The Attractiveness of Commercial Baits Toward Red Imported Fire Ants *Solenopsis invicta* (Hymenoptera:Formicidae)

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Abstract: The Red Imported Fire Ant (*Solenopsis invicta*) is a pest and economic burden around the world. Insecticidal baits of varying formulations are frequently used to control *S. invicta* infestations. Our purpose was to discover the most attractive commercial bait to help inform consumers. Our results indicated that the most attractive bait was the Advion lipid blend, followed by the Advance 375 A protein blend, which were both significantly more attractive than the control honey bait. This experiment was performed in April, so the difference in bait effectiveness may be realtaed to fire ant seasonal food choice.

Keywords: fire ant, bait, pest control, household, Solenopsis invicta

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Ever since its introduction in Alabama in the early 20th century, the Red Imported Fire Ant (*Solenopsis invicta*, Buren 1972) has found its niche in the sun belt of the United States. It is present in every backyard, crop field, and pasture, and affects the life of millions of Americans (Tschinkel 2006). These ants not only disrupt the outdoor experience with painful stings and mounds, but they also present a threat to public health and the economy (Tschinkel 2006). In New Orleans, a survey showed 55% of fire ant stings affect children, and 21% of all stings cause allergic reactions (Clemmer and Serfling 1975). In Texas, farmers face damage to crops and livestock, leading to a derived $90 million dollars in agriculture damage (Willis et al. 2016). Annually, the United States spends approximately $6 billion on fire ant pest control, property damage repairs, and health expenditures (Lard et al. 2006).

The immense spending for fire ant control demonstrates the demand for fire ant insecticides. (Lard et al.

2006) and store shelves have seen a plethora of products in response (Roan and Hopkins 1961).

These products can be broadly grouped in two categories: contact insecticides and baits. Contact insecticides kill through ants by direct contact, usually after soaking a mound. (Hutchins 2014). Baits are slower-acting poisons that fool the ants into thinking a toxin is food, causing the ants to feed the poison to the entire colony. (Barr et al. 2005).

Two advantages of baits over contact formulations is that baits do not require the user to locate each individual mound and can target the inconspicuous still developing colonies. Therefore, baiting is the preferred and most effective method for land treatment (Barr et al. 2005). However, not all baits work on the same species of ants and the wide variety of products can complicate a consumer's ability to pick out the most effective product. (Hara et al. 2014).

Bait products can be further divided into two forms: liquid baits and granular baits. Liquid baits generally have a sucrose sugar base but have been found be ineffective against a variety of fire ants (Hara et al. 2014; Lesne, personal communication). Liquid formulations are more useful for home-invading species (Klotz et al. 2007).

Granular baits are a solid version, often found in large balls or "granules". These products consist of a solid core such as soy grit that contains the killing agent, and an outer gel layer that contains an attracting agent and provides environmental protection. This type of bait is long-lived and resistant to the environment, making it a better choice for fire ant control (Wilson et al. 1989).

The attracting agent is the crucial component of the insecticide, as the attractiveness of the bait will determine whether the insecticide is brought back to the mound. This baiting agent can be various kinds of carbohydrate, lipid, or protein blend.

In our study we evaluated four commercial baits: Advion's soybean oil lipid blend, Amdro's lipid blend, Advance 375 A's unique abamectin, soybean oil, sucrose, and protein blend, and Extinguish Plus's soybean oil lipid blend. (Milks 1993, Ambrands 2012, BASF-SE 2019, & Stanley 2004).

These formulations come at varying price ranges and availabilities, with some sold at general stores and others limited to online purchase only. We expect that there will be great variation in effectiveness as a result and expect that the Advance 375 A bait will attract the most fire ants.

Materials and Methods

Baits

Four bait products were tested during our experiment:

Amdro Kills Ants Ant Bait (Central Garden & Pet Company, Atlanta, GA),

Advion Fire Ant Bait (Syngenta Crop Protection, Greensboro, NC),

Advance 375 A Fire Ant Bait (BASF Corporation, Florham Park, NJ),

Extinguish Plus Fire Ant Bait (Wellmark International, Schaumburg, IL).

Our experiment used both a positive and negative control for increased accuracy. The positive control was a hotdog protein bait, shown in other studies to be effective (Braman & Forschler 2018, Ipser et al 2004). The negative control was a honey sugar bait, shown in other studies to be ineffective (Brinkman et al. 2001, Hara et al. 2014).

Experimental Design

Two wild *Solenopsis invicta* communities were surveyed from two separate fields in College Station, TX. The fire ants were baited following the method outlined in Kaspari et al. (2008) of using two 60-meter transects in each field. 10 Eppendorf tubes were used for each of the four baits and two controls per transect, totaling 60 tubes per transect. Each tube was filled with roughly 0.75mL of bait. The controls were composed of 0.75 mL of blended hotdog and 0.75 mL of honey solution on a cotton ball.

The 60 tubes for each replication were then put in a large plastic bag, randomized, and dropped one meter apart along the transect. The placement time was late afternoon to maximize fire ant foraging. The tubes were retrieved after one hour. (Kaspari et al. 2008). This process was replicated five additional times, once for each transect, to create six total replications.

Data analysis and statistics

The data collected was translated into three different variables in order to capture all the aspects of ant foraging:

Hits: This value is the number of vials containing at least one ant. This variable is a confirmation that the ants have found the vial and shows that the food contained in the vial is valuable enough to trigger recruitment. This variable was arcsin($\sqrt{x}$) transformed to comply with the requirements of parametric statistics and analyzed with an ANOVA.

Recruitment: This value is the number of ants per tube with at least one ant. This value measures the intensity of the recruitment on tubes that have been found and been valuable enough to trigger recruitment. This variable was log-transformed and analyzed with an ANOVA followed by a Tukey HSD test.

Percentage of ants: This value is calculated by dividing the number of ants counted on type of bait in a transect with the total number of ants collected on each transect. This value shows the overall preference for a treatment. This variable was arcsin ($\sqrt{x}$) transformed and analyzed with an ANOVA followed by a Tukey HSD test. Statistical analyses and figures were performed in R (R core team 2019, version 3.6.1).

Results

Validity

Our results first show that the method used in this study efficiently sampled ants from the field, with a total of 2,234 red imported fire ants collected. Secondly, the variable “recruitment” was able to capture a significant difference between the negative control (Honey-water) and the positive control (Hotdog): Tukey HSD – P=0.011, showing that our method can identify differences between treatments.

Hits

The ANOVA on the percentages of tubes in which at least one ant was counted showed that none of the treatments were significantly different ($F_{5,30}$=1.21, P=0.325) (Figure 1A). On average, 31.4 ± 24.7 % (Mean ± SD) of the vials contained one ant or more.

Recruitment

The ANOVA revealed a significant influence of the treatment on the number of ants recruited to the vials ($F_{5,27}$ =3.07, P=0.025). The post-hoc Tukey HSD test detected a significant difference between the honey-water and the hot-dog treatment (P=0.011) (Figure 1B). No other significant difference was detected between treatments.

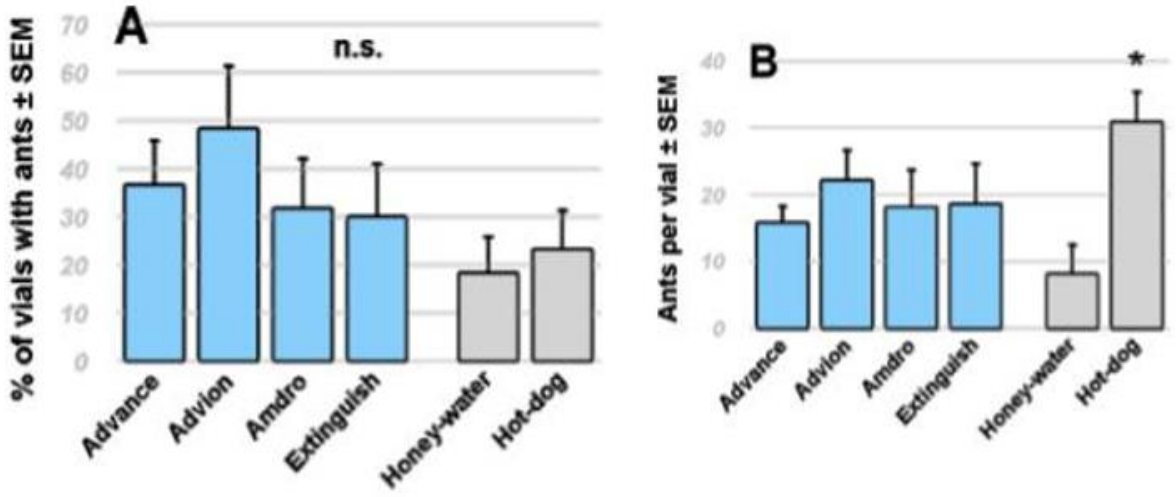

Figure 1: (A) Mean percentages (±SE) of vials with at least one ant (Hits) as a function of bait type (blue) and recruitment (grey). "n.s." indicates none of the treatments differed significantly. (B) Recruitment. The star represents a significant difference from the negative control (Honey-water) ($p < 0.05$).

Percentage of ants

The ANOVA showed a significance difference in the overall number of ants collected from each treatment ($F_{5,30}$ =4.12, P=0.006). The Tukey HSD test showed that Advance and Advion were significantly different form the negative control (Honey-water) with P=0.046 and P=0.002 for Advance and Advion, respectively. No other significant differences were detected between treatments (Figure 2).

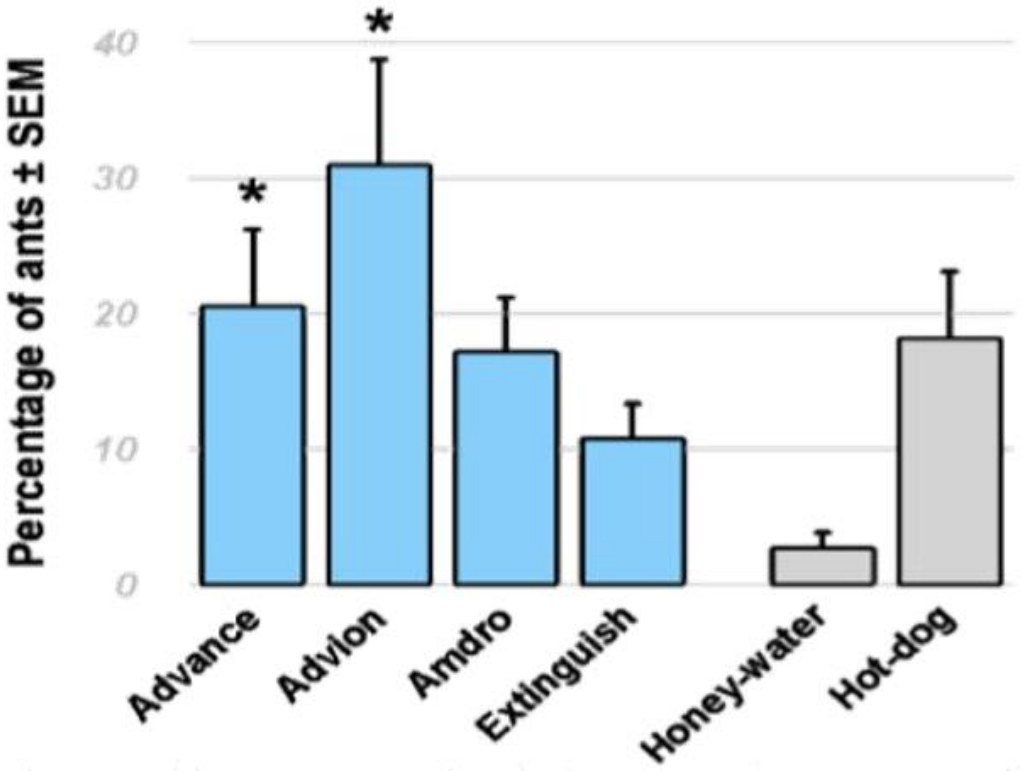

Figure 2: Mean percentage (±SE) of ants counted on each bait (blue) and control (grey). An asterisk marks results that differed significantly from the negative control (honey-water) ($p=<0.05$).

Discussion

Our results indicate that the two lipid coated baits attracted the highest raw percentage of fire ants. The bait that attracted the largest percentage of fire ants overall was Advion at 31.8% followed by Amdro at 21.9%, though the difference in attractiveness between those is not significant. Amdro is also not significantly more attractive than our negative control, honey, which attracted the overall lowest percentage of ants. Our results also show that Advion's lipid-based formula and Advance 375 A's protein blend are significantly more attractive than honey.

To explain why both baits were found to be attractive, we must consider the composition of our positive control. Where the hotdog attracted a total of 13.1% of the ants baited in this study, the Advance 375 A formulation attracted 11.2% of the total ants.

These percentages are relatively close and looking at the chemistry of the hotdogs explains why. The nutritional composition of the hotdog is a blend of 12g of fat, 450mg of sodium, 5g of protein, and 0g of sugar (Bar 2020). By blending both the lipids with protein without encapsulating the unattractive sugars, our positive control hotdogs embody the combined chemical makeup of our two most significantly attractive baits with a lipid and protein composition.

However, if ants are attracted to a complex protein and lipid formulation such as a hotdog, then it is important to ask why Advion was found to have a much larger

percentage of ants and a lower p-value than the Advance 375 A formulation. When out foraging, fire ants have a protein to carbohydrate ratio that they regulate depending on the season; with carbohydrates being heavily preferred in the fall and summer and protein being balanced throughout in order to maintain their energy for activities that need a higher metabolic rate such as reproduction or traveling (Cook et al. 2011).

New fire ant colonies typically form in the spring, meaning fire ants find themselves reproducing late spring and caring for this new brood of ants into the summer (Markin et al.1973 & Tschinkel 1993). Our bait research was conducted in early April, before the ants are searching for large amounts of protein.

This would explain why our lipid-based Advion formula was found to be the most attractive bait, as it would provide the foraging ants with stored energy. Further research should be done to distinguish whether fire ants prefer a lipid-based bait year-round, or if a protein bait is favored further into the summer.

It should be noted that while this study measured the attractiveness of fire ant baits, it did not measure the efficacy of the insecticide in this bait. Further research should be done on the efficacy of Advion and Advance 375 A's insecticidal components.

In summary, our data refutes our hypothesis that Advance 375 A will be the most attractive bait with its protein blended formula. Advion was shown to be the most attractive bait with its lipid formula, having the highest percentage of attracted ants in this study as well as being significantly more attractive than our negative control.

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