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Imported Fire Ant Toxic Bait Studies: The Evaluation of Various Food Materials[1]

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ABSTRACT

Laboratory tests with the imported fire ant, *Solenopsis saevissima richteri* Forel, showed that they would eat a wide variety of foods, including fats, proteins and carbohydrates. Dry foods, or foods that contained a minimum amount of liquid, showed little attractiveness. Field tests with individual imported fire ant colonies employing the dyed food technique indicated that various mixtures of vegetable or fish oils and flour, meals or dried blood were very attractive. Porous breakfast cereals impregnated with oils showed promise as baits which would be dry to handle. In small plot tests the following baits when combined with Kepone® (decachlorooctahydro-1,3,4-metheno-2H-cyclobuta [cd] pentalen-2-one) gave more than 90% control of imported fire ants: peanut meal plus peanut oil, peanut oil and monoglycerides, peanut butter, flour plus soybean oil, cotton seed oil or peanut oil, whole wheat flour and peanut oil, and fish oil plus dried blood.

Several investigators have studied the food habits of the imported fire ant, *Solenopsis saevissima richteri* Forel, in the field (Wilson & Eads 1949, U. S. Dept Agric. 1958, and Hays & Hays 1959). While there are some apparent contradictions in the observations reported, it may be concluded that this insect is an omnivorous feeder. Hays & Arant (1960) conducted extensive studies in the laboratory. From these tests they found tankage, fish meal, ground insect bodies, processed vegetable oils, digested corn and soybean protein plus fat, peanut butter and certain other mixtures high in protein and/or fat to be the most attractive food materials. They also found peanut butter and Kepone® (decachlorooctahydro-1,3,4-metheno-2H-cyclobuta [cd] pentalen-2-one) at a concentration of 0.125% and packed in soda straws to be a very good imported fire ant bait. Bartlett & Lofgren (1961) reported that vegetable oils and animal oils were very attractive foods. In addition they showed that peanut meal-peanut oil and Kepone (0.25%) was an effective imported fire ant bait.

In 1957 studies were begun to determine which types of food would be most acceptable for use in a toxic bait.

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This paper presents the results of laboratory and field tests conducted in these studies.

LABORATORY TEST PROCEDURES.—The tests were conducted with captive imported fire ant colonies. Ant colonies and their mounds were dug up in the field, placed in large wash tubs and removed to the greenhouse. The ants were kept from escaping either by placing the tubs in large, shallow pans filled with water, thus creating a moat around the tubs, or by dusting the inner side of the tubs with talc. The colonies were fed for a week or more before they were used in any tests. The food consisted of insects, vegetable oils, dog food and 10% sucrose solution in water. This feeding period was necessary to decrease the activity of the ants and make them more selective in their food preference. Colonies which continued to feed very avidly or fed very sparingly were not used.

The test procedure was as follows: The acceptance of each candidate food material was compared with that of a standard, 10% sucrose solution in water. This food was used because in laboratory tests it is taken by the ants as readily as peanut oil, and because it is a chemically definable substance thus insuring a uniform standard. The foods were exposed to the ants on pieces of aluminum foil (1 in.×1 in.). The liquid foods were soaked on 1-inch squares of blotting paper and the paper placed on the foil. An effort was made to expose equal surface areas or feeding areas to the ants. After 5 minutes, the numbers of ants feeding on each food material were counted and recorded. After this, the ants were removed from the food, the positions of the foods on the mound reversed, and a second 5-minute test conducted. A total of eight replications were made with each material, two with each of four colonies. The acceptance ratio of each material to the standard was calculated as follows:

$$\frac{\text{No. of ants feeding on candidate food}}{\text{No. of ants feeding on standard food}} = \text{acceptance ratio}$$

RESULTS.—Two hundred and twenty-two foods or combinations of foods have been evaluated. Most of these foods were purchased in grocery stores and were selected so as to obtain information on as many types of foods as possible. A list of all those which gave an acceptance ratio of 0.75 or higher is contained in table 1. While the list of materials is quite diverse, it is evident that all the acceptable foods contain some liquid. This is very evident with a material such as yeast hydrolysate, which is completely unacceptable when dry, but is taken as readily as the standard when dissolved in water. Undoubtedly, the reason for this is that worker ants do not ingest solid food but extract the fluids.

Nontoxic Bait Studies in the Field.—Food materials which showed promise in the laboratory tests were tested next in the field on individual imported fire ant colonies. The method employed for the field evaluation was the same as that described by Bartlett & Lofgren (1961) and consisted of incorporating dye in the test food, offering it to the ant colony for 24 hours and then examining 100 worker ants for the presence of dye in the alimentary tract. The percentage of worker ants containing dye when compared with the standard indicates the attractiveness of the food. Six replications were made for each food. The standard material used in all of these tests was peanut butter. It contains approximately 50% oil.

One of the big difficulties associated with a bait is to protect it from high amounts of rainfall. For this reason, of all materials listed in table 1, those considered most promising for field use were those containing oil. Field observations have shown that a material such as peanut butter will lose some of its oil during a rainfall but this does not appear to affect its attractiveness. During 1960 a series of tests was conducted to evaluate various combinations of vegetable oils, fish oil (Menhaden) or tallow, with some flours, meals or dried blood. The results are presented in table 2.

Table 1.—A list of food materials which gave an acceptance ratio of 0.75 or higher in laboratory tests.

Anchovy filet
Anchovy paste
Apple Sauce
Baby foods
  Chicken with broth
  Egg yolks and bacon
  Ham and broth
  Lamb flavored with mint
  Liver and broth
  Strained bananas
  Strained fruit dessert
  Strained pears
Bean dip
Blood hydrolysate
  (1:10 ratio with water)
Casein hydrolysate
  (1:10 ratio with water)
Cat food, canned, ground
Chocolate syrup
Cheese
Cheese spread
Cocktail meatballs
Corn, creamed
Corn, whole kernel, in milk
Corn oil
Cottonseed oil
Cranberry sauce
Dog food, canned, ground
Dextrose (1:1 ratio with water)
Fish oil
Honey, diluted with water
Insects, freshly killed
Lard
Meat and bones, fresh
Meat and bones, cooked
Meat, potted
Neat's-foot oil
Peanut butter
Recovered soy fatty acids
Salad dressing
Sardines, canned
Soft drink syrups
Soybean oil
Tallow
Yeast hydrolysate (1:10 ratio with water)
A. E. Staley Co. SPIB FA-19 enzyme digested corn proteln, digestion variable
A. E. Staley Co., SPIB FA-19A enzyme digested corn protein, digestion variable
A. E. Staley Co., SPIB FA-19C enzyme digested corn protein, digestion variable
National Dairy Products Co., N-Z-amine type E (moistened with water)
National Dairy Products Co., N-Z-amine type YT (moistened with water)
National Dairy Products Co., N-Z-amine type A
National Dairy Products Co., Edamin (moistened with water)

Table 2.—Results of tests to determine the acceptability of various food materials combined with vegetable or animals oils to imported fire ants.[a]

Type of Food (%)	Oil (%)	Ants Containing Dye After 24 Hours (%)
Wet Mash or Slurry-Type Baits		
Series I		
Whole wheat flour, 58	Peanut, 42	86
Peanut meal, 53	Peanut, 47	84
Cottonseed meal, 61	Peanut, 39	82
Wheat shorts, 41	Peanut, 59	80
Corn meal, 65	Peanut, 35	77
White flour, 65	Peanut, 35	77[b]
Peanut butter (standard)	—	81
Series II		
Whole wheat flour, 57	Peanut, 43	73
White flour, 56	Cottonseed, 44	63
61	Fish, 39	61
58	Soybean, 42	57
55	Peanut, 45	55
Whole wheat flour, 58	Corn, 42	54
58	Fish, 42	49
White flour, 51	Corn, 49	49
Whole wheat flour, 59	Cottonseed, 41	35[b]
62	Soybean, 38	35
Peanut butter (standard)	—	65
Series III		
Fish meal, 60	Fish, 40	79
Bone meal, 51	Cottonseed, 49	71[b]
66	Peanut, 34	67[b]
68	Fish, 32	50
53	Tallow, 47	40
Peanut butter (standard)	—	70
Series IV		
Dried blood, 67	Fish, 33	79
62	Cottonseed, 38	67
65	Corn, 35	59
69	Peanut, 31	50
68	Soybean, 32	43
Peanut butter (standard)	—	54
Oil-Impregnated Breakfast Cereal Baits		
Series I[c]		
Cheerios, 39	Peanut, 56	87
Rice Krispies, 47	Peanut, 48	86
Puffed Rice, 21	Peanut, 74	82
Peanut butter (standard)	—	65
Series II		
Rice Krispies, 29	Peanut, 71	83
Cheerios, 29	Peanut, 71	79
Puffed Rice, 25	Peanut, 75	73
30	Cottonseed, 70	67
25	Soybean, 75	62
24	Corn, 76	59
29	Fish, 71	34
Peanut butter (standard)	—	76
Series III		
All Bran, 69	Peanut, 31	78
Bran 100%, 70	Peanut, 30	73
All Bran, 75	Cottonseed, 25	69
74	Fish, 26	61
Bran 100%, 74	Fish, 26	57
76	Cottonseed, 24	53
Peanut butter (standard)	—	78

[a] Average of six tests.
[b] One of the colonies moved during test period and results are based on five replicates.
[c] Five per cent monoglycerides added to the oil in each formulation.

A majority of the combinations tested were highly acceptable to the ants, thus indicating that this type of formulation shows good promise for use in a toxic bait.

Because the slurry-type baits in the previous tests are limited in application principally to open areas, an effort was made to develop a dry, granular bait. Early tests with oils formulated on nonfood particles such as clay granules were not encouraging because it was necessary to keep the formulation very oily to obtain acceptance. It appeared from these observations that it would be necessary to use some type of food granule. Therefore, a series of tests was conducted to evaluate various commercially manufactured breakfast cereals as carriers for the oil. It was found that some of these would absorb two to three times their weight in oil under vacuum and still remain dry on the surface. In these preliminary tests it was necessary to roll the cereals with dry clay granules to remove the excess oil. Later investigations have shown that the cereals can be impregnated very easily by heating the oil to 150° to 175° C. before it is poured or sprayed on the cereal granules. This procedure is similar to that used for making insecticide granules. Three series of tests were conducted with five different cereals and five oils. The names and contents of each cereal were as follows.[2]

Cheerios, marketed by General Mills, Inc., general offices, Minneapolis 26, Minn., and composed of oat flour, wheat starch, sugar, salt, Na Phosphate, Ca Carbonate, coloring, niacin, thiamine and riboflavin.

Rice Krispies, marketed by Kellogg Co., Battle Creek, Mich., and composed of toasted rice, sugar, salt, malt, flavoring, butylated hydroxytoluene, vitamin B_1, niacinamide and iron.

Puffed Rice, marketed by the Quaker Oats Co., Chicago, Ill., contains thiamin, niacin, and iron.

All Bran, marketed by the Kellogg Co., Battle Creek, Mich., consists of wheat bran, sugar, salt, malt flavoring, butylated hydroxytoluene, vitamins B_1 and D.

Bran 100%, marketed by the National Biscuit Co., Special Products Division, New York, New York, consists of bran, sugar, salt, malt extract, and fig and prune juices.

All of the combinations were taken readily by the ants with the exception of the formulations containing fish oil. (See table 2.)

[2] The use of this and other trade names does not constitute an endorsement of any such product by the U. S. Department of Agriculture.

Table 3.—Average results of three field tests with three different baits containing Kepone (0.125%) as the toxicant.

Bait Components (%)	Pre-treatment Count of Active Colonies	Per Cent Reduction in Active Colonies After Weeks Shown				
		1	2	4	8	16
Peanut meal, 71, peanut oil, 29	114	32	80	69	85	98
Peanut oil, 80, monoglyceride, 20	97	7	56	61	79	94
Peanut butter	80	1	27	42	73	97
—Check	82	7	17	2	39	65

Toxic Bait Studies in the Field.—Three experiments were carried out to evaluate food materials for use in toxic baits. In the first experiment an evaluation was made of two toxic baits which had been reported effective previously. They were (1) peanut butter and Kepone packed in soda straws, Hays & Arant (1960) and (2) peanut meal-peanut oil (5 to 3 ratio) and Kepone, Bartlett & Lofgren (1961). In addition a third bait, peanut oil-monoglyceride (4 to 1 ratio), which had shown promise in laboratory tests, was also tested. The addition of monoglycerides to peanut oil at concentrations of 10%, or more, results in a product with a consistency similar to that of lard or tallow.

Kepone, at a concentration of 0.125% by weight of total formulation, was the toxicant in all three baits. The test plots were 2 to 3 acres in size. Two replications were in pastures and one was in a lightly wooded area. The peanut butter was dispensed in soda straws cut into lengths of $2\frac{2}{3}$ inches. The peanut oil-monoglyceride bait was applied with a hand grease gun and the peanut meal-peanut oil bait was applied by hand. The application rate for the peanut butter and peanut oil baits was 6 pounds per acre and for the peanut meal-peanut oil bait, 20 pounds per acre. All formulations were put out at bait stations in a 5- by 10-foot grid pattern. Table 3 summarizes the results.

After 16 weeks the control by the three baits ranged from 94% to 98%. The speed of control was comparatively slow for a bait treatment. Usually the maximum effect is noted after 2 to 4 weeks. The slowness may have been due to the fact that the baits were applied in April 1960, when the average daily maximum temperature was only 78.2° F. Tests conducted in the fall of 1960 under similar temperature conditions have also shown a delayed action. There was a big reduction in active colonies on the check plots. This was probably the result of not having an untreated zone between the plots with the result that some of the check colonies fed on the bait. After 6 months, the plots had become reinfested with incipient imported fire ant colonies.

The second experiment was initiated to determine if additional peanut oil in the peanut butter and peanut oil-monoglyceride formulations would affect their acceptability to imported fire ants. The baits formulated were: peanut butter alone and at ratios of 1 to 10, and 1 to $2\frac{1}{2}$, with peanut oil and peanut oil-monoglyceride at ratios of 5 to 1, 10 to 1, and 20 to 1. Each of the baits contained 0.25% by weight of Kepone and 0.25% by weight of Calco oil blue dye. The tests were conducted on 3-acre plots in a Bahia grass pasture. The test was not replicated. The peanut butter-peanut oil (1 to $2\frac{1}{2}$ ratio) and peanut oil-monoglyceride (20 to 1 ratio) were applied with a compressor type hand sprayer without a nozzle at bait stations in a 5- by 10-foot grid pattern across the plot. The other formulations were packed in straws and applied in the same grid pattern. Twenty-four hours after application, 100 worker ants from each of 10 colonies in each plot were examined for dye. Table 4 shows the per cent reduction in active imported fire ant colonies after 1, 2, 4 and 8 weeks and the average percentage of ants examined which contained dye for each bait.

Complete control of imported fire ants was obtained with all of the bait formulations after 4 weeks. The number of workers accepting the bait after 24 hours varied from 41% to 64%. Any correlation between the degree of acceptance and the control obtained was not determinable because all formulations gave complete control. The landowner disked the plots after the 8-week count, thus making it impossible to obtain an accurate count after 16 weeks. However, general observations showed that the plots were completely reinfested with incipient imported fire ant colonies.

Experiment three consisted of four series of tests conducted during the summer of 1960 to determine the effectiveness of nine food materials combined with Kepone as toxic baits. In all the tests Kepone was used at a dosage of 0.125% by weight of total formulation. The baits tested were as follows: (1) peanut oil and white flour, (2) soybean oil and white flour, (3) cottonseed oil and white flour, (4) peanut oil and whole wheat flour, (5) fish oil and white flour, (6) fish oil and dried blood, (7) Cheerios breakfast cereal impregnated with peanut oil,

Table 4.—Results of tests with imported fire ants to determine the acceptance and control with peanut butter and peanut oil-monoglyceride baits containing various amounts of peanut oil, Kepone (0.25%) and Calco oil blue dye (0.25%).

Bait Components (%)	Pretreatment Count of Active Colonies	Worker Ants Containing Dye After 24 Hours[a] (%)	Per Cent Reduction in Active Colonies After Weeks Shown[b]			
			1	2	4	8
Peanut oil, 95.2, monoglyceride, 4.8	108	60	69	99	100	100
Peanut oil, 90.9, monoglyceride, 9.1	59	53	51	88	100	100
Peanut oil, 83.3, monoglyceride, 16.7	48	54	21	79	100	100
Peanut oil, 9.1, peanut butter, 90.9	79	41	66	100	100	100
Peanut oil, 28.5, peanut butter, 71.5	72	56	72	94	100	100
Peanut butter	64	64	73	95	100	100
—Check	74	—	27	42	45	47

[a] One hundred worker ants examined from each of 10 mounds.
[b] All plots were reinfested with incipient colonies after 16 weeks

Table 5.—Average results of three field tests with baits consisting of miscellaneous food materials and Kepone (0.125%).

Bait Components (%)	Pretreatment Count of Active Colonies	Per Cent Reduction in Active Colonies After Weeks Shown				
		1	2	4	8	16
	Series I					
Peanut oil, 55, white flour, 45	26	56	81	94	90	58
Soybean oil, 42, white flour, 58	23	38	70	97	99	54
Cottonseed oil, 44, white flour, 56	14	62	81	83	95	60
Peanut oil 1, peanut butter, 99 (Standard)	22	62	92	92	94	80
—Check	15	28	17	39	28	17
	Series II					
Peanut oil, 43, whole wheat flour, 57	17	56	92	84	56	—
Fish oil, 39, white flour, 61	18	7	59	72	52	—
Peanut oil, 1, peanut butter, 99 (Standard)	17	74	96	88	72	—
—Check	16	10	19	13	0	—
	Series III					
Fish oil, 33, dried blood, 67	25	77	84	83	68	—
Peanut oil, 1, peanut butter, 99 (Standard)	29	87	83	76	76	—
Peanut oil, 1, peanut butter, 99 (No insecticide—check)	20	0	0	0	7	—
	Series IV					
Cheerios breakfast cereal, 29, impregnated with peanut oil, 71	18	29	73	86	69	78
Purina Dog Chow (finely ground)	22	3	36	9	11	—
Staley's Protein Bait No. 76[a]	44	0	8	8	30	—
Peanut oil 1, peanut butter 99	35	33[b]	32	54	89	91
—Check	29	3	7	3	29	0

[a] Material supplied by A. E. Staley Manufacturing Company, Decatur, Illinois, consisting of amino acids, oils and proteins.
[b] One-week count based on only two plots; remainder on three plots.

(8) Purina dog food, and (9) A. E. Staley's Protein Bait No. 76. Baits 1 through 6 were all slurry-type materials which simulate peanut butter. The breakfast cereal bait is comparable to a granular insecticide formulation. The last two baits are dry, powdery to granular materials, which contain only a small percentage of oil. Peanut butter with 1% by weight of peanut oil added was employed as the standard bait in each test series.

The plots were 1 acre in size and were arranged in either a checkerboard pattern so that the treated plots touched only on the corners or with an untreated buffer zone between the plots (60 feet or more). The tests were in triplicate. The slurry-type baits were applied with a specially designed jeep-mounted applicator. Essentially it consisted of a compressed-air-driven grease pump connected to a 15-foot boom with discharge orifices at 5-foot intervals. The flow rate was controlled by the orifice diameter, the length of the tubing leading to the discharge orifice and the air pressure into the pump. The bait flowed from the nozzles in large drops or in a coarse stream. The whole wheat flour-peanut oil and the dried blood-fish oil baits were too heterogeneous to pass through the grease pumps and therefore were applied by hand. All of the dry baits in series IV were put out by hand. They were applied in strips every 10 feet across the plot. The application rate with the slurry-type baits and the breakfast cereal-peanut oil bait was 6 pounds per acre. The dog food was applied at the rate of 20 pounds per acre and the Staley Protein Bait No. 76 at the rate of 15 pounds per acre.

Table 5 shows the results of these tests over a period of 8 to 16 weeks. The formulations in series I, peanut oil, soybean oil or cottonseed oil and white flour, gave reductions ranging from 90% to 99% after 8 weeks as compared with 94% for peanut butter. In series II and III peanut oil and whole wheat flour or dried blood and fish oil gave control comparable to the peanut butter standard. A reduction of 86% after 4 weeks was given by the breakfast cereal impregnated with peanut oil bait in series IV as compared with 91% after 16 weeks for peanut butter.

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