Insecticidal Soap and Orange Oil Toxicity to Red Imported Fire Ant Workers: Development of a "Home Remedy" Recipe for Use as an Ant Mound Drench Treatment

Bastiaan M. Drees and Bill Summerlin
Texas Cooperative Extension, Texas A&M University System, College Station, TX

There are a number of "home remedies" reported for treating the red imported fire ant, *Solenopsis invicta* Buren (Hymenoptera: Formicidae) including use of very hot or boiling water to drench ant mounds (see Fire Ant Plan Fact Sheet FAPFS012 on http://fireant.tamu.edu). However, many of these treatments are not supported with scientifically conducted and analyzed studies. These laboratory trials were conducted to assess the toxicity of soap or orange oil products, individually and in combination, in order to document the most cost-effective concentrations for potential use as an ant mound drench treatment. Products assessed included:

• Safer® Brand Concentrate Insecticidal Soap Multi-Purpose Insect Killer (Woodstream Corp.,
69 North Locuat Street, Lititz, PA 17543) contains 49.52% potassium salts of fatty acids with use directions for use as a foliar spray for small soft bodied arthropods (such as aphids, spider mites, caterpillars) at a rate of 2.5 fl. Oz. (5 Tbsp.) per gal. water.

• Erath Earth Orange Oil (Erath Earth a Gathering and Holding Co., Rt. 2, Box 111, Hico, TX 76475) is sold with directions for use of 8 fl.oz. per gal for a "soil drench" soil amendment.

For these laboratory assessments, worker ant mortality to various dilutions of products or their combinations were assessed using the "straw technique" described by Drees (2002).

Materials and Methods

All trials were conducted under laboratory conditions at room temperature. Time, temperature and relative humidity were recorded daily for each trial. Red imported worker ants were removed from ant colonies maintained in the laboratory under standardized feeding and watering regime. For each trial, roughly 10 red imported fire ant workers were placed in a clear soda straw on a piece of ear cleaner (Q-Tip) stem and clamped on each end. There were four replicates or straws containing ants per treatment or rate of diluted insecticide and one set of four straws received water as an untreated control. Using a pipet bulb and starting with the untreated control followed by the lowest dilution of candidate material to highest concentration, the straw was filled with the solution for roughly 10 seconds, completely submerging ants, before the solution was blown out of the straw. The ants were observed periodically following exposure to the test solution and number of live ants counted. At the end of the trial the total number of ants per straw were counted after freezing the straws and numbers were converted to number of live ants per 10 ants.

Safer® Brand Concentrate Insecticide evaluation. On January 11, 2007 (12:30 p.m.), the trial was initiated. Temperatures were 74, 76, and 72 degrees F, and relative humidities were 72%, 72% and 71% for Jan. 11, 12 and 13, respectively. The trial was conducted for

48 hrs, with mortality observed at 5, 24 and 48 hrs. following exposure (10 second submersion) into dilutions of insecticidal soap (**Table 1**). Mortality was documented 5, 24 and 48 hrs. following 10 second exposure.

Erath Orange Oil evaluation. We simply started with the concentrated material and prepared half rate dilutions in water, calling the first, 50% solution the 1X rate. The 0.25X rate is equivalent to the 8 fl oz per gal of water listed on the Erath orange oil container. Trial 1, to document mortality of orange oil dilutions to imported fire ant workers, was initiated Jan. 22, 2007 (4:25 p.m., 68 degrees F and 60% relative humidity using dilutions listed in **Table 2**. It was terminated 8:30 a.m., Jan. 23 (67 degrees F and 58% relative humidity). Mortality was observed at 6 and 22 hrs. following 10 second exposure. Trial 2, using lower concentrations of orange oil (**Table 3**), was initiated on Jan. 29, 2007 at 11:20 a.m. (68 degrees F and 53% relative humidity). It was terminated Jan. 31, at 11:20 a.m. (66 degrees F, 55% relative humidity), with mortality documented at 5, 24 and 48 hrs. following 10 second exposure.

Orange oil and insecticidal soap combinations. Based on results of the trials described above assessing ant mortality from either Safer insecticidal soap or orange oil, this series of trials assessed all combinations of the mixture of dilutions showing the lowest range of toxicity to worker ants listed in **Table 4**. Assessments were made in a series of four trials conducted between Feb. 6 and 15, 2006, with mortality documented only after 24 hrs of 10 second exposure (Trial 1, Feb. 6-7; Trial 2, Feb. 7-8; Trial 3, Feb. 8-9; Trial 4, Feb. 1-14). In order to mix dilution combinations, a “stock solution” of the desired concentration of Erath orange oil was prepared (e.g., for Trial 1, 8 ml Erath orange oil was mixed in 232 ml water for the 0.6X concentration). Then the highest concentration of insecticidal soap was mixed using the stock solution (38 ml stock solution plus 2 ml insecticidal soap). Thereafter, each of the serial dilutions was prepared by using 20 mls of the soap plus oil mixture and adding 20 mls of stock solution, thereby diluting only the insecticidal soap (Treatment 1 = 0.6X oil and 2X soap = 1.3 ml oil + 1 ml soap in 40 ml solution; Treatment 2 = 0.6X oil and 1X soap = 1.3 ml oil + 0.5 ml soap in 40 ml solution; Treatment 3 = 0.6X oil and 0.5X soap = 1.3 ml oil + 0.25 ml soap in 40 ml solution; Treatment 4 = 0.6X oil and 0.25X soap = 1.3 ml oil + 0.125 ml soap in 40 ml solution; Treatment 5 = 0.6X oil and 0.125X soap = 1.3 ml oil + 0.06 ml soap in 40 ml solution; Treatment 6 = 0.6X oil and 0X soap = 1.3 ml oil + 0.0 ml soap in 40 ml solution; Treatment 7 = 40 ml water as untreated control). All combinations tested are shown in **Table 5**.

Results and Discussion

Safer® Brand Concentrate Insecticide evaluation. After 24 hrs of exposure, only the 8X rate (37 ml Safer insecticidal soap plus 236 ml water) provided total elimination of live imported fire ant workers (**Table 6**). Some mortality occurred at dilutions as low as th 0.25X rate (0.1 ml soap in 272.5 ml water), and no mortality was documented at greater dilutions.

Erath Orange Oil evaluation. After 22 hrs of exposure to dilutions used in Trial 1, all had produced 100 percent mortality of imported fire ant workers (**Table 7**). Trial 2, conducted using lower dilutions documented 100 percent mortality of concentrations as low as 0.06X (1.3 ml orange oil in 38.7 ml. water), with some mortality at the lower, 0.6X and 0.3X dilutions (**Table 8**). In this trial, total ant mortality occurred in one of the untreated control tubes. Orange oil and insecticidal soap combinations. Although insecticidal soap, such as Safer® Brand Concentrate Insecticide, acts as an active ingredient or an emulsifier for preventing orange oil from separating to the top when mixed in water is difficult to ascertain what role it plays in the mixture. However, in this series of trials, after 24 hrs of exposure to a 10-second "drench" in a soda straw, worker ant mortality was improved. For instance, at the 1X rate, 6.6 or 10 ants survived with soap alone (**Table 6**), the addition of 0.015X orange oil killed all ants in the sample (**Table 9**). Conversely, whereas after 24 hrs of exposure, 2.7 live ants of 10 survived the 0.03X dilution rate of orange oil alone (**Table 8**), addition of the 0.25X rate of insecticidal soap killed all ants in the sample (**Table 9**). The "best" mixture of soap and oil would depend, in part on the cost of each material. However, a good recipe from these results suggests a combination or mixture of 0.25X or higher concentration of insecticidal soap plus a 0.3X orange oil or higher concentration of orange oil. A lower concentration of citrus oil (0.015X) could be effective by adding more (1.0X) insecticidal soap. Conversion of these values to mls. or fl. oz. per gal are provided in **Table 4**:

0.25X soap plus 0.3X oil = 0.42 fl oz or 12.3 ml soap + 2.11 fl oz or 62.5 ml orange oil per gal; 1.0X soap plus 0.15X oil = 1.6 fl oz or 47.9 ml soap + 1.1 fl oz or 31.0 ml orange oil per gal.

These concentrations are good candidates for conducting field evaluations of these formulations as individual imported fire ant mound drench treatments.

Literature cited

Drees, B. M. 2002. A new technique for laboratory assessment of red imported fire ant mound drench treatments. Southwestern Entomologist 27(2):177-183.

Table 1. Safer® Brand Concentrated Insecticide dilutions evaluated for mortality to red imported fire ant workers.

Rate	Amount Insecticidal Soap (ml)	Amount Water (ml)
8X	37	236.5
4X	18.5	255.0
2X	9.3	264.2
1X (near 2.5 fl oz label rate: 2.19 fl oz/ gal)	4.6	268.9
0.5X	0.2	271.5
0.25X	0.1	272.5
0.125X	0.05	273.0
0.0X (untreated control)	0	273.5

Table 2. Erath orange oil dilutions evaluated for mortality to red imported fire ant workers, Trial 1.

Rate	Amount Erath orange oil (ml)	Amount water (ml)
Full strength	236	0
1X	118	118
0.5X	59	177
0.25X (=8 fl oz/ gal)	29.5	206.5
0.123X	14.75	221.25
0.06X	7.375	228.625
0X	0	236

Table 3. Erath orange oil dilutions evaluated for mortality to red imported fire ant workers, Trial 2.

Rate	Amount Erath orange oil (ml)	Amount water (ml)
0.25X	5.0	35.0
0.125X	2.5	37.5
0.06X	1.3	38.7
0.03X	0.6	39.4
0.015X	0.6	39.7
0X	0	40

Table 4. Dilutions of Safer® Brand Concentrated Insecticide insecticidal soap and Erath orange oil dilutions evaluated for mortality to red imported fire ant workers.

Ingredient	**Amount Ingredient (ml)**	**Amount Water (ml)**	**ml or fl oz/ gal**
Untreated Control		40	0.0
Insecticidal Soap			
2X	1.006	39.0	97.64 or 3.30
1X	0.5	39.5	47.9 or 1.6
0.5X	0.25	39.75	23.8 or 0.81
0.25X	0.13	39.87	12.34 or 0.42
0.125X	0.065	39.35	6.32 or 0.21
Orange Oil			
0.6X	1.3	38.7	127.15 or 4.30
0.03X	0.65	39.35	62.53 or 2.11
0.015X	0.325	39.68	31.00 or 1.05
0.0075X	0.1625	39.84	15.44 or 0.52
0.00752X	0.06	39.04	5.82 or 0.20

Table 5. Combinations of ratios of Erath Orange Oil and Safer® Brand Concentrated Insecticide dilutions (ml oil:ml soap/40 ml total volume with water) evaluated for mortality to red imported fire ant workers.

			Insecticidal Soap					
Trial		**ml:ml**	*0*	*0.125X*	*0.25X*	*0.5X*	*1.0X*	*2.0X*
	Orange Oil	*0.004X*	0.007:0.0	0.007:0.006	0.007:0.125	0.007:0.25	0.007:0.05	0.007:1.0
4		*0.008X*	0.015:0.0	0.015:0.006	0.015:0.125	0.015:0.25	0.015:0.05	0.015:1.0
3		*0.015X*	0.3:0.0	0.3:0.006	0.3:0.125	0.3:0.25	0.3:0.05	0.3:1.0
2		*0.03X*	0.6:0.0	0.6:0.006	0.6:0.125	0.6:0.25	0.6:0.05	0.6:1.0
1		*0.06X*	1.3:0.0	1.3:0.006	1.3:0.125	1.3:0.25	1.3:0.05	1.3:1.0

Table 6. Average number of live red imported fire ant workers of four 10 ant replicates following exposure to dilutions of Safer® Brand Concentrated Insecticide, Jan. 11-13, 2007 (72 to 76 degrees F, 71-72% relative humidity).

	No. Live Worker Ants/ 10		
Dilution	**5 hrs**	**24 hrs**	**48 hrs**
8X (37 ml soap/ 236 ml water)	0.9	0.0	0.0
4X	5.3	3.5	2.0
2X	5.9	4.4	3.8
1X (label rate 2.5 fl oz/ gal)	7.7	6.6	5.7
0.5X	9.1	9.0	9.1
0.25X	9.2	7.6	6.8
0.125X	10.0	10.0	10.0
0.0X (untreated control)	10.0	10.0	9.8

Table 7. Average number of live red imported fire ant workers of four 10 ant replicates following exposure to dilutions of Erath orange oil, Jan. 22-23, 2006 (67 to 68 degrees F, 58-60% relative humidity). dilutions evaluated for mortality to red imported fire ant workers.

	No. Live Worker Ants/ 10	
Dilution	**6 hrs**	**22 hrs**
Full strength	0	0
1X	0	0
0.5X	0	0
0.25X	0	0
0.123X	0	0
0.06X	4.6	0
0X	10	10

Table 8. Average number of live red imported fire ant workers of four 10 ant replicates following exposure to dilutions of Erath orange oil, Jan. 29-31, 2007 (66 to 70 degrees F, 53- 55% relative humidity). dilutions evaluated for mortality to red imported fire ant workers.

	No. Live Worker Ants/ 10		
Dilution	**5 hrs**	**24 hrs**	**48 hrs**
0.25X	0.0	0.0	0.0
0.125X	0.0	0.0	0.0
0.06X	0.0	0.0	0.0
0.03X	3.0	2.7	2.7
0.015X	3.4	2.7	2.9
0X	7.8	7.8	7.8

Table 9. Average number of live red imported fire ant workers of four 10 ant replicates following exposure to dilutions of Erath Orange Oil and Safer® Brand Concentrated Insecticide (insecticidal soap) combinations after 24 hrs of exposure to a 10 second drench, Feb. 6 - 15, 2007.

Trial*			**Insecticidal Soap**					
	Orange Oil		*0*	*0.125X*	*0.25X*	*0.5X*	*1.0X*	*2.0X*
5		*0.004X*	8.5	9.6	5.5	5.0	1.0	1.0
4		*0.008X*	9.7	8.4	6.9	1.2	0.5	0.7
3		*0.015X*	1.6	4.0	0.3	0.3	0.0	0.0
2		*0.03X*	0.3	0.3	0.0	0.0	0.0	0.0
1		*0.06X*	0.0	0.0	0.0	0.0	0.0	0.3

* **Trial 1:** (0.06X stock solution = 8 ml orange oil in 232 ml water = 240 ml total volume) Feb. 6, 2007 at 70 degrees F and 60% relative humidity, untreated control at 24 hrs. -10 live ants; **Trial 2:** (0.03X stock solution = 4 ml orange oil in 236 ml water = 240 ml total volume) Feb. 7 at 72 degrees F and 70% relative humidity, untreated control - 9.6 live ants; **Trial 3:** (0.015X Stock solution = 2 ml orange oil in 238 ml water = 240 ml total volume) Feb. 8 at 74 degrees F and 66% relative humidity, untreated control - 10 live ants; **Trial 4:** (0.008X stock solution = 1 ml orange oil in 239 ml water = 240 ml total volume) Feb. 15, untreated control - 10.0 live ants; **Trial 5:** (0.004X stock solution = 0.5 ml orange oil in 239.5 ml water = 240 ml total volume) Feb. 13 at 66 degrees F and 59% relative humidity, untreated control - 9.7 live ants

Volume conversions:
1 gal = 4 qts = 8 pts = 128 fl oz = 3.785 l = 3785.3 ml
½ qt = 1 pt = 0.4732 l = 473 ml
1 fl oz = 29.573 ml
1 qt = 2 pts

Erath Earth Orange Oil Erath Earth Gathering and Holding Company, Rt. 2, Box 111, Hico, TX 76457) - cold press citrus peel extract - “6 to 8 oz per gallon of water for soil drench” $19.95/qt (32 fl oz); Note: 1 Tbsp. = 1 oz of liquid

GreenSense 100% Citrus Oil (RO 1651 Wall St., Garland, TX 75041; http://www.greensense.net) - 100% d-limonene (orange oil) - “As a mound drench, mix one-third GreenSense Citrus Oil, one-third compost tea and one-third blackstrap molasses. Add one cup of this mixture to one gallon of water. Shake well. Pour directly on affected area.” - $16.95/qt

Murphy Pure Vegetable Oil Soap (Colgate-Palmolive Co., NY, NY 10022; http://www.murphypoilsoap.com) - “biodegradable and phosphate free”

Safer® Brand Fire Ant Killer (Safer® Inc., Lititz, PA 17543; http://www.victorpest.com D-limonene (5.6 lbs/gal) 78.20%, inert ingredients 21.80% WARNING - 5.0 fl oz/gal water

Safer® Brand Insecticidal Soap (Woodstream Corp., 69 North Locust St., Lititz, PA 17543 (717/626-2125); http://www.victorpest.com - potassium salts of fatty acids 49.52%, other ingredients 50.48% WARNING - 2.5 fl oz/gal water