**A Study Comparing Essential Oils as Repellents and Pesticides Against the Red Imported Fire Ant, *Solenopsis invicta* (Hymenoptera: Formicidae)**

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**Abstract.** *Solenopsis invicta,* the Red Imported Fire Ant, is an invasive species that poses a threat to certain individuals by entering homes and living spaces. However, pesticides are overused and finding other more natural methods of repelling and killing these insects is necessary. In this experiment, the essential oils lemongrass, lavender, and tea tree oil were tested to determine their efficacy as repellents and insecticides against these ants. To test them as repellants, the ants were placed inside of a square, plastic container close to the wall opposite of the bait. There was a line of oil with a space left for the ants to walk through to access the bait. Tea tree oil proved to be the best repellant, deterring the ants from accessing the Oreo bait one-hundred percent of the time. To test these oils as insecticides, the ants are placed in small drops of each oil and left until they were deceased. Lavender was shown to be the most effective insecticide, but the results of this portion were deemed inconclusive. The results of this experiment were important in demonstrating that using natural insect repellants is possible to decrease the amount of chemical pesticides used globally.

Keywords: *Solenopsis invicta,* Red Imported Fire Ant, essential oil, natural pesticide

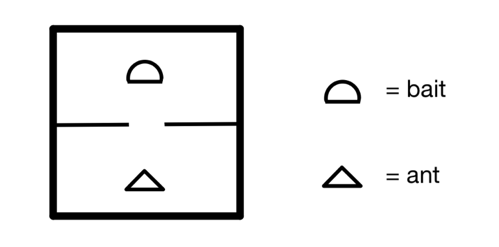
The *Solenopsis invicta* (Hymenoptera: Formicidae), otherwise known as the Red Imported Fire Ant (IFA), is an aggressive species of ant that has displaced different ant species since its introduction to the United States from South America. (Ling et al 2005) This occurred in 1940 in Mobile, Alabama, and have since expanded their territory across the United States. (Lofgren et al 1975) Only limited in range by cold temperatures and dry deserts, IFA are extremely invasive. However, these limitations are diminishing as they have evolved the capability to interbreed with other ant species to become more resilient to these factors. This is problematic as they cause Hymenoptera venom allergy that will result in deadly anaphylactic shock in individuals hypersensitive to the IFA venom after a sting. Following the sting, an inflamed, red pustule forms that is surrounded by localized swelling in most cases. The venom affects the nervous system, causing hallucinations, loss of conscious, and confusion in hypersensitive persons with large numbers of stings. (Villines 2018) It is important that *S. invicta* numbers are controlled and that they are not permitted entrance to households to ensure the safety of those at risk. Many types of insecticides are used against them, such as long acting ones like granular fipronil or mound treatments like hydramethylnon. Producers and individuals are gravitating towards using more natural products to repel and eliminate IFA. It has become increasingly prevalent to use essential oils as repellents and insecticides upon direct contact. In this experiment, repellant has been defined as a substance that deters and discourages the insects from contacting the substance, but does not kill them. Insecticides have been defined as substances that terminate an insect’s life. Essential oils have been shown to be effective repellents and insecticides when used against IFA. Lavender oil has been shown to function as an ascaricide and insecticide with aphids and other insects when applied directly and when inhaled. (Cavanagh 2002) Tea tree oil has been shown to kill some ant species. (Beverly 2007) Lemongrass has also been shown to repel insects, such as flies. (Baldacchino 2013)

*Materials and Methods*

Methods for collecting and identifying *S. invicta*

The *S. invicta* ants were collected from a mound at the base of a tree in Wolf Pen Creek Park in College Station, Texas. A hand shovel and a closed, non-airtight plastic container was used in the collection process to scoop and place part of the ants into the container. Two-hundred ants were gathered to ensure the number of specimens would be adequate for identifying and testing. They were identified as IFA using a Binocular Stereo Zoom microscope.

*Methods for testing lavender, tea tree, and lemongrass oil as repellent*

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***Figure 1:*** *Oil line, bait, and ant inside of experiment bin.*

Each trial was identical when testing the different essential oils. A line of oil drops with a one inch gap dividing the line in the center was made across the length of the center of a five inch by five inch square, plastic container. A single ant was placed on one side of the oil barrier and an Oreo cookie dipped in water was placed on the opposing side of the container. Each oil had its own identical container set-up, but the fourth container was used as the control, which only composed of the Oreo cookie and the ant with nothing dividing them. A timer was set for four minutes and the ants’ activity was observed. This was repeated for five trials using a different ant each time in each oil’s container.

*Methods for testing lavender, tea tree, and lemongrass oil as insecticides*

To test the efficacy of the oils as insecticides, groups of three ants were placed in small, shallow drops of each oil in their individual plastic containers used in the repellant test. The ants were observed until they stopped showing signs of movement while a stopwatch was set.

*Results*

**Essential Oils used as repellent**

|  |  |
| --- | --- |
| Oil Test | Number of ants that reached bait |
| Lavender | 4 |
| Tea Tree | 0 |
| Lemongrass | 1 |
| Control | 5 |

***Table 1:*** *This data shows the number of ants during the five trials that reached the bait.*

Three oils, lavender, tea tree, and lemongrass, were compared to each other and the control across a total of five trials for each. Eighty percent of ants crossed the lavender oil barrier, zero ants crossed the tea tree oil barrier, twenty percent of ants crossed the lemongrass barrier, and one-hundred percent of ants in the control test trials reached the cookie. See Table 1 for this information. Tea tree oil was shown to serve as the most effective ant repellent while lavender was shown to be the least effective.

*Essential Oils Used as Insecticide*

With each test, all of the oils effectively exterminated the groups of ants. The group of ants in the lavender oil died first within seven minutes, the group in the tea tree oil died next at nine minutes and thirty-three seconds, and the group in the lemongrass died last at fifteen minutes and twelve seconds.

*Discussion*

The purpose driving this experiment was to find alternative ways of preventing ants from accessing households using fragrant substances that have been used frequently in homes. This way, people would be more inclined to utilize them and thus decrease the amount of chemical pesticides that are used. More than one billion pounds of chemical insecticides are used every year in the United States; these products can poison users and this danger poses a greater risk within homes and enclosed spaces. (Alavanja 2010) Ants are highly attracted to carbohydrates and moisture, which was why an Oreo dipped in water was chosen for the bait. It was shown to be an effective bait as one-hundred percent of the ants reached the bait during the control trials. It would be expected then for the ants to reach the bait during the other trials if the repellant was not effective. The tea tree oil was the most effective oil when used as a repellent as no ants crossed its formed barrier. The active ingredient in this oil is terpinen-4-ol, which was been seen to kill *Demodex* mites. (Tighe et al 2013) This ingredient has also been shown to be an antiparasitic agent. It appears to function more efficiently when used on its own rather than in combination with other ingredients as it is in the oil. The non-oxygenated terpenes found in the oil lower terpinen-4-ol’s solubility, thus reducing its chemical availability. It likely would have repelled the ants better had it been used alone rather than using the oil.

As for the test using the oils as an insecticide, the results were contrary to what was found during the repellant tests. It was expected that the same oil would work as the best repellent and insecticide in both experiments, but this was not the case. While lavender was the least effective as a repellent, it was the most effective as an insecticide. It is unclear whether the ants died because of the effects of the oils or if they simply drowned. The results of this part of the experiment were regarded as inconclusive.

Some observations that were noted included the attractiveness of the bait. Although the ants did go near the Oreo in the control test and during the various trials in which they crossed the barrier, they were not seen to crawl on, contact, nor attempt to consume the bait. It was assumed the ants approaching the bait was indicative of their attraction to it. Another observation was that during some of the trails, the ants also attempted to escape the container but were pushed back into it using tweezers. Due to the ants’ inconsistency with this behavior, it was unclear whether it was the repellant effects of each oil or that the ants were exploring the territory.

To improve the experiment in the future, the ants would be prevented from crawling on the walls of the container. To make the experiment testing the oils as insecticides reliable, future experiments would have the ants sprayed with a thin layer of each oil and observed rather than putting the ants in droplets of oil. This would avoid any chance of the ants drowning.

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