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Small Plot Experimental Study for Testing Efficacy of ant Repelling Activity of Essential Oils

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Abstract

This experiment was conducted to evaluate the use and effect of essential oils as a natural, environmentally-friendly repelling agent to the Carpenter Ants Camponotus tortuganus (Emery) & Camponotus Floridanus (Buckley). Essential oils such as Clove Oil, Peppermint Oil, and Tea Tree Oil were generated through a steam method and used as choice of barriers. The test was performed with a hypothesis that the essential oils would repel ants due to how their strong smell interferes with the ants' scent trails, pheromones and communications. On the basis of the data collected from persistent ant repellent test activity, Clove oil showed 88% of efficacy and performed very close to industrial repellent which has a 97% efficacy. There were very consistent results among all trials, pointing towards the effectiveness of the organic choice of product. This alternative can reduce the harmful impact that the chemical and commercial products have on the environment, wildlife and even humans in the long run.

INTRODUCTION

When identifying common problems both globally and in Florida, the excessiveness of certain species of ants seems to be a concern. Finding methods to repel ants through simple and organic solutions would be beneficial to many facing these issues. Natural solutions were preferred to chemical solutions due to their abundancy in consumer settings and affordability. They also tend to be safer and minimize negative impact both for the consumer itself as well as the environment. The extraction of essential oils was done to determine their ability to repel common Floridian ant species was chosen as the

experiment.

Millions get uncomfortable and painful ant bites every year. Some people even develop rare reactions to the ant bites, such as anaphylaxis, which is potentially life threatening. Ant related problems are considerable in Florida due to their inclination towards hot and humid environments. One major issue is that people must use environmentally unfriendly, toxic ant repellents to prevent bites and stings, as well as to prevent ants from coming into their residence. These chemicals can harm us humans and also damage the wildlife around us.

Various natural substances were researched to determine which could serve as possible ant repellants. Each essential oil chosen comes from a different plant. The current method of extracting essential oils is to first heat the nearest water source to the point where there is steam. The steam will automatically pull the oil from the plant. Then the steam is collected. Since oil is less dense than water, it will float to the top. The oil is simply extracted from the water and the process is complete.

The research showed that essential oils could be effective against insects and arthropods. Essential oils may be effective against ants due to their strong smell and its impact on the ants' pheromones and communications. Pheromones are the scent that ants leave to keep track of where they have travelled, as well as to inform other ants. In essence pheromones are scent trails. It was hypothesized before testing that if ants were exposed to the essential oils, then the stringent smell of the essential oils would repel the ants because the ants might dislike the smell since it interferes with their scent trails and communication.

LITERATURE REVIEW

Ants

Ants are both a concern and an annoyance around the world and people are always looking for ways to avoid them. Ant bites can cause pain, allergic reactions, and other complications and they are also very common and difficult to deal with. Ants are drawn to humid and hot environments, which makes Florida a perfect habitat for them. In fact, a survey of four metropolitan areas in the state found that carpenter ant infestations accounted for 20%of all ant complaints by homeowners (1). Ants prefer to nest in areas close to moisture and food and away from predators and environmental stresses (1). Due to this they often find their way into houses and can excavate into damaged wood and other places where they become an inconvenience to many homeowners. Carpenter ants are one of the state's most common indoor pests and homeowners often have to deal with them by spraying insecticides or calling pest control operators. Ant bites can also be concerning, especially for those who develop serious complications due to them, such as anaphylaxis or hypersensitivity. Due to their prevalence in Florida and the

dangers they pose to health, many turn to pesticides as a way to avoid ants and other pests.

Limitations of Commercial Ant Repellents

The shift in preference from chemical to natural repellents is due in large part to the shortcomings of the pesticides that consumers are so used to. From their effects on the environment to humans and wildlife, pesticides seem to have many detrimental consequences.

It is estimated that the amount of applied pesticides that actually reach their target pests, ants in our case, is 0.1%. The other 99.9% of the applied pesticides simply just affect the environment and other surroundings (2). This statistic makes obvious that almost all of the pesticides that are used go towards influencing other sensitive living things that are better left unharmed. This has become a large concern for today's farmers, scientists, and consumers as environmental conservation has come to the forefront as one of our most pressing issues.

Since there are such a large portion of pesticides and chemicals that are left in the environment, they have to go somewhere. Most of the leftover pesticides find their way into both groundwater and surface water. Pesticides have even been detected in rain and fog at times (3). This is a very dangerous result of pesticides as unwanted chemicals are contaminating surface water (streams, lakes, and rivers) (3). Much of this surface water is used as drinking water and for other recreational activities. The pesticides that make their way into drinking water tend to remain in the water due to the fact that most treatments for drinking water do not accommodate for pesticide contamination. A study by R.D. Kelley took samples of drinking water in Iowa and discovered that at least one pesticide was found in approximately 90% of drinking water tested (4). Pesticides are also dangerous in groundwater as most of the US population gets their drinking water from wells. Also, pesticide residue has the capacity to remain in groundwater for extended periods of time (3). Even if it is not always visible, pesticides are greatly influencing the environment and humans as a result.

Another environmental effect of pesticides is their influence on other wildlife. For example, data shows that arthropods, such as honey bees, face highly negative effects from pesticides including learning performance, neurophysiology, and behavior (5). Beneficial arthropods like honey bees are vital to keeping an ecosystem healthy and balanced. Beneficial species also help keep the environment foliated which is required for clean air, as well as doing other important things (3). These beneficial species are negatively affected by pesticides as well. One of the major issues of the death of certain species is that it causes an imbalance in the populations of animals that they consume. For example, if a specific pest that is important to an ecosystem is eradicated through pesticides, the secondary pest that it preys on will continue to grow in unprecedented numbers. This causes many issues within the environment. Larger animals can also be

affected negatively by these practices. Birds and other animals have been killed directly by toxic or heavily applied pesticides and some other effects can eliminate food supplies, habitats, or upset reproductive practices (3).

The most direct way insect repellents affect humans are through their consequences to health. Pesticides have been found to contain carcinogens, which are substances with the potential to cause cancer (6). Exposure to pesticides can cause acute problems like dermatitis and asthma exacerbation or more long-term issues like cancer and COPD (7). Poisonings and illnesses resulting from pesticide use are also relatively common and can be avoided by switching to a more natural solution. One of the most concerning influences of pesticides on humans is how they can affect children. Younger kids can be exposed to them by having contact with floors and surfaces with either their skin or mouths (8). As discussed before, many of the ingredients in pesticides can have terrible health repercussions on both animals and humans, ranging from cancer to neurobehavioral issues. All of these serious issues and more clearly show why the search for organic and natural alternatives to chemical pesticides are necessary.

Essential Oils and Natural Alternatives to Pesticides

Due to the obvious demand and need for safer repellents that are less harmful to the environment and human health, essential oils from a variety of plant species have been tested in recent years (9). According to the Oxford English Dictionary, an essential oil is a natural oil that is usually taken by distillation and has the characteristic scent of the source or plant it is extracted from (10).

Natural, plant-based repellents have been used to keep away pests, such as mosquitos, for many generation in more traditional settings (11). Essential oils and the plants they come from are used as insect repellents around the world. Residents of rural areas have burned and hanged the plants in their homes in hopes of avoiding insects while other places have used oils for a long time (11). Some of the most effective essential oils have been found to be thyme, peppermint, cedar, and clove. They are practical and efficient solutions for repelling malaria and yellow fever vectors; however, the repelling activity only works for short periods of time (approximately 60- 180 minutes) (11). One of the ways to combat this and make essential oils last longer is to pair them synergistically with other natural products, such as vanillin (9). This has been shown to increase the protection times and makes essential oils more feasible as an alternative to repellents.

Much research has been done on repellent activity of natural, organic products in recent years. A specific study shows the effect of essential oils towards mosquitos, showing the demand for natural based repellents to be developed and replace compounds that have toxic, damaging results. The study showed that many essential oils from Argentinian aromatic plants are effective repellents (12). Another study with a similar purpose was done to see the effects of certain essential oils on American and German

cockroaches and Carpenter ants. The American cockroaches that were exposed showed a period of hyperactivity and then hyperextension of their abdomen and legs. Afterwards, they experienced a quick knockdown or immobilization and finally death. Similarly, Carpenter ants and German cockroaches also showed quick immobilization/knockout and the death shortly after. This study found that essential oils can be neuro-insecticides that affect different species differently and that when different oils work synergistically they can be much more effective (13).

These studies show that while there is much to still be discovered and learned about essential oils, they are already a promising and effective substitute. These discoveries are important and more research is continuously being done in order to provide substitutes that are not toxic or harmful to humans and the environment.

METHODOLOGY

The essential oils were extracted using a steam distillation method. The specific plant mixture and water were brought to a boil. Steam was produced from this, which was then collected and condensed. The layer of oil that was floating at the top of water was separated and then used for the experiment. The three different plants used to extract essential oils were Tea Tree plant (Leptospermum scoparium), Clove plant (Eugenia caryophyllata or Syzygium aromaticum), and Peppermint plant (Mentha).

Six well cell culture petri plates were prepared for experiment. Each well was filled with cotton balls that had been dampened with 6 grams of sugar water. Each cotton ball was topped with 0.6 grams of Tea tree oil on the. This was repeated two more times with similar oil and measures. This was also done again to create two plates filled with clove oil and two plates filled with peppermint oil. Similarly, the two plates were prepared with an application of 6 grams of sugar water on the cotton balls, topped with Industrial Ant Shield product.

All of the plates were kept outside at approximately the same distance away from an ant hill. Ant activity was observed and recorded 4 times a day at same times of the day. The experiment was performed for a 72-hour period of time. Deceased ants were counted with naked eye where possible. In other cases, the area with ants in each well was measured with a ruler and ants were calculated by area. The whole experiment was repeated five times for a total of five trials.

RESULTS

Data Tables show the percentage of repellency calculated per oil and Industrial ant shield product.

Set 1	Day 1				Day 2				Day 3				**Average**
Time>	**8:30 AM**	**10:30 AM**	**12:30 PM**	**2:30 PM**	**8:30 AM**	**10:30 AM**	**12:30 PM**	**2:30 PM**	**8:30 AM**	**10:30 AM**	**12:30 PM**	**2:30 PM**	
Clove oil	100 %	95.45%	92.30%	100 %	98.37%	92.76%	90%	93.62%	84.71%	80.25%	80%	88.64%	91%
Peppermint oil	86.36%	63.63%	52.85%	72.41%	83.60%	52.20%	47.78%	55.32%	40%	25.70%	30%	68.19%	57%
Tea Tree oil	- 2	7.75 %	7.14 %	6.45 %	11.48%	-7	7.76 %	-12	10.60%	- 1	12%	11.30%	4%
Industrial Product	100 %	98.50%	100 %	100 %	96.20%	95.60%	100 %	97.80%	100 %	92.50%	100 %	97.70%	98%

Set 2	Day 1				Day 2				Day 3				**Average**
Time>	**8:30 AM**	**10:30 AM**	**12:30 PM**	**2:30 PM**	**8:30 AM**	**10:30 AM**	**12:30 PM**	**2:30 PM**	**8:30 AM**	**10:30 AM**	**12:30 PM**	**2:30 PM**	
Clove oil	100 %	93.76%	82.41%	82.37%	88.97%	96.72%	75.71%	85.69%	93.56%	87.56%	80.51%	81.78%	87%
Peppermint oil	85.45%	58.23%	61.11%	58.65%	78.65%	67.34%	45.54%	77.56%	63.86%	62.57%	39.57%	70.98%	64.12 %
Tea Tree oil	- 2	8.15 %	5.37 %	6.12 %	4.22 %	12.10%	- 8	- 5	5.16 %	- 6	- 3	1.12 %	13%
Industry Product	100 %	98.50%	100 %	100 %	96.20%	95.60%	100 %	97.80%	100 %	92.50%	100 %	97.70%	98.16 %

Set 3	**Day 1**				**Day 2**				**Day 3**				**Average**
Time>	**8:30 AM**	**10:30 AM**	**12:30 PM**	**2:30 PM**	**8:30 AM**	**10:30 AM**	**12:30 PM**	**2:30 PM**	**8:30 AM**	**10:30 AM**	**12:30 PM**	**2:30 PM**	
Clove oil	100 %	88.64%	87.15%	97.06%	93.99%	90.83%	82.18%	86.05%	71.70%	57.15%	53.20%	73.34%	82%
Peppermint oil	52.64%	64.82%	52.86%	67.65%	63.16%	61.40%	56.44%	55.82%	47.17%	22.45%	14.52%	71.43%	52.53 %
Tea Tree oil	-21	18.52%	7.15 %	17.65%	12.29%	10.10%	- 7	6.66 %	13.21%	- 10	11.29%	7.33 %	5.51 %
industry ant shield	100 %	100 %	97.00%	95%	97%	95.40%	100 %	100 %	100 %	93%	98.50%	96%	97.67 %

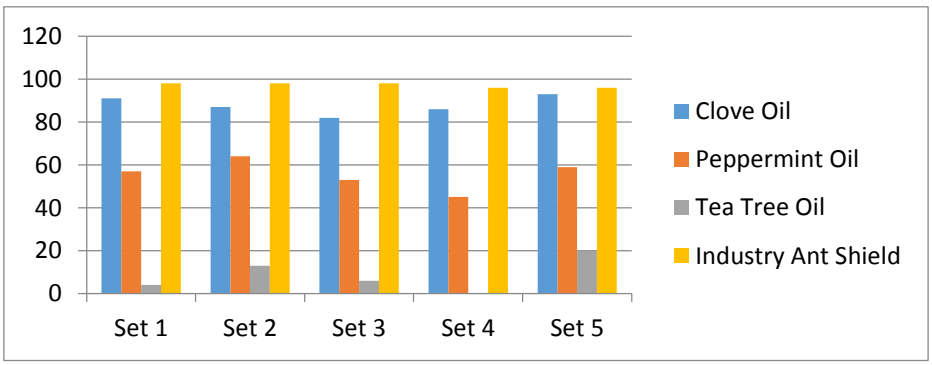
Set 4	**Day 1**				**Day 2**				**Day 3**				**Average**
	8:30 AM	**10:30 AM**	**12:30 PM**	**2:30 PM**	**8:30 AM**	**10:30 AM**	**12:30 PM**	**2:30 PM**	**8:30 AM**	**10:30 AM**	**12:30 PM**	**2:30 PM**	

Clove oil	94.92%	86.28%	90.79%	0%	96.88%	93.34%	0%	0%	33.34%	90%	100%	0%	85.68%
Peppermint oil	66.11%	35.30%	50%	0%	71.88%	53.34%	0%	0%	0%	30%	54.95%	0%	45.19%
Tea Tree oil	20.34%	- 17	11.85%	0%	28.13%	- 20	0%	0%	- 18	50%	- 4	0%	0.00%
Industry ant shield	100%	95.16%	95.45%	0%	99%	98.83%	0%	0%	93.75%	94.50%	93%	0%	96.12%

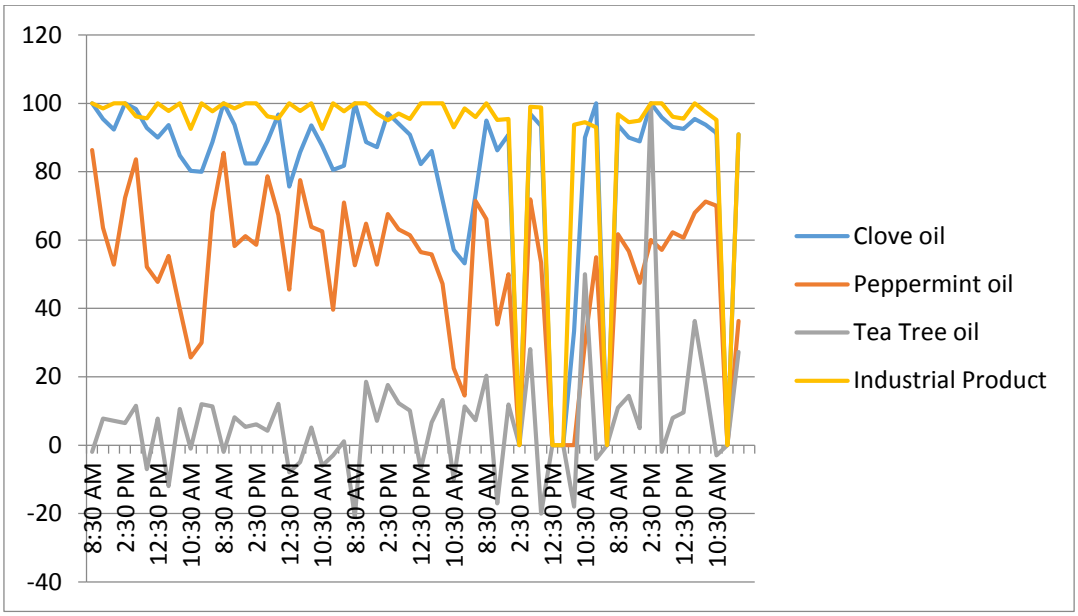
Set 5	**Day 1**				**Day 2**				**Day 3**				**Average**
Time	**8:30 AM**	**10:30 AM**	**12:30 PM**	**2:30 PM**	**8:30 AM**	**10:30 AM**	**12:30 PM**	**2:30 PM**	**8:30 AM**	**10:30 AM**	**12:30 PM**	**2:30 PM**	
Clove oil	93.60%	90%	88.90%	100%	95.90%	93.06%	92.50%	95.45%	93.75%	91.26%	0%	90.90%	93.21%
Peppermint oil	61.70%	56.75%	47.47%	60%	57.10%	62.30%	60.70%	68%	71.25%	70%	0%	36.36%	59.20%
Tea Tree oil	11%	14.40%	5%	100%	-2	8.00%	9.60%	36.30%	17.50%	- 3	0%	27.27%	20.33%
industry ant shield	96.80%	94.50%	94.94%	100%	100%	96.03%	95.50%	100%	97.50%	95.10%	0%	90.90%	96.47%

Average repellency by oil/ ant shield for each set of experiment.

Time	**Set 1**	**Set 2**	**Set 3**	**Set 4**	**Set 5**	**Average**
Clove oil	91%	87%	82%	85.68%	93.21%	87.78%
Peppermint oil	57%	64.12%	52.53%	45.19%	59.20%	55.61%
Tea Tree oil	4%	13%	5.51%	0.00%	20.33%	8.57%
industry ant shield	98%	98.16%	97.67%	96.12%	96.47%	97.28%



Performance of each oil Vs Industrial Ant Shield is clearly shown in the chart.



DISCUSSION

This experiment was similar to a previous experiment conducted by Scocco, Christopher, and Daniel R. Suiter, titled The Repellency of Five Essential Oils Against the Argentine Ant. The original experiment utilized different ant species as well as different essential oils; however, both had the same purpose of finding an effective natural alternative that could repel ants. The experiment was successful, as all of the data gathered was very consistent.

6 well cell culture plates were used in place of single petri dishes in order to gain more data per trial. Instead of having simply one plate, there was data for 6 plates for each oil and each trial. At first, honey was used to attract ants to the experiment set-up; however, it was decided that sugar water would be more effective as the ants began to stick and sink into the honey, making them more difficult to count. The sugar water was used as the control and compared to an industrial ant repellent called “Ant Shield”, after which efficacies of both were determined. There was consistent data gathered through all 5 trials.

Human error may have slightly influenced the data and results, as the ants were counted with the naked eye for the most part. Small numbers of ants were counted with the naked eye while larger groups were calculated using a ruler. Another source of error could be inconsistencies in the natural environment such as ant behavior (such as them slipping away), the sun, wind, and water. An example is the variance in data due to the temperature and wind. On windier days, there was little to no ant activity.

In the future, the experiment could use an aspirator to make the counting of ants more accurate and efficient. There are plans to build on this experiment in the future in order to create an ant repellent using absorbent strips. The absorbency of the strips would be tested to determine how long the oils can stay in the fabric and keep their smell, as well as how effectively they can repel ants.

The hypothesis for this experiment was that if essential oils were introduced to ants, then their stringent smell would repel the ants due to their strength and interference with the ants' pheromones and communication. Essential oils have been used in insect and arthropod repellents. There is also some research that has been done on essential oils and their ability to repel insects. The data retrieved from the clove oil trials strongly support the hypothesis and confirm that certain essential oils can be used as ant repellents.

CONCLUSION

The purpose of the experiment was to try and see if natural alternatives to pesticides, such as essential oils, could be as effective as the commercial products that are typically used. This was important to research, as there are many unfavorable effects of chemical pesticides on the environment, wildlife, and humans which would be reduced by using a more natural approach. The original hypothesis for the experiment was that if essential oils were introduced to ants, the stringent smell of the oils would repel the ants due to their aversion to the smell. The hypothesis was strongly supported by the data gathered from the trials of clove oil. On the basis of the data collected from all five trials, clove oil showed 88% of efficacy and performed very close to industrial repellent which has an efficacy of 97% efficacy. Among all of the oils tested, clove oil has the highest ant repelling ability, which persisted for at least 72 hours. This project helped prove that there is an organic solution to repel the ants without harming the environment and humans. Clove oil could potentially develop into a commercial product and be used for personal and residential purposes. This organic product will reduce the harmful impact that the chemical commercial product has on environment, aquatic animals and maybe humans in the long run.

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