Level of Insecticide Control in *Pseudomyrmex brunneus* (Hymenoptera: Formicidae) Using Raid

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Abstract: Ants have been considered major household pests for some time, leading to the introduction of several different insecticides to protect against them. These insecticides have proven to be harmful to mammals in multiple metabolic functions. In this experiment, the ant species *Pseudomyrmex brunneus,* of the order Hymenoptera and the family Formicidae, was used as a test subject to show the effectiveness of different insecticides. The three different insecticides tested were Raid, Spectracide, and a home remedy. The first experiment performed had many methodological flaws that resulted from not using a correct time frame for recording ant death and improper use of Spectracide. Due to these experimental errors, a second experiment was performed in which dilutions of Raid with water were used to test which would be most effective in killing the ants. This resulted in the 1:1 dilution being most effective and the 1:3 dilution being least effective in regards to time of death, but all three dilutions did result in 100% ant death in less than six minutes. This result is important because it shows that dilutions of a common household insecticide can be used to kill the same number of ants and could possibly be safer for those who are exposed to the insecticide in the home.

Keywords: *Pseudomyrmex brunneus,* pyrethroid, insecticide

Ants have been a nuisance to homes and families for as long as time has been recorded. While certain species of ants can be beneficial to various habitats, these arthropods are mainly seen as pests in society today. The demand for a commercial product that could get rid of these invertebrate species led to the creation of the insecticide line “Raid” in 1956 by S.C. Johnson and Son. Although the World Health Organization (WHO) was present in 1956, there was a lack of pesticide evaluation scheme guidelines for repellent testing which led to the use of cyfluthrin, a toxic synthetic pyrethroid (Bradberry et al. 2005). Over time and especially in recent times, guidelines for what chemicals are available for commercial use within the general population have become increasingly regulated. This has led to the decreased usage of cyfluthrin and forced top repellent company lines, such as Raid, to turn to safer alternative pyrethroids such as piperonyl butoxide and permethrin.

In recent years, the Environmental Protection Agency (EPA) has released numerous articles on the dangers of insecticides on infants and children, alarming parents nationwide. This was further brought to light when the Journal of Medical Case Reports released a case in 2009 over a baby born with bladder exstrophy (Martin et al. 2009). Upon further inquiry, it was discovered that the mother had used a full bottle of bug spray every other day as a control measure against their home bug infestation. Eventually after some detection tests were run permethrin, the

main ingredient in Raid was found in the newborn's blood sample. The EPA has claimed that it is a risk to use any type of insecticide or pesticide around children due to the fact that their livers and kidneys are not able to filter out these toxins as well as adult bodies. Another patient case occurred in 2011, when a 15-year-old girl was admitted to a hospital for diabetes ketoacidosis. The diagnosis was made when the physicians found high levels of organophosphates in the child's blood, correlating to insecticides found on fields (Prakash, 2017). Subsequently, home remedies that employ the usage of plant leaves and baking soda formulas have been sought after and while they have showed some glimpses of success, it is evident that the use of pyrethroids are most effective in killing off pests. In this study, the issue of Raid's chemical potency is addressed, as we test dilutions of Raid and their efficiency in killing ants relative to other methods. It was hypothesized that raid, due to its chemical composition, would be the most effective insecticide.

Materials and Methods

Trapping

In order to trap the ants, we chose a single ant hill for specimen collection shown in Figure 2. The ants were identified to be of the *Pseudomyrmex brunneus* species. To begin, the inside of a 5-gallon plastic bucket from Home Depot (Home Depot, Atlanta, GA) was coated with all-purpose flour (HEB, San Antonio, TX) to prevent the ants from escaping. The ant hill was then shoveled into the bucket, recoated with powder, and left undisturbed for several days to allow for organization. To extract ants from the bucket for testing, water was dripped into the bucket forcing the ants to the top where they were scooped up with a slotted spoon and placed into the testing containers (Drees 2012).

First Attempt

This experiment tested for 3 different types of insecticides: Raid (S.C. Johnson and Son, Racine, WI), a home remedy, Spectracide (Spectrum Brands, Madison, WI) and a control. The control insecticide for the experiment was water. In the experiment, *Pseudomyrmex brunneus* ants were collected as the testing subjects. For the purpose of statistical validity, a minimum of 30 ants were used for each trial.

An example of a single trial went as follows: A population of ants was gathered of at least 30. Then, this population was placed in a separate container (SOLO, Lake Forest, IL) free of insecticides where the ants were allowed to settle in the new environment. The student then added a predetermined quantity of the insecticide into the container, and the number of ants that were still alive in the population was to be recorded at 2-minute intervals over a 30-minute period. This experiment was repeated for a minimum of three times, and the average of the three results was to be used as a later comparison for the next insecticides, however, the experiment did not go as planned and the timing was recorded in much shorter intervals as shown in the results section in Table 1.

The first insecticide to be tested was Raid Ant and Roach Killer 26 with lemon scent. This product contains the following active ingredients: 0.060% Imiprothrin and 0.100% Cypermethrin. After the ants were collected and placed into their respective groups, the product was thoroughly shaken and sprayed into the container while maintaining the advised distance of 18 inches. The second insecticide was a home remedy composed of 2 cups Hill Country Fare Apple Cider Vinegar (HEB, San Antonio, TX), 2 Tablespoons Ajax lemon scented liquid Dish Soap (Colgate-Palmolive Company, New York, NY), 2 Tablespoons Hill Country Fare Baking soda

(HEB, San Antonio, TX) combined with water into a large spray bottle (Target, Minneapolis, MN). The combined product was shaken thoroughly and then sprayed on the separated group of ants from 18" distance. The third insecticide evaluated was a commercial ant killer called Spectracide Ant Shield Insect Killer Granules, which kills ants and other listed insects on contact. This product makes it easy to spread the granules around the ant hill, creating a barrier. The package itself effectively treats up to 1500 sq. ft. This product contains the active ingredient Lambda-Cyhalothrin 0.040%. When the ant pile was detected and separated into the respective groups, a total of 2 inches in diameter of granules was spread on top of each group of ants. Three trials for each of these insecticides were repeated on different groups of ants of the same species.

Second Attempt

After testing the original hypothesis, a new hypothesis was created along with a new experimental design and materials, as shown in Figure 1. Different dilutions of Raid Ant and Roach Killer were tested in order to determine the effectiveness of the insecticide in possibly safer concentrations. The dilutions tested were 1:1, 1:2, and 1:3 (insecticide: water) with each dilution tested on three separate occasions. The control tested was water, sprayed three times from six inches away. Each round was conducted as follows: At least 50 ants were placed in a testing container with the edges lined with flour in order to inhibit the ants from escaping. The dilution was measured out and mixed in a spray bottle for even distribution. The spray bottle was held 6 inches away from the test container and exactly three sprays of diluted insecticide was administered. The ants were then closely monitored and times were recorded when approximately 80% of the ants were dead and again at 100%. These results were then recorded, placed in a table, and plotted.

Fig. 1. Materials

Fig. 2. Ant Hill

Results

For our first attempt we tested three different insecticides and used one control to see which chemical would be most effective. First, we tested the insecticide Raid for three rounds, recording data every 2 minutes. For all three rounds using Raid, the ants all died in less than 90 seconds; therefore, the entire 30 minutes allotted was not required, considering the effectiveness of the spray. The second insecticide was a home remedy spray. The spray was effective and killed the 100% of the ants in three minutes or less. The last insecticide tested was Spectracide Ant Shield Insect Killer Granules which was ineffective at killing any ants. Although both Raid and the home remedy killed the ants, Raid was more effective and proved to be the faster treatment option; however, due to the error in the timing of the experiment we felt it was best to reevaluate the experiment and establish a new hypothesis. The results of the first attempt are recorded in Table 1.

Table 1: Results of first attempt

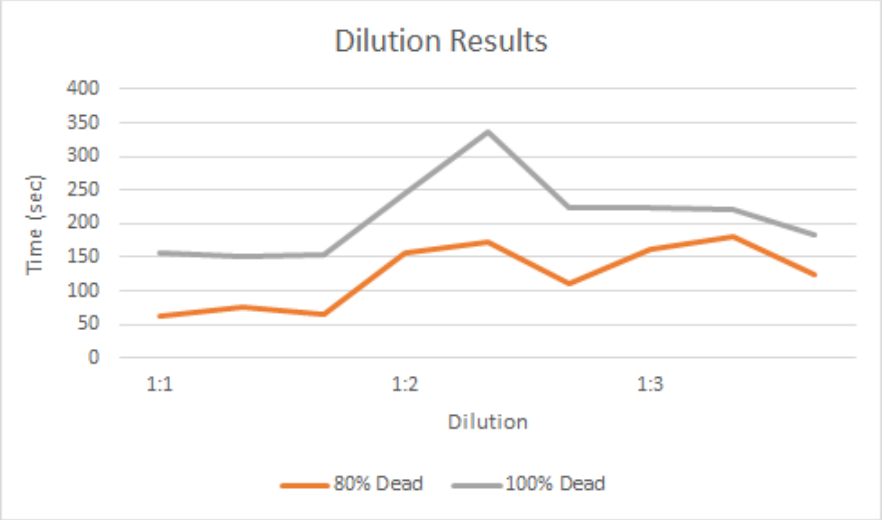
Insecticide	Round	Time passed allowing 100% to die
Raid	1	96 sec
	2	80 sec
	3	88 sec
Home Remedy	1	178 sec
	2	126 sec
	3	145 sec
Spectricide	1	N/A
	2	N/A
	3	N/A

For the second experimental attempt the insecticide, Raid, was tested in three different dilutions. The following results are summarized in Table 2 and Figure 3. The first test was a 1:1 ratio of Raid to water. This dilution was evaluated on three occasions. In this test, 80% of the ants died in less than two minutes. Overall, 100% of the ants died within less than three minutes. The second round was conducted with a 1:2 dilution. Approximately 80% of the ants in the containers died within less than three minutes. In this test, 100% of the ants died in less than six minutes. The third dilution was 1:3 and 80% of the ants died within four minutes. With this last dilution, 100% of the ants died in less than four minutes.

Table 2: Results of second attempt

Dilution	Round	80% Dead (sec)	100% Dead (sec)
1:1	1	62	156
	2	75	150
	3	64	155
1:2	1	158	246
	2	172	336
	3	112	225
1:3	1	162	225
	2	181	222
	3	125	183

Fig. 3. Dilution Result of second attempt



The ant species was determined to be *Pseudomyrmex brunneus* (Ward 1989). This is an uncommon ant species in Texas as it is usually found in different regions of northern Mexico. They have also been found to inhabit and nest in dead mint stalks (Ward 1985).

Discussion and Conclusion

The objective of this study was to compare the overall effectiveness of three different types of insecticides. The first insecticide tested was Raid Ant and Roach Killer 26 with lemon scent. This product contained 0.060% Imiprothrin and 0.100%

Cypermethrin which are both synthetic pyrethroids. Insecticides are effective because they contain pyrethroids. Pyrethroids are chemicals that locate neurons which focus on the inhibiting the nerves of the insect, eliminating their ability to de-excite, thus causing paralysis and death (Shafer et al. 2005).

In the first attempt, the use of Raid resulted in killing all of the ants in less than two minutes in each of three trials that were conducted. Subsequently, the experiment was replicated with Raid Ant and Roach Killer 26 with lemon scent in a series of dilutions with water at ratios of 1:1, 1:2, and 1:3 to properly test the effectiveness of a safer concentration. The use of water in the dilution does not affect the rate of degradation of the pyrthroids. In a report on the physical and chemical properties of these chemicals, it was shown that the aerobic and anaerobic degradation rates were the same for those studied in water as opposed to those studied in soil (Laskowski 2002). The dilution with Raid and water at a ratio of 1:1 had killed a total of 80% of the ants within a range of 62-75 seconds, the 1:2 dilution killed 80 % of the ants within a range of 112-174 seconds, and the 1:3 dilution of Raid and water killed 80% of the ants at a range of 181-225 seconds. A clear trend is visible that as the concentration of water in the dilution increased, the time it took for Raid to kill the ants also increased. It was determined that a greater dilution will kill the same amount of ants as compared to a dilution with a lower water concentration. The only difference that was observed was the rate at which the three dilutions killed the ants.

The second insecticide tested during the first experiment was the home remedy spray. The results from the home remedy spray were promising because the insecticide killed the ants in less than three minutes during the test trials. No significant trends were observed related to the home remedy. The Spectracide granules, the third insecticide, were ineffective in our experiment due to flawed experimental design. This choice of insecticide became an experimental source of error because it required the usage of gallons of water to be effective which was a detail that was overlooked until tests were begun.

Overall, the hypothesis was supported by the data collected because Raid was the most efficient insecticide at killing ants in both of the experiments that were conducted. In future studies this experiment could be improved by comparing different pesticides instead of using granules or Raid. Possibly even conducting a different experiment where the purpose is to determine which home remedy or commercial product is the least effective at killing ants, instead of most effective. The second experiment provided more valuable results in showing that diluted samples of modern-day insecticides can be used to kill 100% of an ant population with only a slight increase in time.

This is important because chemicals used in insecticides have proven to be dangerous upon exposure to different mammals, including humans. One study was conducted on the adverse effects of dietary exposure to Raid which resulted in the inhibition of metabolic processes in Wistar rats. The study indicated that the mortality rate of the Wistar rat was higher as the insecticide concentrations were increased. The insecticide induced hepatotoxicity and oxidative stress in the animals which has adverse effects on glucose uptake. This led to impaired liver functionality (Achudume et al. 2010). In another study, Raid demonstrated a reduction of glucose-6-phosphatase and lactic acid dehydrogenase production in the muscle and liver of Wister rats (Achudume et al. 2009). These results did not show any substantial brain damage,

but did show inhibition of major metabolic enzymes resulting from the accumulation of Raid in the tissue of Wister rats. In addition, after taking into account all of the errors in this experiment, further testing with different insecticides is recommended in order to discern if Raid is the most effective and safest insecticide option to kill ants. This will help to ensure that children are safe from bioaccumulation of the insecticide in the tissues that could affect lipid, muscle, liver, and possible brain functions.

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