Efficacy of Professional and Homemade Residual Pesticides on *Solenopsis invicta* (Hymenoptera: Formicidae)

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Abstract: The invasive red imported fire ant, *Solenopsis invicta*, has recently gained attention in the United States due to its increased prevalence in urban areas. The species has been linked to aggressive attacks that primarily affect young children and the elderly. Because *Solenopsis invicta* is an invasive species, it has been able to reproduce without hindrance and has made its way into people's homes. The purpose of this experiment was to determine the effectiveness of various residual insecticides on individual ants. The insecticides that were studied included commercially available products such as *Raid*, as well as home remedies like *Dawn* Dish Soap. The experiment tested the insecticides' residual effects with five trials each, and each trial had one ant in the testing chamber. The time allotted for each test was an hour, and the chamber was observed at different time intervals. The results indicated commercial insecticides kill ants rather faster than most known home remedies. And most of the products tested killed an ant within an hour. The known insecticides tended to kill upon contact with the ants, while the home remedies killed over a longer period of time. Lastly, this study concluded the cost of most products tested were comparable, and lemongrass insecticides may have a newfound place in fire ant control effort.

Keywords: Solenopsis invicta, fire ant, insecticide, lemongrass, household

Introduction.

Solenopsis invicta, the red imported fire ant (Fig. 1), was accidently introduced to the United States at the end of the 1920s and has been an invasive species ever since (Core 2003). Fire ants have been able to reproduce with little to no natural predators in the United States, creating a growing concern for people because of their increased presence. The pain of the sting fire ants inflict on people varies from species to species. A major issue that is associated with this insect is that when they sting, they also bite. This is particularly a problem for individuals who are not able to move on their own, especially infants and the elderly (Vinson 2013). There is also a small portion of the population that is severely allergic to fire ant stings, resulting in anaphylactic shock or even death. Since fire ant populations are on the rise, the number of people affected by them will also increase.

In addition to personal health risks, the red imported fire ant also contributes to large economic losses within the agricultural community. These fire ants disrupt the budding process of fruiting plants, as well as the roots and shoots (Wu et al. 2014). As a result, the damages to these crops can be substantial. The range of crops these ants can decimate is astounding, and because they are so versatile, the losses impact more than just crops. Cattle production can also be jeopardized, as one of the crops at risk is sorghum, a common feed for cattle. Fire ants are such a problem within the cattle industry that some production lines have altered the calving season to the months where these ants are less active (Drees et al. 2013). Additional costs associated with production ultimately affect the consumers, resulting in an increased price for all.

To reduce these costs, different insecticides are employed. Each works differently when affecting an ant's biology. Periplocoside X is an insecticidal component that targets the insect's midgut and induces a severe, time dependent cytotoxicity in epithelial cells (Li and Zeng 2013). Because Periplocoside X damages the cells in the midgut, it also causes swelling and eventual death. Further, Boric acid is an active ingredient in some insecticides and when ingested, causes severe breakdown inside the digestive system. Boric acid first affects the midgut, followed by the post pharyngeal gland and Malpighian tubules (Malaspina et al. 2010). Additionally, pyrethroids (such as Lambda-Cy and cypermethrin) are some of the most common insecticides used in both residential and commercial applications, as they act to effectively shut down the nervous system's ion channels following either ingestion or simple contact with the product (NPIC 1998). The concentrations used in both residual and bait applications must be optimized to a percentage that is high enough to be effective, but low enough to avoid repelling insects before contact (Kafle and Shih 2012). Various cocktail-like combinations of ant killers in products such as *Raid*, also display various other properties. Permethrin, an active ingredient in *Raid* and other readily available insecticide products, has demonstrated its ability to prevent fire ants from colonizing certain treated areas with 100% experimental efficacy (Costa et al. 2005). Bait products designed to be picked up by worker ants may also be used in households and continue to be improved for better results (Kafle et al. 2010).

Fig. 1. Example of a *Solenopsis Invicta*

In response to these consequences, this experiment will focus on residual contact killing in a controlled environment, with the potential application of choosing insecticides based on rapid effectiveness in terms of kill time and economic prudence (cost per complete treatment). The importance of knowing how to get rid of a colony is imperative and which insecticides are most effective. Whether they be simple home remedies, large cans of *Raid* spray, or professional strength solutions.

Materials and Methods

Collection Method. The ants were collected by floating into "rafts" via a drip flotation method (Banks et al. 1981). Once a colony was located, a metal shovel was used to quickly transfer a large amount of the mound with the residing ants into a five gallon bucket. Prior to loading ants into the bucket, baby powder (Johnson & Johnson, New Brunswick, NJ. USA) was used to prevent escape on the sides. Further, the bucket was slowly filled with water by a dripping water faucet (added dropwise). The time needed to "float" ants varies based on mound size but was expected to be approximately an hour. Once all ants were forced to the surface, forceps were used to carefully transfer ants to each container. The researcher wore gloves and the handles of the forceps were covered in baby powder to prevent climbing.

Treatment.

Thirty five, 20 mL clear Solo cups (Solo, Mason, MI, USA) were placed on a lab bench. 5 cups were not treated, while five cups were treated with Lambda-Cy insecticide (United Phosphorus, Inc. Kiggng of Prussia, PA) and five cups were treated with Raid Insecticide containing cypermethrin (SC Johnson, Racine, Wisconsin). Five more cups were treated with Dawn Dish Soap solution (Procter & Gamble, Cincinnati, OH) and five cups were treated with lemongrass oil (United Industries Corporation, Earth City, MO). Lastly, five cups were treated with Lysol disinfectant spray (Reckitt Benckiser Professional, Parsippany, NJ), and the final five cups were treated with a Borax solution (Henkel Corporation, Stamford, CT). Each cup was treated by pipetting one mL of the treatment into the cup and swirling the cup to cover the entire bottom surface. Both Borax (66 mg/mL solution) and Dawn soap had to be diluted with water in order to create a residual substance. Dawn was diluted in the same way as Borax for continuity in further experimental comparisons. The cups were left to dry for 10 minutes. Further, all cups, including the controls, were treated with baby powder to prevent escape. After the cups were dried, one ant was placed into each. The cups then sat for one hour while they were periodically checked for living and dead ants. Every 15 minutes, the number of dead ants was recorded. Long term lethality of each pesticide was not measured for the purposes of this study.

Results

Each treatment was repeated five times on different ants. The insecticides varied in efficacy; with Raid, Lysol, and commercial-grade Lambda-Cy killing all of the ants (Fig. 2). Raid and Lambda-Cy killed ants almost instantly upon contact with residue (100%), while Lysol took 20-30 minutes (100%). The lemongrass treatment killed most of the ants (80%) in under 10 minutes, with one ant surviving the duration of the experiment. Dawn dish soap only killed two of the specimens (40%) in under 10 minutes while Borax solution was completely ineffective. All remaining ants were then killed in ethanol during the preservation process. One untreated ant died due to mishandling by an experimenter (Table 1).

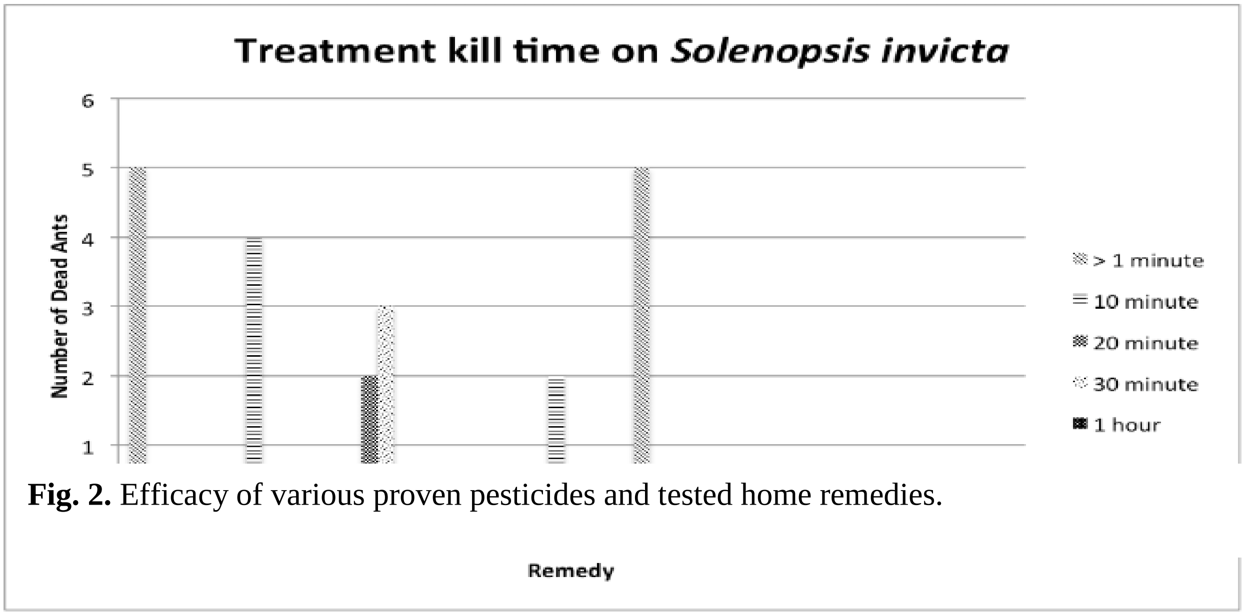

Fig. 2. Efficacy of various proven pesticides and tested home remedies.

	Ants that died within:						
Treatment	>1 minute	10 minutes	20 minutes	30 minutes	1 hour	Total Killed	Total Alive
Raid	5	0	0	0	0	5	0
Lemongrass	0	4	0	0	0	4	1
Lysol	0	0	2	3	0	5	0
Borax	0	0	0	0	0	0	5
Dawn	0	2	0	0	0	2	3
Lambda-Cy	5	0	0	0	0	5	0
Untreated	0	0	0	0	0	1*	4*
Total	**10**	**6**	**2**	**3**	**0**	**22**	**13**
						*1 died (mishandled)	

Table 1. Ants That Died In Certain Time Brackets

Discussion

At the conclusion of this experiment, the results show *Raid* and commercial-grade Lambda-Cy products to be the most effective at killing ants in a timely matter. In regards to availability, Raid is the most accessible product for the public of those tested. As for home-remedies, lemongrass was shown to be successful. Lysol, Borax, and Dawn, all supposed "home-remedies" that are expected to serve as ant repellents and insecticides. Since direct treatment can cause drowning, this experiment focuses on residual effect. Lysol is shown to be an effective killer over the course of the experiment. However, practical application is limited as it evaporates quickly and leaves limited residue. Speculation points to the ants being killed by residual

Lysol vapor in the sealed treatment cups. Borax (0% kill rate) and dawn (40% kill rate), both household cleaners, were relatively ineffective. The borax residue may have been ineffective because borax was not consumed by the ants, but rather, the cup had solution residue. Dawn was largely ineffective against the robust *Solenopsis invicta*, presumably for the same reasons as Borax.

Furthermore, each of the other home remedies tested can be bought in a relatively large amount (i.e. one box or can) for under $5.00 in most Texas retailers. Studies in lower income countries have shown the cost of a 7-month residual spray of insecticide, with lemongrass infusion, can cost as little as $0.024 (USD) per day per person (Moore et al. 2007). Clearly, the economics of this type of treatment are viable.

Citral, an active ingredient in the lemongrass insecticide, is not fully understood in terms of how it kills insects. Presumably, it interferes with various enzymatic activities and causes neurophysiological effects that ultimately kill the exposed insect (Tak and Isman 2016). No significant research on citral's effect on *Solenopsis invicta* has been reported. Future studies could search for various properties, including citral's killing mechanism, its effective concentrations, and other similar attributes. The prevalent theory is that the only surviving ant in the lemongrass treatment was most likely in a treatment cup that was not adequately prepared with lemongrass oil residue, allowing it to survive.

The researchers call for further experiments on citral and lemongrass when fighting off invasions of *Solenopsis invicta*. Lemongrass shows the potential to be a natural, economical, and viable pesticide based on the above preliminary testing.

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