that any of the mortality indicated is the result of excessive dryness. Under the conditions existing at the beginning of the experiments, it was not possible to obtain accurate counts of the insects involved without disturbing their positions and crushing the

[1] Pook, Gustav. 1910. Die Anwendung von Kalte zur Verwichtung des Tabakwurms. Chemiker-Zeitung, Jahrg. 34, No. 126, p. 1127.

[2] Jones, C. R. 1913. The Cigarette Beetle (*Lasioderma serricorne* Fabr.) in the Philippine Islands, Philline Jr. Sci., Ser. D, vol. 8, No. 1, pp. 1-39, illus.

[3] Runner, G. A. 1919. The Tobacco Beetle: An Important Pest in Tobacco Products. U. S. Dept. Agr. Bul. 737, p. 77, illus.

eggs or young larvae. The cigars must be entirely free of all living stages of the beetle, as the whole box may be returned to the manufacturer upon detection of a single sign of infestation. Thus detailed counts of the extent of the infestation after treatment are not particularly important, as the presence of any living stages, however few, in the treated cigars, invalidates the treatment.

In these experiments an exact duplicate of the treated material was reserved as a check, unless otherwise noted, and both lots of material were kept under the same conditions both before and after exposure. Where cigars were used, these were fresh and were packed in a box with sufficient paper to prevent them from rolling about. The boxes were sealed with adhesive tape or with strips of paper. Usually 100 specimens were exposed in each experiment.

The various "stations" referred to in the table were of the character indicated below.

Station No. 1 was the humidor of a cigar factory. The daily temperature fluctuated mainly between 50° and 60° F., with brief periods of higher and lower temperatures, and there were a few isolated days during which the temperature was maintained between 60° and 70° F. The relative humidity usually ranged between 45 and 50 per cent.

Station No. 2 was a cave. The material was placed well back where the temperature was constant at 56° F. The relative humidity was high.

Station No. 3 was the humidor of a cigar factory. The temperature was maintained at about 65° F., varying two or three degrees above or below this temperature. The relative humidity was taken only a few times and ran about 95 per cent.

The details of the various "conditions" referred to in table 1 are as follows:

"Vials." Eggs of the cigarette beetle were placed on a slightly moistened strip of tobacco which was then inserted in a vial having a cover of cheesecloth over the mouth. This vial was inserted in a second vial containing moist tobacco and the screw cap of the outer vial was screwed down tightly.

"Capsules." A hole was made in the bottom of a gelatin capsule and a compact wad of pliable tobacco was forced into the capsule, closing the hole, after which larvae, or eggs on a strip of tobacco, were introduced. The capsules were then given to a cigar maker, who rolled one or two capsules into each cigar. This arrangement allowed the larvae to escape into the cigar after the tobacco in the capsule had been consumed.

TABLE 1.—EXPERIMENTS IN THE TREATMENT OF STAGES OF THE CIGARETTE BEETLE BY PROLONGED EXPOSURE TO COOL TEMPERATURES, TAMPA, FLA., 1927-28.

Stages Treated	Condition	Sta. No.	Temp. °F.	Exposure Days	Results: Treated	Results: Check
Eggs	Capsules	1	50-60	8	Hatched after removal.	Eggs hatched.
do	do	1	50-60	15	Some hatched after removal.	do
do	Cigars	1	50-60	21	A few hatched after removal.	Cigars very wormy.
do	Vials	1	50-60	23	1 out of 60 hatched after removal.	No check.
do	Leaf	1	50-60	28	Hatched, possibly before entered. No larvae in cigars.	A few larvae.
do	do	1	50-60	30	Few hatched, one live larva.	do
do	Cigars	1	50-60	31	1 out of 100 hatched after removal.	Cigars very wormy.
do	Capsules	1	50-60	35	None hatched.	Eggs hatched.
do	Vials	1	50-60	40	do	do
do	Leaf	1	50-60	47	do	A few larvae.
do	Cigars	1	50-60	53	do	All cigars punctured.
do	Vials	2	56	16	Hatched after removal.	Eggs hatched.
do	do	2	56	24	6 out of 100 hatched.	do
do	do	2	56	33	None hatched.	do
do	do	2	56	41	do	do
do	do	2	56	47	do	do
do	Capsules	3	65	12	Hatched before removal.	No check.
do	do	3	65	18	do	do
do	do	3	65	28	do	do
do	Cigars	3	65	29	Hatched, two live larvae in cigars.	Nearly all cigars punctured.
do	Leaf	3	65	32	Hatched, larvae dead.	No check.
do	Capsules	3	65	42	Hatched, 2 larvae alive.	do
do	Leaf	3	65	47	Hatched, larvae dead.	A few larvae in cigars.
Newly Hatched Larvae	Slit cigars	1	50-60	21	None alive.	Only a few alive.
do	do	1	50-60	31	do	do
do	do	1	50-60	32	do	do
do	do	1	50-60	42	do	do
Large Larvae, Pupae	Capsules	1	50-60	22	Nearly all alive.	Alive.
do	do	1	50-60	45	Many alive, one punctured cigar.	Nearly all cigars punctured.
do	do	3	65	12	Nearly all alive.	No check.
do	do	3	65	42	About 16 per cent survived.	do
do	do	3	65	53	Cigars punctured, live adults and larvae.	do
do	do	3	65	59	Cigars punctured, live adults and larvae.	do

"Leaf." Beetles were allowed to oviposit on leaf tobacco and this was placed among cigars in a sealed box.

"Cigars." Fresh cigars were packed, open end up, in quart jars containing a large number of beetles. The cigars were removed and entered in experiments after they had become heavily infested with eggs.

"Slit Cigars." A slit was cut in fresh cigars and into this slit eggs of the tobacco beetle were inserted, 10 or more to each cigar, after which the cigars were kept under favorable conditions until the eggs were hatched.

The results of these experiments are indicated in table 1.

We draw the following conclusions from the results of these experiments:

At a temperature of from 50° to 60° F. eggs do not hatch and they are nonviable upon removal to normal temperature after an exposure of 35 days; a limited number of experiments with just-hatched larvae indicate that these larvae do not survive an exposure of 21 days; large larvae survive for at least 45 days and sometimes puncture cigars at this temperature.

At 56° F. eggs do not hatch, and they are nonviable upon removal to normal temperatures after an exposure of 33 days.

At a temperature of 65° F. development of all stages of the beetle continues at a reduced rate; eggs hatch, larvae pupate, adults emerge, and adults and the surviving larvae puncture the cigars. The newly-hatched larvae seem to be very susceptible to reduced temperature and very few small larvae survive after the eggs and resulting larvae have been exposed for a period of 32 days at this temperature.

Since stages other than the eggs and very small larvae occur very rarely in fresh cigars, it seems that storage of fresh cigars at a temperature of 55° F. for a period of 35 days should provide a satisfactory control of the tobacco beetle if sufficient care is taken to prevent reinfestation after the cigars are removed from storage.