Observations of the Effectiveness of Essential Oils as a Repellent for Cockroaches (*Periplaneta americana*)

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Abstract: In July 2007, the effectiveness of essential oils were tested as repellents against cockroaches in Thailand. This experimental study tested the effects of several different essential oils on three different species of cockroaches. In this study, only one of the species from the experiment completed in Thailand was used, *Periplaneta americana,* as well as a different set of essential oils: peppermint, eucalyptus, lavender, and orange. By only observing the effectiveness of different essential oils as a repellent for *Periplaneta americana*, in comparison to multiple species at once, a more controlled experiment was able to be conducted with the reduction of variables. As a result, the data can be used in species specific control. Sticky traps with each repellent were placed around a building at Texas A&M University - College Station. In the conclusion of the experiment, the insecticide, Raid, was found to be the most effective as a repellent. The second most effective, and first most for the essential oils, was peppermint. Lavender and orange were the least effective in comparison to the control.

Keywords: repellent, essential oils, *Periplaneta americana*, cockroaches

Periplaneta americana, also commonly known as the American cockroach. *P. americana* is under the family Blattidae because of their flattened and broadly oval body, the presence of a pronotal shield, and a leathery forewing that protects the membranous wings called tegmina. These cockroaches are hardy creatures that often live in moist areas but can survive in dry areas if they have access to water with an average lifespan of about 200 days. They are found mostly in basements, crawl spaces, underneath porches, and in sewers. Since they are endophilic, they often come into close contact with humans. They substantially affect the economy and human health due to its potential of harm as an agent of disease transmission (Al-bayati, 2011).

Along with spreading pathogens, *P. americana* have the potential to cause harm through the allergens they possess. One example of this is their presence of a serine protease (Sudah, 2008). This protease stimulates an allergic response in human respiratory systems, making it hard to breathe and leading to congestion. Frass from cockroaches can also trigger an immune response as it is a skin irritant.

Due to the danger cockroaches can present to humans, there have been many efforts made to control the population and keep them out of residential infrastructure. Homeowners for years have been using repellents with high concentration of DEET and other chemicals. Prolonged use of chemical control agents has been proven to have harmful effects on the environment and

can have a negative impact on human health. (Kumarasamy, 2012). Hence, researchers have been looking for new ways to control cockroaches that are derived from a natural source as well as have a lesser impact on human health. There is a lack of scientific research on essential oils and their effects on cockroaches, but there are a lot of anecdotal stories and claims made of using essential oils as an alternative cockroach repellent. According to clientele testimony, the most effective scent is peppermint because of its fumigant properties on other insects. The research done on the repellent properties of peppermint oil done at Auburn University on cockroaches stated the toxicity for mammalian species are low, while being effective against cockroaches makes it an ideal repellent (Appel 2001). Peppermint is not the sole essential oil candidate to function as an insect repellent. A few examples are lemongrass and eucalyptus oil with the former being considered a very strong repellent (Manzoor 2001).

Studies have shown that essential plant oils can be considered a viable alternative as a conventional insecticide. In the evolution of agriculture synthetic chemical insecticides have been helpful, but with essential oils as an alternative repellent there can be less environmental contamination. Some essential oils and their main constituents can exert similar insecticidal activity (Cutler, 2015). These essential oils have been used on species such as ants and mosquitoes with positive results. A study has been conducted using essential oil *P. cablin* on the ant species *C. melanoticus and D. thoracicus*. The oil showed toxicity and repellency to ants, so a further study could determine if the oil has potential to control ants (Albuquerque, 2013). In addition to ants, essential oils have the ability to repel mosquitoes. Ancient practices have been utilizing natural repellents as they were readily available to all where the burning of neem leaves would keep mosquitoes at bay (Maia, 2011). As the understanding of botany grew, the Chinese found that *Corymbia citriodora* (lemon eucalyptus) potency was enhanced by the waste produced after distillation was the most effective mosquito preventative thus far in the 1960's (Maia, 2011). This could also benefit underdeveloped countries that cannot afford harsh chemicals to rid themselves of pests. The repellent properties of essential oils can be seen in different insect species, but it is left to be explored what the effect of essential oils could be on *P. americana*.

There are numerous misleading articles that can be found on the internet about the use of essential oils as a repellent. These articles provide information that is false and written by authors who have not completed the proper research to support their findings. An example of an unreliable piece of information is that lavender is an effective form of repellent. There are many articles about this theory on the internet despite trials proving this theory to be inaccurate.

Materials and Methods

With *Periplaneta Americana* being a common cockroach species in the Bryan-College Station area they were the focus of capture for this experiment. The data collection took place outside one of the buildings of Texas A&M University that is well known for the abundant number of *P. americana* found outside its walls. The main objective for the study was to lay sticky traps each saturated with a different treatment, outside the

building. Periodically a group member would stop by and record any observations while also collecting the roaches that have been captured, in a container labeled with that specific treatment.

To begin the experiment, 5 Harris Roach traps (Harris, Cartersville, GA), where saturated with approximately 5 oz of one of the 5 treatments including Lagunamoon essential oils (LagunaMoon, Guangzhou, Guangdong): lavender, orange, peppermint and eucalyptus, and a commercial pesticide to act as the positive control: Raid Ant and Roach killer (Johnson, New Brunswick, NJ). One final trap was left untreated to serve as the experimental control. All traps were labeled and kept in its indicated 66 qt plastic container (Sterilite, Townsend, MA) until dropped off at the experimental location. The traps were placed on the grass, in areas of the building that remained shaded for the majority of the day, since *P. americana* likes dark moist places.

After the first two days, members of the group returned to the location to observe, record and collect any *P. americana* that may be present on the traps. The collected *P. Americana* were placed in the plastic containers that the traps were initially transported in, so that an accurate overall record could be kept. The traps were also retreated with 2 oz of the essential oils and the commercial pesticide on these visits so that a strong influence can still be present. The process of observation, collection, and retreatment occurred every 2 days for a week, ending the first trial.

As a final means to observe the effectiveness, the same process for the first trial was then repeated 5 more times, each with a fresh sticky pad. The order/location of each pad was also switched in order to observe any environmental factors that could have played a role in the collection process. This made the study last a total of 6 weeks and the data from each trial was averaged together.

Results

Treatments	Average # of *P. americana* captured using sticky traps
Raid	1
Peppermint	2
Eucalyptus	5
Lavender	7
Orange	7
Control	10

Table 1. *Chart of results of the different traps in ascending order.*

A total of approximately 192 *P. americana* were collected over the 6-week trial periods. Each trial, which ran a total of a week, ended with approximately 32 total *P. americana* being collected across all 6 sticky traps. The average number of *P. Americana* for each trap was calculated across all trials (Table 1).

Alternating the location of each trap from position 1-6 (Figure 1) after each trial resulted in some slight variation in the number of each P. americana collected from each trap in trial 6 compared to 1-5. But it was also noted that during this particular trial there was more rainfall than in the weeks preceding it.

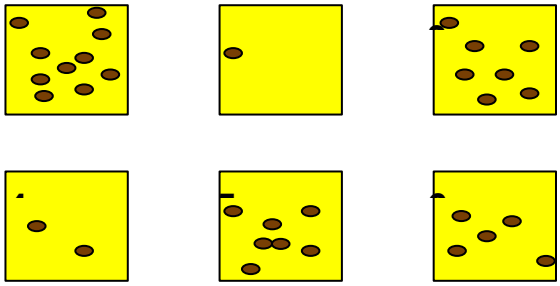

Figure 1. *Pictorial depiction of the traps that were treated with raid, lavender, peppermint, orange, eucalyptus, and along with the non-treated control trap. The oval represents the P. americana.*

The sticky traps that resulted in a collection of the most *P. americana* included the control traps that had no outside substance added (10 on average), the orange essential oil (7 on average) and the lavender essential oil (7 on average). Falling after these was the eucalyptus essential oil traps which on average attracted 5 *P. americana* placing it in the middle of the most effective and least effective *P. americana* repellents. The traps treated with peppermint essential oil and raid performed the best overall, only collecting 2 and 1 P. americana respectively.

The overall frequency involving the number of P. americana collected for each trap is indicated in Figure 2. Showing that both raid and peppermint essential oil acted as an effective repellent for this cockroach species.

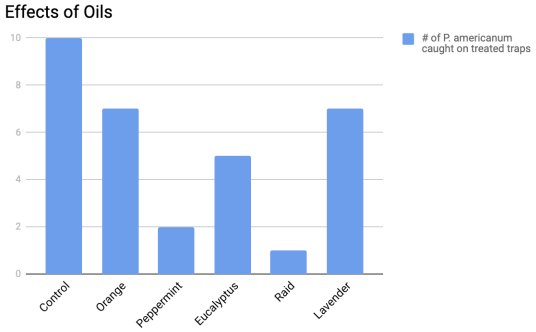

Figure 2. *Bar graph that depicts the frequency of trapped P. americana on oil treated traps along with the control untreated trap*

Discussion

Pesticides are known to contaminate vegetation, soil, and even water where it has been shown that 90% of fish and water samples are contaminated with a variety of chemical control agents (Aktar et al. 2009.) Commercial pesticides are an easy and inexpensive solution for controlling weeds and insect pests in landscapes, but the use of them comes at a cost. The use of pesticides brings risks to the environment and may damage non-target organisms populations. This growing concern to the secondary effects of pesticides has created a need to research alternatives such as essential oils.

Over the years, the study and use of botanical insecticides have increased due to environmental concerns and insects being resistant to conventional chemicals. Botanical insecticides are derived from plants. Studies have shown that essential oils from different types of plant species have ovicidal, larvicidal, and repellent properties against many different insect species. Essential oils are also known to be a more environmentally compatible control method as they are less likely to damage plant or animal populations (Ayvaz et al. 2010). Research would need to be done to make essential oils more affordable and to find a way that requires a smaller amount of plant material to make the essential oils. For instance, to make a single drop of rose oil, it takes 30 to 50 roses (FALK Aromatherapy). One drop of oil is highly concentrated, but compared

to pesticides, oils require a greater application rate. If a more affordable and efficient way to produce these oils is found, then it is expected that essential oils will have a great impact in integrated pest management strategies.

In this study it was shown that the peppermint and eucalyptus based essential oils were the most impactful in repelling the insects from the traps. In a previous study, it was seen that *Blattella germanica* demonstrated avoidance and modified behavior to areas exposed to peppermint essential oils (Yeguerman et al.2020). The results found in this previous study coincide with the information garnered from the experiment using the American cockroach. Both species of cockroaches demonstrate avoidance behaviors, an indication that peppermint essential oils are a possible repellent for all species of cockroaches. The other plant based essential oil found to be effective was eucalyptus. Although not as effective as peppermint, eucalyptus outperformed the lavender and orange essential oils. Liu et al. concluded similar findings in that eucalyptus based essential oils outperform many other aromatic herbs but was not considered having the greatest ability to repel cockroaches (2011). The data collected in this paper are one of the few that compare the effectiveness of peppermint and eucalyptus essential oils directly against another. The data would imply that peppermint has the ability to repel *P. americana* more so than eucalyptus as well as lavender and orange essential oils.

The other essential oils tested were not as effective on keeping the cockroaches away from the traps. Both lavender and orange yielded the same result of seven cockroaches, on average, being collected. The negative control of our experiment yielded ten specimens on average. The slight difference in these groups shows that the lavender and orange scents are only slightly effective in comparison than not using any type of repellant, but far more ineffective than peppermint. Therefore, the use of a citrus scent, such as orange, and lavender should not be advised as there are better essential oil alternatives for pest management.

After looking at the data and analyzing which oil seemed to act as the best pesticide, we must also consider underlying factors in this experiment that might have affected the outcome and produced inaccurate data. To begin we must consider the locations of the sticky traps used in this experiment. Placement of the traps was random and constantly readjusted, but the surrounding area of the trap was not taken into consideration. Some traps might have been close to areas of high roach population, and others might not have been. For example, the southwestern side of the building used in this experiment is close to another building with restaurants and numerous dumpsters. The traps placed closer to this might have a higher chance of a roach coming into contact with it, which would create imbalance in the data collection. Also, traps placed in areas with lower daily foot traffic that are closer to areas where roaches might nest are more likely to have come into contact than traps that were in an area with more human activity. Another factor to consider is the pesticide use not controlled by this experiment. As this experiment was done on the campus grounds of Texas A&M University, we must assume that the university carries out their own pesticide regiment for pest control. This in itself could have lowered

roach population around the entirety of the building, especially indoors and near entrances of the building, making it more difficult for our traps to come into contact with the roaches, and lowering the ability of our experiment to test the individual power of each essential oil as a pesticide. Last, we must also consider the climate through the duration of our experiment trials, particularly rainfall. College Station is known for its rainy spring weather, and unfortunately, this could have created issues with the potency of the oils and pesticide placed on the sticky traps. Since these traps were placed outside, heavy rains could have washed off the oil and effectively yielded inaccurate data once the traps were checked.

After analysis of data and consideration of error, we concluded that the findings of this experiment were reliable. The data collected showed consistent patterns that the best essential oil for cockroach repellent purposes was peppermint. We believe our method for determining the best natural deterrent for cockroaches is scientifically significant and could be applied for common use as a safer alternative to common pesticide.

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