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Attractancy of Bait Insecticides to the Little Fire Ant, *Wasmannia auropunctata* (Roger) (HYMENOPTERA: Formicidae)

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Abstract

The little fire ant (LFA), *Wasmannia auropunctata* (Roger), was first detected in plant nurseries in the Puna district of Hawai`i island in 1999. Since then, LFA have spread out to much of East Hawai`i island and are reported in homes, gardens and yards. Commercial and homeowner bait insecticides formulated as granules, liquid, gel, or pastes are available in garden shops in Hawaii. This study evaluated the attractiveness of several of these ant bait insecticides to LFA as compared with granular baits containing hydramethylnon, known to be attractive and effective against LFA. Granular and paste insecticidal ant baits found to be as attractive were Advance 375A (abamectin),), Raid Ant Bait III (abamectin) and Raid Double Control Ant Baits II (abamectin), Amdro Fire Ant Bait (hydramethylnon), Maxforce Complete (hydramethylnon), Extinguish Plus (hydramethylnon and S-methoprene), Amdro Ant Block Home Perimeter Ant Bait (hydramethylnon), Amdro FireStrike Yard Treatment (hydramethylnon and S-methoprene), Hot Shot MaxAttrax Ant Bait (indoxacarb). None of the gel or liquid insecticidal ant bait products evaluated (active ingredients were hydramethylnon, sodium tetraborate pentahydrate, thiamethoxam or indoxacarb) were attractive to LFA. Evaluation of the persistence of attractancy among granular hydramethylnon ant baits (Probait, Extinguish Plus, Maxforce Complete) indicated that after 7- and 14-days of weathering, these insecticidal baits attracted 40 to 96% less LFA than fresh deposits, necessitating re-application after 1 to 2 wk under tropical climatic conditions.

Introduction

The little fire ant (LFA), *Wasmannia auropunctata* (Roger) (Hymenoptera: Formicidae), native to South and Central America, is considered to be one of the most destructive global invasive ant species, and has been introduced to tropical and subtropical localities including the Caribbean and Pacific islands, West Africa and Australia (DPIF 2006; Lowe et al. 2000, Holway et al. 2002; Wetterer and Porter 2003). LFA was first reported in Hawaii in 1999 at a plant nursery (Conant and Hirayama 2000) and has spread to other agricultural sites such as orchards and pastures (Conant, personal comm.) as well as non-agricultural structures and landscaping, including residential areas. High populations of LFA have been correlated to reductions of other ant species, especially where LFA are not native and have been introduced (Clark et al. 1982, Lubin 1984, Ulloa-Chacón and Cherix 1994). Field studies suggest that LFA use interference competition, resource competition, and predation to eliminate other ant species (Clark et al. 1982; Meier 1994; Achury et al. 2008). LFA delivers a painful sting (Wetterer and Porter 2003), and agricultural workers face hazardous conditions when LFA "rain" onto them from infested vegetation (Williams and Whelan 1992). LFA stings to the eye have been linked to keratopathy in pets and other animals (Theron et al. 2007).

A bait insecticide, consisting of an attractive food source, toxicant, and carrier, provide effective control of many ant species, with the greatest potential to reach the colony's queen or queens, and reduce or eliminate their capacity to produce new offspring (Williams et al. 2001). Granular ant bait insecticides were first formulated with hydramethylnon, in a soybean oil-defatted corn grit carrier, to control the red imported fire ant (RIFA), *Solenopsis invicta* in 1980 (Williams et al. 2001; Causton et al. 2005); subsequently, ant baits were developed with other effective active ingredients, such as abamectin, borates, fipronil, methoprene, and spinosad (Williams et al. 2001). Granular ant bait insecticides applied at ground level effectively reduce populations of foraging worker ants; however, LFA develop 3-dimensional super-colonies that occupy ground as well as arboreal habitats (Spencer 1941, de Souza et al. 1998, Wetterer and Porter 2003, Le Breton et al. 2004) where dry, granular baits cannot be effectively applied. In addition, LFA tend honeydew-producing insects (mealybugs, soft scales) and protect them from natural enemies, which encourages larger populations of these pests (Clark et al. 1982; Ulloa-Chacon and Cherix 1990). With this ample food source, LFA may not descend from arboreal nesting sites to forage on insecticidal baits applied at the ground level. As such, a paste or gel formulation is warranted (Vanderwoude and Nadeau 2009; Vanderwoude et al 2010) to accommodate LFA nesting and foraging preferences.

The earliest incidences of LFA in Hawai`i in 1999 were mainly confined to plant nurseries and landscaping (Conant and Hirayama 2000); therefore, effective insecticidal ant baits were mainly available through agricultural suppliers. Within a few years, LFA spread to many residential areas on the eastern side of Hawai`i island through movement of infested plant and construction material (Krushelnycky et al. 2005); therefore, demand grew for products available through garden shops and big box retailers. Insecticidal ant baits for homeowner use are available as granules, liquid, gel, or pastes, with different formulations of attractants, carriers and active ingredients, often prepackaged in plastic bait stations or stakes to deter human and pet consumption.

Since LFA are susceptible to most active ingredients used in ant baits (Williams et al. 2001), if a bait insecticide successfully attracts foraging workers, then the toxicant will be relayed to the nest and ultimately cause the demise of the workers, brood and queen. This study evaluated the attractiveness of several granular, paste, gel and liquid ant bait insecticides to LFA as compared with standard hydramethylnon granular bait insecticides.

Due to high humidity, temperature, and rainfall in subtropical and tropical areas, our second objective was to verify the persistence of the attractancy of several popular granular ant bait insecticides, Probait, Maxforce Complete, and Extinguish Plus, under such climatic conditions.

Materials and Methods

Insecticidal ant bait attractancy

Attractancy trials were conducted at the University of Hawaii at Hilo, College of Agriculture, Forestry and Natural Resource Management (CAFNRM) farm near Hilo, Hawaii where known LFA infestations were located. Insecticidal ant bait products were obtained from several retail (grocery, hardware, garden) stores and evaluated in three trials: 1) Amdro Kills Ants Stake (1.0% hydramethylnon), Combat Source Kill Ant (0.01% fipronil), Hot Shot MaxAttrax Ant Bait$_2$ (0.05% indoxacarb), Probait (0.73% hydramethylnon), Raid Ant Baits III (0.01%

avermectin B1), and Raid Double Control Ant Baits II (0.05% avermectin B1); 2) Amdro Fire Ant Bait (0.73% hydramethylnon), Grant's Kills Ants Ant Control 91.0% hydramethylnon), PIC Liquid Ant Bait Killer Killing System (5.0% sodium tetraborate pentahydrate), Raid Ant Gel Precision Placement Bait (0.003% thiamethoxam), and TomCat Ant Killer Gel Bait (0.03% indoxacarb); and 3) Advance 375 (0.11% abamectin), Amdro Ant Block Home Perimeter Ant Bait (0.88% hydramethylnon), Amdro FireStrike Yard Treatment (0.0360% hydramethylnon, 0.0172% S-methoprene), Amdro Fire Ant Bait (0.73% hydramethylnon), and Green Light Fire Ant Control with Conserve (0.015% spinosad). A fourth trial was conducted comparing granular oil-corn grit-based baits containing different levels of hydramethylnon, Maxforce Complete (1.0%) and Probait (0.73%). Peanut butter, highly attractive to LFA (Williams and Whelan 1992), was also included as a treatment in each trial to confirm the presence of LFA at trial sites.

Potential sites were visually surveyed with nontoxic peanut butter bait for presence of foraging LFA workers just prior to conducting each trial. Insecticidal ant bait products in prepackaged bait stations, stakes or syringes were extricated, and approximately 1.1 g of each solid bait or 1.2 ml of each liquid and gel bait were weighed and placed onto a semi-transparent plastic lid (45mm diameter, L100 PC Lids, Fabri-Kal, Kalamazoo, MI). The ridge and valley contours on the inner surface of the lid allowed foraging worker LFA to access the bait but deterred them from carrying off the bait during the observation period. In each trial, lids with different baits were randomly placed 3 cm apart at the base of rainbow shower trees (*Cassia fistula* x *javanica*) where LFA activity was observed, and replicated at 10 sites within a 400 sq ft plot. Each baited lid replicate was digitally photographed at 15 minute intervals for a 2-h period. The digital images were later enlarged on a computer monitor in the laboratory, and the LFA workers on each lid were counted and recorded as number of LFA attracted to the bait per observation time interval.

Weathered ant bait insecticides

Extinguish Plus (0.365% hydramethylnon, 0.250% S-methoprene), Maxforce Complete (1.0% hydramethylnon), and Probait (0.73% hydramethylonon) baits were weathered by exposing the baits to sunlight and simulated rainfall for 7 or 14 d. Approximately 50 g of each bait were spread onto wire screens (1x1 mm mesh) in wooden boxes (34.3 L x 34.3 W x 7.6 H cm) containing potting media (layer of peat moss, perlite, and vermiculite mix), placed in a greenhouse with 60% shade cloth, and exposed to sunlight and overhead irrigation (5.7 l per min for 5 min daily) for 7 or 14 d (8 or 15 d for Extinguish Plus). Approximately 1.1 g of 7-8 and 14-15 d exposed (DE) and fresh (unweathered) bait were placed onto individual plastic lids (n=10 per treatment), and attractancy trials were conducted as previously described. Peanut butter was included as a treatment to confirm the presence of LFA at sites where the trials were conducted.

For each attractancy trial, LFA worker counts were compared by one-way ANOVA, and means were separated by Tukey's procedure (Minitab 2010).

Results and Discussion

Insecticidal ant bait attractancy

Peanut butter, as a nontoxic bait, verified the presence of LFA at all trial sites, and in all but one trial, attracted as many or more LFA workers as the most attractive insecticidal bait or baits being evaluated.

Among household ant bait insectides for indoor use evaluated in trial 1(table 1), both avermectin products, which contain peanut butter and sucrose, Raid Double Control Ant Baits II and Raid Ant Baits II, and an indoxacarb product, Hot Shot MaxAttrax Ant $Bait_2$, which exudes a peanut butter scent, attracted as many LFA as granular Probait (hydramethylnon) and the non-toxic peanut butter bait ($P>0.05$). A gelatinous formulation containing hydramethylnon (Amdro Kills Ants Stake) and a solid fipronil bait (Combat Source Kill Ant) were the least attractive ($P<0.05$) to LFA.

None of the household ant bait insecticides for indoor use evaluated in trial 2 (table 2) attracted as many LFA as the non-toxic peanut butter bait or granular Amdro (hydramethylnon) ($P<0.05$). TomCat Ant Killer Gel Bait (indoxacarb) and Raid Ant Gel Precision Placement Bait (thiamethoxam) were colorless to opaque, odorless gels, and PIC Ant Killing System (sodium tetraborate pentahydrate) was an odorless blue liquid; their labels specified "not for fire ants" and were formulated for "sweet or grease feeding ants". Grant's Kills Ants Ant Control was similar in appearance and odor to Amdro Fire Ant Bait but was formulated with a higher concentration of the same active ingredient, hydramethylnon, which LFA workers may have found repellent.

All but one of the granular ant bait insecticides for outdoor use evaluated in trial 3 (table 3) attracted as many LFA as Amdro Fire Ant Bait. LFA were least attracted to oil-corn grit bait formulated with spinosad (Green Light Fire Ant Control with Conserve), averaging less than one ant per treatment rep 2 h after placement; however, there were no statistical differences between its attractancy and that of the abamectin bait (Advance 375A) and the non-toxic peanut butter bait, possibly due to high variability among the latter two treatments' reps despite random bait placement. There was no difference ($P>0.05$) in attractancy among the three baits with hydramethylnon concentrations ranging from 0.36% (Amdro FireStrike Yard Treatment) to 0.88% (Amdro Ant Block Home Perimeter Ant Bait).

In trial 4 (table 4), there were no differences ($P>0.05$) between the numbers of LFA attracted to either hydramethylnon bait or to the non-toxic peanut butter bait.

Weathered ant bait insecticides

Comparing fresh to weathered hydramethylnon granular baits, LFA were immediately attracted to the fresh deposits and the non-toxic peanut butter bait within 15 minutes of placement, and this preference ($P<0.05$) over the weathered baits persisted for the entire 2-h observation period (tables 5-7). The weathered granular baits were partially (Extinguish Plus) or fully covered with black mold (Probait, Maxforce Complete), which reduced their attraction as a food source, resulting in much lower ($P<0.05$) total ant counts over time. Oil-corn grit baits should be formulated with anti-mold ingredients for more residual activity in tropical environments with high rainfall.

Conclusions

Granular ant bait insectides found to be attractive to little fire ants, *Wasmannia auropunctata*, were Amdro Fire Ant Bait (hydramethylnon), Maxforce Complete (hydramethylnon), Extinguish Plus (hydramethylnon and S-methoprene), Probait (hydramethylnon), Advance 375A (abamectin), Amdro Ant Block Home Perimeter Ant Bait (hydramethylnon), and Amdro FireStrike Yard Treatment (hydramethylnon and S-methoprene). Paste baits that were as attractive to LFA as peanut butter were Raid Ant Bait III (abamectin) and Raid Double Control Ant Baits II (abamectin). None of the gel or liquid ant bait products evaluated (active ingredients: hydramethylnon, sodium tetraborate pentahydrate, thiamethoxam or indoxacarb) were attractive to LFA, possibly due to sugar rather than protein food source in those baits. Evaluation of the weathered granular hydramethylnon ant baits (Probait, Extinguish Plus, Maxforce Complete) indicated a dramatic drop in attractancy after 7 to 8 d of exposure to tropical climatic conditions, suggesting the need for an anti-mold ingredient or reapplication every 1 to 2 wk.

Table 1. Field attractancy of household ant bait insectides for indoor use to little fire ants (LFA), *Wasmannia auropunctata,* as compared to Probait, 2 h after placement.

Ant Bait	Active Ingredient	Number of LFA at 2 h
Peanut butter (control)		151.6x
Raid Ant Double Control Ant Baits II	0.05% abamectin	126.8xy
Raid Ant Baits III	0.01% abamectin	125.8xy
Hot Shot MaxAttrax Ant $Bait_2$	0.05% indoxacarb	103.5y
Probait	0.73% hydramethylnon	98.6y
Amdro Kills Ants Stake (gel)	1.0% hydramethylnon	12.6z
Combat Source Kill Ant	0.01% fipronil	9.4z

Means in a column followed by different letters were significantly different (P<0.05).

Table 2. Field attractancy of household ant bait insecticides for indoor use to little fire ants (LFA), *Wasmannia auropunctata,* as compared to Amdro Fire Ant Bait, 2 h after placement.

Ant Bait	Active Ingredient	Number of LFA at 2 h
Amdro Fire Ant Bait	0.73% hydramethylnon	141.1x
Peanut butter (control)		70.2y
TomCat Ant Killer Gel Bait	0.03% indoxacarb	9.0z
Grant's Kills Ants Ant Control	1.0% hydramethylnon	4.6z
PIC Ant Killing System	5.0% sodium tetraborate pentahydrate	0.5z
Raid Ant Gel Precision Placement Bait	0.003% thiamethoxam	0.2z

Means in a column followed by different letters were significantly different (P<0.05).

Table 3. Field attractancy of granular ant bait insecticides for outdoor use to little fire ants (LFA), *Wasmannia auropunctata,* as compared to Amdro Fire Ant Bait, 2 h after placement.

Ant Bait	Active Ingredient	Number of LFA at 2 h
Amdro FireStrike Yard Treatment	0.360% hydramethylnon, 0.0172% s-methoprene	85.8x
Amdro Fire Ant Bait	0.73%hydramethylnon	71.6x
Amdro Ant Block Home Perimeter Ant Bait	0.88% hydramethylnon	68.9x
Peanut butter (control)		42.0xy
Advance 375A	0.011% abamectin	39.9xy
Green Light Fire Ant Control with Conserve	0.015% spinosad	0.2y

Means in a column followed by different letters were significantly different (P<0.05).

Table 4. Field Attractancy of different rates of hydramethylnon in granular ant baits to little fire ants (LFA), *Wasmannia auropunctata,* 2 h after placement.

Ant Bait	Active Ingredient	Number of LFA at 2 h
Peanut butter (control)		189.8x
Maxforce Complete	1.0% hydramethylnon	165.3x
Probait	0.73% hydramethylnon	150.9x

Means in a column followed by same letters were not significantly different (P>0.05).

Table 5. Field attractancy of weathered versus fresh Maxforce Complete ant bait to little fire ants (LFA), *Wasmannia auropunctata,* 2 h after placement.

Ant Bait	Active Ingredient	Number of LFA at 2 h
Peanut butter (control)		292.4x
Maxforce Complete	1.0% hydramethylnon	97.7y
7 DE Maxforce Complete	1.0% hydramethylnon	18.8z
14 DE Maxforce Complete	1.0% hydramethylnon	5.5z

Means in a column followed by different letters were significantly different (P<0.05).

Table 6. Field attractancy of weathered versus fresh Probait ant bait to little fire ants (LFA), *Wasmannia auropunctata*, 2 h after placement.

Ant Bait	Active Ingredient	Number of LFA at 2 h
Peanut butter (control)		264.8x
Fresh Probait	0.73% hydramethylnon	184.6y
7 DE Probait	0.73% hydramethylnon	6.8z
14 DE Probait	0.73% hydramethylnon	13.1z

Means in a column followed by different letters were significantly different (P<0.05).

Table 7. Field Attractancy of weathered versus fresh Extinguish Plus ant bait to little fire ants (LFA), *Wasmannia auropunctata* at 2 h

Ant Bait	Active Ingredient	Number of LFA at 2 h
Peanut butter (control)		337.7x
Fresh Extinguish Plus	0.365% hydramethylnon, 0.25 s-methoprene	135.7y
8 DE Extinguish Plus	0.365% hydramethylnon, 0.25 s-methoprene	53.6z
15 DE Extinguish Plus	0.365% hydramethylnon, 0.25 s-methoprene	82.2yz

Means in a column followed by different letters were significantly different (P<0.05).

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