Efficacy of lemon juice and peppermint oil in eliminating *Solenopsis invicta* (Hymenoptera:Formicidae)

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Abstract: *Solenopsis invicta* (Hymenoptera:Formicidae) (Buren), also known as the Red Imported Fire Ant, is a common nuisance in the United States. Known for its painful sting and the potentially severe effects it can have as well as the damage it can cause to agriculture, this insect increasingly becoming a dangerous pest. As commercial insecticides are not always available or safe, this experiment was designed to determine if some household items could serve as effective replacements. This was done by spraying the ants with five milliliters of varying concentrations of lemon juice and peppermint essential oil. The results showed that the peppermint oil was the most effective in eliminating *S. invicta* for all concentrations tested.

Key Words: *Solenopsis invicta*, red imported fire ant, peppermint essential oil, lemon juice

Solenopsis invicta is an invasive species of Hymenoptera native to South America that has been incidentally introduced to many geographic regions of the world. Since being introduced to North America, *S. invicta* has spread to over twelve states including Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, and Virginia (Kemp et al., 2000). The medical relevance of *S. invicta* stems from its capacity to cause allergic reactions via its venom, which can have lethal effects derived from anaphylaxis. Anaphylaxis is caused when the body creates antigens against a substrate that is otherwise harmless causing the immune system to trigger an allergic reaction. The response can occur quickly and can cause a drop in arterial pressure, edema of the airways, nausea, vomiting, and in some cases death. The *S. invicta* also has widespread relevance in its ability to undermine the topography of fields via their mounds, potentially costing farmers thousands in damaged equipment. In a 2006 study done by Texas A&M University, it was estimated that the *S. invicta* cost the United States and Puerto Rico over $6 billion annually in damages (Lard et al., 2006). We intend to explore the viability of two household remedies, peppermint oil and lemon juice, in eliminating S. invicta. More specifically, we are investigating the lethality per varying concentration as a means of determining the effectiveness of each respective mixture. We have chosen peppermint oil due to its inclusion of monoterpenoids, a substance present in many cedars, citrus, eucalyptus, mints, and spices (Appel et al., 2001). Monoterpenoids have been shown to induce a variety of responses in insects such as deterring insects and even killing them (Rice and Coats 1994). Lemon juice was also chosen due to its use as an insect repellant and its high acidic content (Wiltz et al., 2007). We predict that the peppermint oil will have a more lethal effect on the insects due to its proven effectiveness against insects in the past. Furthermore, we hope that our compiled data may be useful as

a guide to preparing a fire ant insecticide within a domestic setting.

Material and Methods

The ants used in this experiment were collected from ant hills found in College Station, Texas. For this experiment, four different concentrations of pure lemon juice and peppermint essential oil were used to effectively test kill rate of *S. invicta* at variable concentrations. The lemon juice used was ReaLemon 100% Lemon Juice (Dr Pepper Snapple Group, Houston, TX) and the peppermint essential oil used was Nature's Truth Peppermint Aromatherapy Essential Oil (Piping Rock Health Products, Ronkonkoma, NY). For the first concentration, *S. invicta* was separated into two separate plastic containers which were Rubbermaid Easy Find Lids Food Storage Containers (Rubbermaid, Atlanta, GA). One was used to test peppermint essential oil and the other was used to test lemon juice. 5 mL of 100% pure lemon juice and 100% peppermint essential oil were sprayed in their corresponding container using a Made By Design 32 fl oz Spray Bottle (Target Corporation, Minneapolis, MN). The ants were defined as dead by a complete lack of mobility by the end of two minutes of the chemical application. The same trial and conditions were repeated three times for each concentration. The bottle was cleaned before each new concentration was placed in it. Additionally, trials at 75%, 50%, and 25% concentrations of each substance were also used three times with 5 ml sprayed. For the 75% concentration, 15 ml substance and 5 ml water were mixed together, making the total of 20 ml. For the 50% concentration, 10 ml substance and 10 ml water were mixed together. Finally, for the 25% concentration, 5 ml substance and 15 ml water were mixed together. A control group was used to verify the exclusivity of environmental and other confounding variables. For the control group, 10 ants were added in a clean plastic container with no added substances.

Results

Results showed that peppermint essential oil has a stronger effect on killing *S. invicta* than lemon juice. During the control trial, all of the ants survived. For all the concentration groups, there was only one where lemon juice actually killed a higher percentage of ants. The 100% concentration group is very similar to each other in data. Whenever each is diluted down with water, peppermint oil still seems to have a strong effect on the ant species. For the tables below the fractions are represented as a ratio between the number of ants that died and the number of ants that were used in each trial.

Table 1. Control Group showing the number of ants used in the trial compared to the number of ants that died.

Number of Ants Total	Number of Ants that died
10	0

Table 2. 100% Concentration is used and the fraction of the number of dead ants to the total ants is used next to their respective percentages for three different trials.

	Lemon Juice Fraction (Dead Ants/Total Ants)	Lemon Juice Percentage	Peppermint Oil Fraction (Dead Ants/Total Ants)	Peppermint Oil Percentage
Trial 1	15/25	60%	14/24	58.3%
Trial 2	3/15	20%	11/14	78.57%
Trial 3	4/44	9.09%	27/32	84.38%

Table 3. 75% Concentration is used and the fraction of the number of dead ants to the total ants is used next to their respective percentages for three different trials.

	Lemon Juice Fraction (Dead/Total Ants)	Lemon Juice Percentage	Peppermint Oil Fraction (Dead/Total Ants)	Peppermint Oil Percentage
Trial 1	2/24	8.33%	10/29	34.48%
Trial 2	2/40	5%	20/46	43.48%
Trial 3	1/14	7.14%	11/46	23.91%

Table 4. 50% Concentration is used and the fraction of the number of dead ants to the total ants is used next to their respective percentages for three different trials.

	Lemon Juice Fraction (Dead/Total Ants)	Lemon Juice Percentage	Peppermint Oil Fraction (Dead/Total Ants)	Peppermint Oil Percentage
Trial 1	1/29	3.45%	14/33	42.42%
Trial 2	2/31	6.45%	9/24	37.5%
Trial 3	1/14	7.14%	6/11	54.55%

Table 5. 25% Concentration is used and the fraction of the number of dead ants to the total ants is used next to their respective percentages for three different trials.

	Lemon Juice Fraction (Dead/Total Ants)	Lemon Juice Percentage	Peppermint Oil Fraction (Dead/Total Ants)	Peppermint Oil Percentage
Trial 1	1/17	5.88%	8/16	50%
Trial 2	1/15	6.67%	5/14	35.71%
Trial 3	0/18	0%	3/25	12%

Discussion

The results of the experiments confirmed that the initial hypothesis was correct in that the peppermint oil is more effective at killing fire ants than the lemon juice. In the control group trial, no ants died. This shows that the cause of death was in fact the homemade remedy and not stress. In one case, it was shown that the lemon juice was more effective at killing the ants than the peppermint oil (Table 2: Trial 1). This could have been due to the high concentrations of substances being used, since the lemon juice had the highest lethality rate at 100% concentration (Table 2). However, the following trials showed that the ants had a significantly higher mortality rate when the peppermint oil was used. This demonstrates that peppermint oil is a more effective agent in ant mortality. The results of the experiment show that peppermint oil, and in some cases possibly lemon juice, has some potential to serve as a viable substitute for insecticides. Other studies conducted on the use of peppermint oil as potential fire ant repellent and insecticide have also concluded that there could be a use for peppermint oil in integrated pest management scenarios (Appel et al., 2004). This opens the possibility of looking further into testing the attributes of these “household remedies” when combatting insects. Possible follow up experiments could include testing lemon juice, peppermint oil, and other essential oils in a domestic setting to explore their viability to be used as a lasting insecticide, insect or insect repellent. The use of peppermint oil as

potential home insecticide has shown to be possible given the mortality rates induced by its exposure to fire ants. This gives good reason to continue testing the use of plant derived substances, like peppermint oil, to use against insects.

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