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Source: Florida Entomologist, 91(2) : 277-282

Published By: Florida Entomological Society

URL: https://doi.org/10.1653/0015-4040(2008)91[277:EOSBAR]2.0.CO;2

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EFFICACY OF SELECTED BAIT AND RESIDUAL TOXICANTS FOR CONTROL OF BIGHEADED ANTS, *PHEIDOLE MEGACEPHALA* (HYMENOPTERA: FORMICIDAE), IN LARGE FIELD PLOTS

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ABSTRACT

Residual and bait product efficacies were compared against foraging ant populations in a field test for efficacy against bigheaded ants, *Pheidole megacephala*. At 7 d after exposure (DAE), the residual product Transport (23% acetamiprid with 27% bifenthrin), Advion fire ant bait (0.045% indoxacarb), and Siesta fire ant bait (0.063% metaflumizone) had significantly fewer ants than Arena 50WP (50% clothianidin) and MaxForce fire ant bait (0.0005% fipronil) which did not differ significantly from each other. All products had fewer ants than the controls. At 14 DAE, Transport had fewer ants than the controls and other products, while Arena was not different from Advion or Siesta. At 28 DAE, MaxForce had fewer ants than the controls and other treatments with the exception of Advion, which did not have fewer ants than the controls. Residual treatments will likely need greater water volume to penetrate ground covers and soil to reach subterranean ants, and combined with a longer acting bait such as MaxForce, should suppress BHA populations for at least 3 weeks.

Key Words: bigheaded ant control, *Pheidole megacephala*, acetamiprid, bifenthrin, clothianidin, fipronil, indoxacarb, metaflumizone

RESUMEN

Las eficacias de productos residuales y de cebos fueron comparadas através de poblaciones de hormigas forrajedoras de cabeza grande, *Pheidole megacephala*. A los 7 días después de la exposición (DDE), el producto residual Transport (23% de acetamiprid con 27% de bifenthrin), el cebo de la hormiga de fuego Advion (0,045% de indoxacarb), y el cebo de la hormiga de fuego Siesta (0,063% de metaflumizone) tuvieron significativamente menos hormigas que Arena 50WP (50% de clothianidin) y el cebo de la hormiga de fuego MaxForce (0,0005% de fipronil), las cuales no difirierón el uno al otro. Todos los productos tuvieron menos hormigas que los controles. A los 14 DDE, el Transporte tuvo menos hormigas que los controles y otros productos, a excepción de Arena que no fue diferente de Advion ni Siesta. A los 28 DDE, MaxForce tuvo menos hormigas que los controles y otros tratamientos a excepción de Advion, que no tuvo menos hormigas que los controles. A lo major, los tratamientos residuales necesitarán un volumen de agua más grande para penetrar el coburatura de vegetación y el suelo para lograr la población de hormigas, y eso en combinación con un cebo de actuación más largo como MaxForce, deberían dar una suppressión de la población por lo menos 3 semanas.

Translation provided by the authors.

The bigheaded ant (BHA), *Pheidole megacephala* (Fabricius), also known as the coastal brown ant or African bigheaded ant, is a very successful invasive species that is sometimes considered a danger to native ants and other invertebrates, and has been listed among 100 of the "World's Worst" invaders (Lowe et al. 2000). Originally recorded from the Indian Ocean island of Mauritius (Fabricius 1793), the BHA is a widespread invasive tramp ant found in many subtropical and tropical regions throughout the world. The BHA is both an urban pest ant that invades landscape and structures, depositing piles of sandy debris, and an agricultural pest adversely affecting pineapple, coffee, and sugarcane production (Loke & Lee 2004). In Hawaii, the BHA tends mealybugs that cause mealybug wilt disease in pineapple (Taniguchi et al. 2003, 2005, 2006).

The BHA has been a pest in southern Florida for over 100 years (Wheeler 1910), and according to observations by pest control operators, it is becoming an even more pervasive nuisance as it apparently displaces other ants, such as the red imported fire ant (RIFA), *Solenopsis invicta* Buren, and the white-footed ant *Technomyrmex* cf. *albipes* (Fr. Smith) in some areas. It is possible that the increase in BHA infestations was augmented by several years of high hurricane activity (2003-5) in Florida that damaged lawns and killed trees necessitating the use of increased amounts of sod and other replacement vegetation that may have been infested with this ant (Warner & Scheffrahn

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2007). The BHA does not sting or cause structural damage, and usually does not bite unless the nest is disturbed, and even then, the bite is not painful.

The BHA, a soil-nesting ant, is sometimes confused with subterranean termites because it may create debris-covered foraging tubes that are somewhat similar, albeit much more fragile, than termite tubes. More often these ants leave piles of loose sandy soil. Homeowners are annoyed by these "dirt piles" and by ants foraging in bathrooms, kitchens, around doors, and windows, as well as on exterior paved or brick walkways or driveways. Although BHA mating flights have not been observed in Australia (Young 2000; Hoffman & O'Conner 2004), they are seen in Florida.

Control is difficult because the BHA is polygynous, colonies are numerous, and populations usually extend across property lines. Successful control has been obtained in Hawaiian pineapple fields with Amdro bait (0.73% hydramethylnon, Ambrands, Atlanta, GA) broadcast at 2.24 kg/ha (Su et al. 1980). Taniguchi et al. (2003, 2005) placed 20 g Distance (0.50% pyriproxyfen, Valent Professional Products, Walnut Creek, CA) in Perimeter Patrol System (B&G Chemicals and Equipment Co.) bait stations spaced approximately 15 m apart for 7 d and then replaced with 20 g Amdro for 14 d, obtaining control for 5 months. Zerhusen & Rashid (1992) report control of BHA for about 5 months using Amdro in a coconut plantation in Zanzibar. Hoffmann & O'Conner (2004) reportedly eradicated BHA from Kakadu National Park in northern Australia using broadcast applications of Amdro at 2.5 kg/ha. Eight small infestations in buildings had to be treated with bait stations placed inside the buildings. It was not stated what was placed in those interior bait stations, but it is assumed it was Amdro. After approx. 2 years of periodic inspections, no re-infestations were observed.

The current study was conducted to evaluate the field efficacy of selected chemical treatments to control the BHA in south Florida.

Materials and Methods

The University of Florida's Fort Lauderdale Research and Education Center (FLREC), located in Davie, FL, has a robust population of BHA in an area of about 1 hectare. It is thought that the population was introduced about 1999 when several seagrape trees (*Coccoloba uvifera* (L.) L.) were planted. The BHA were most likely nesting in the soil packed around the tree roots. This location and one other smaller infested area nearby were selected for the present study.

After numerous preliminary trials, we observed that ants would invade small test plots from adjacent areas, so we decided to use large plots (see below). Due to limitations in the area infested by BHA on the FLREC property, it was not possible to replicate large plots. Therefore the experimental design used for this test used large plots having 1 treatment per plot, with 10 stations (described below) in each plot to collect population data (n = 10). Two controls were used; 1 for residual products (water only) and 1 control for baits (no treatment).

Seven rectangular plots (approximately 7.6 × 15.2 m = 115.5 m^2) were delineated on the FLREC property (Fig. 1) where BHA activity was apparent. Along the edges of each plot were placed 10 numbered 3.5 × 7cm plastic floor tiles (Fig. 2) having a vertical line drawn at 5 cm (creating a 3.5 × 5 cm rectangle), and a 5-mm-diam. hole on the side through which a 6-cm-long aluminum nail was placed to hold the tile in place in the soil. These tiles (count stations) were placed in areas where BHA activity was observed. Liverwurst (Jones Dairy Farm, Ft. Atkinson, WI) was used as oil/protein bait. Approx. 30 g of liverwurst was completely mixed with 2 mL of warm tap water to form a pliable paste. This mixture was dispensed with a pipetter having a 50 mL dispenser tip with the tip trimmed to allow the liverwurst to be applied in approx. 0.75- × 2- cm strip along the center of the tile. After approximately 30-60 min., digital images were taken of each tile and the number of ants within the 3.5 × 5 cm area was counted on a monitor. Pre-treatment counts were taken on 2 and 13 Mar 2007, and post-treatment counts were taken 1, 3, 7, 14, 21, and 28 d after exposure (DAE) to the test products.

Seven treatments (1 treatment per plot, assigned randomly) were applied to plots, each separated by at least 5 m on 13 Mar 2007. Granular baits, applied at approx. 2.5 g formulated bait/m^2 with a hand-held fertilizer spreader, included 450 ppm indoxacarb (AdvionB) (11.044 g AI/ha) (Advion Fire Ant Bait, E. I. du Pont de Nemours and Co., Wilmington, DE), 630 ppm metaflumizone (SiestaB)(15.462 g AI/ha) (Siesta Fire Ant Bait, BASF Corp., Florham Park, NJ), and 5 ppm fipronil (MaxforceB) (0.123 g AI/ha) (MaxForce FC Fire Ant Bait, Bayer CropScience, Kansas City, MO). Separate control plots for bait (ControlB, no treatment) and residual (ControlR, water only) treatments were established.

Residual treatments, diluted in 9.5 L of water per plot, included a mixture of 23% acetamiprid with 27% bifenthrin (TransportR) (Transport, FMC Corp., Philadelphia, PA) applied at 0.257 and 0.302 g A.I./L water respectively, and 50% clothianidin (ArenaR) (Arena 50 WDG, Arysta LifeScience North America Corp., Cary, NC) applied at 0.466 g A.I./L water. These products were applied with a 15-L, CP-15 back pack sprayer (Cooper-Pegler, Denmark).

The number of BHA 11 D and 0 D before treatment, and at 1, 3, 7, 14, 21, and 28 DAE were compared by repeated measures ANOVA with the treatments as the between-subject factor and sam-

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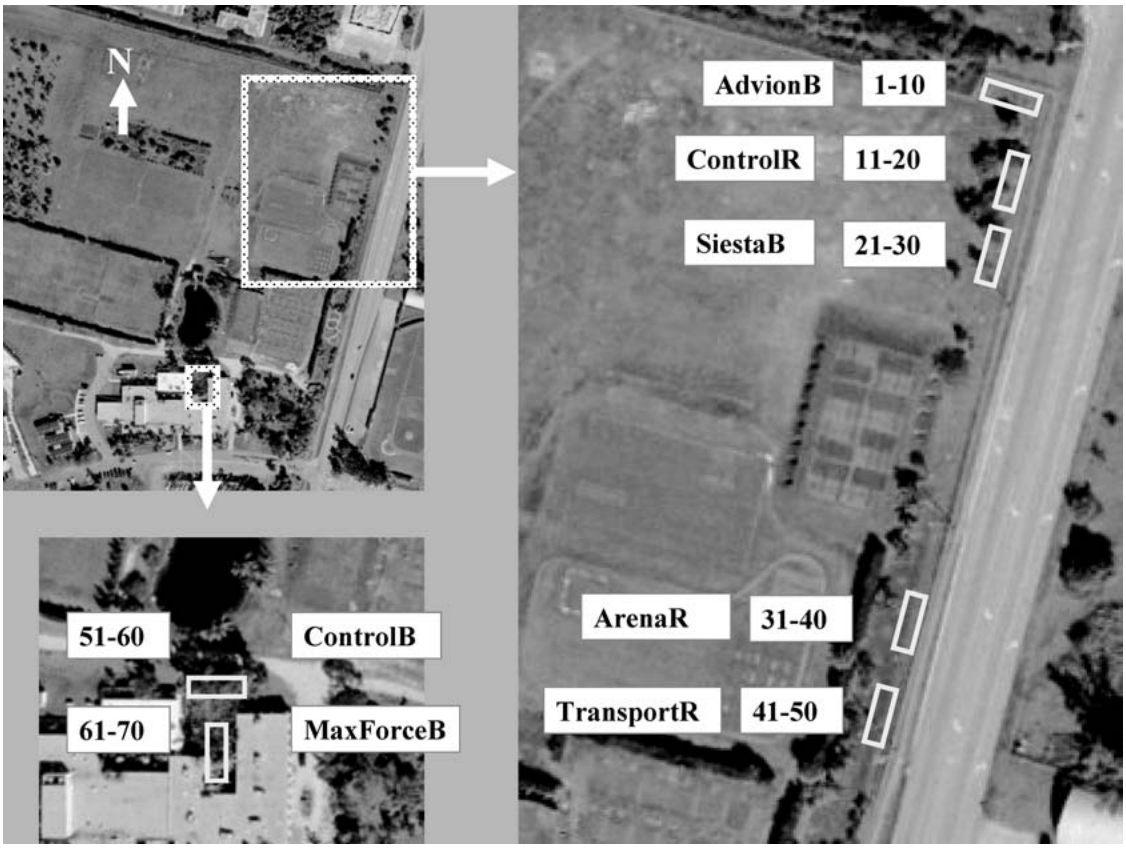


Fig. 1. Bigheaded ant test area. Overview map (upper left); 5 plots along fence line (right), and 2 plots established in a courtyard (lower left). Numbers indicate count stations at each plot.

pling time as the within-subject factor (Proc GLM, SAS Institute 1990). This analysis gave an interaction term for sampling time by treatment. Significant differences among treatment or daily means were separated by Fisher's least significant difference (LSD) test ($\alpha = 0.05$, SAS Institute 1990).

Results

Pre-treatment ant counts were normally distributed. The number of ants feeding on baits changed with days after treatments ($F_{7, 441}$=113.9, P<0.0001), and the change pattern in ant number across days depended on treatments (time × treatment interaction, $F_{42, 441}$=13.8, P<0.0001).

One DAE, ControlB (131.3 ± 17.6) had significantly more ants feeding on the liverwurst bait than ControlR (58.2 ± 4.9), which was not different than MaxforceB (62.4 ± 9.6). All the other treatments yielded fewer ants than the controls but were not different from each other (Table 1). At 3 DAE the relationships among all treatments were similar to 1 DAE, except for MaxforceB (32.9 ± 13.6) which was no longer different from the other products. At 7 DAE, TransportR (5.6 ± 5.4), AdvionB (9.3 ± 2.7), and SiestaB (16.9 ± 6.4) had fewer ants at bait stations than ArenaR (48.8 ± 9.3) and MaxForceR (48.4 ± 9.7), which did not differ from each other, and all products had fewer ants than the controls. At 14 DAE, TransportR (10.8 ± 4.8) had fewer ants than all other treatments except for ArenaR (34.3 ± 7.3), which did not differ from SiestaB (44.7 ± 12.6). All products had fewer ants than ControlB (107.3 ± 16.3), and AdvionB (44.4 ± 9.6), ArenaR (34.3 ± 7.3), and TransportR (10.8 ± 4.8) had fewer ants than ControlR (73.7 ± 9.5). At 21 DAE all treatments had fewer ants than ControlR (186.9 ± 20) and only MaxForceB (67.3 ± 8.8) and AdvionB (88.3 ± 9.1) had fewer ants than ControlB (142.7 ± 22.5), but did not differ from each other. At 28 DAE, only MaxforceB (38.8 ± 10.7) and AdvionB (82 ± 22.7) had fewer ants than the controls (128.1 ± 24.5, 165.8 ± 11.9, controls B and R, respectively), and these did not differ from each other. By 21 DAE, SiestaB, ArenaR, and TransportR had foraging ant populations that were approaching pretreatment levels, while MaxforceB and AdvionB main-

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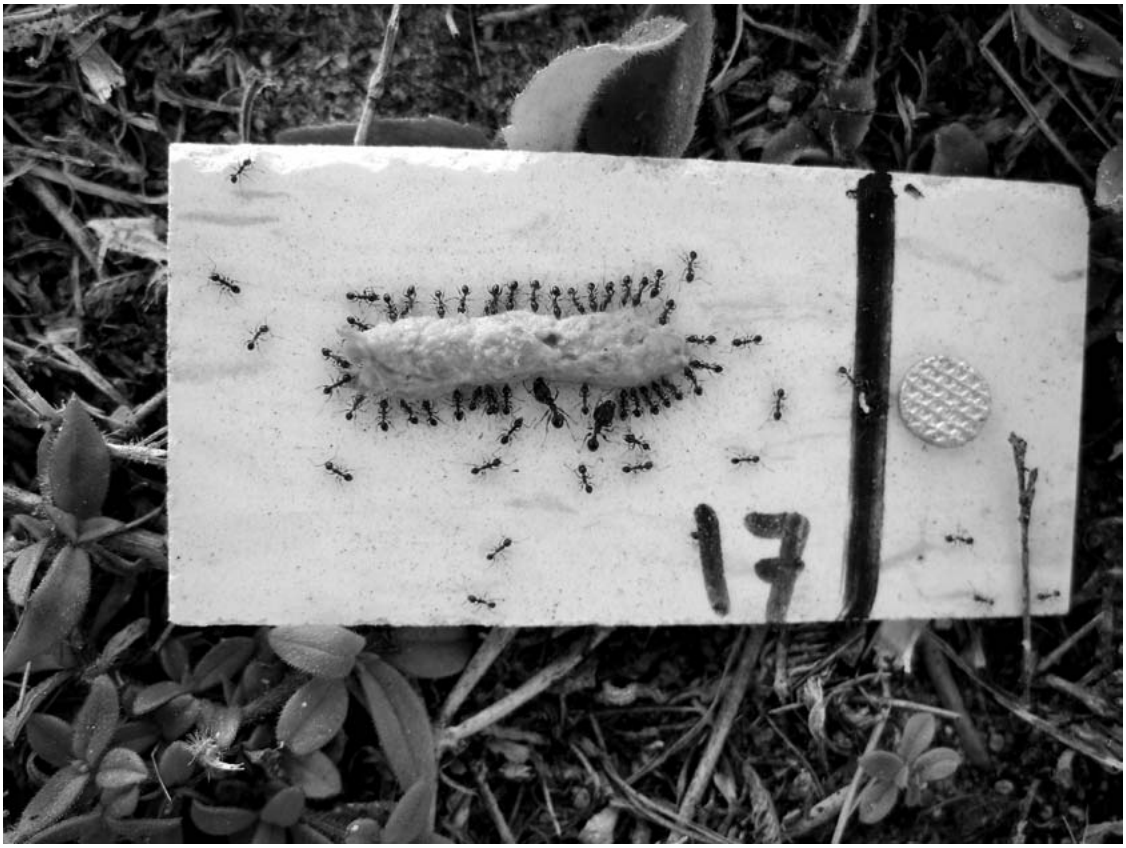


Fig. 2. Count station (approx. 3.5 × 7 cm). Bigheaded ants are feeding on oil/protein bait. Ants on the tile to the left of the black line were counted. A nail to the right of the line holds the tile in place on the soil surface.

tained lower numbers than the other treatments. These relationships continued to 28 DAE after which data were no longer collected.

Discussion

Because of large overlapping foraging territories of the BHA, the test plots in this experiment could not be replicated. This kind of experiment where it is not possible to have replications with plots that are equally sized, uniformly spaced apart, and having fairly equal initial insect populations is not unusual when dealing with pest ants that live in mega-colonies, such as Argentine ants *Linepithema humile* (Mayr). Klotz et al. (1998) tested boric acid bait for efficacy against Argentine ants that were infesting a water treatment facility. Bait stations and controls were placed along the sides of buildings at sites of ant activity determined by pre-treatment counts. Procedures followed by Forschler & Evans (1994) testing containerized bait stations around infested buildings were similar. Large sized plots are often selected because ants are forced to traverse greater distances over treated surfaces before reaching the counting stations providing more opportunity for the products to have an effect.

The area of the plots (approx. 116 m^2) used in this experiment was meant to be similar to the backyard of a typical zero-lot-line house (of approx. 185 m^2), i.e., area that would be treated by a pest control operator. Typical perimeter infestations of BHA show uneven populations throughout the area, with apparently larger concentrations being found around the roots of trees (the ants use the roots as structural support for tunnels and galleries), under materials found on the soil surface, such as stepping stones, flower pots, cement slabs, and in flower beds and other disturbed areas. In addition, BHA excavate into the soil to varying depths depending on the soil profile, depth of the water table, and possibly the amount of soil organic material, soil organisms, presence of roots, and debris.

We thought that a residual spray application to infested areas would need to pass beyond ground covers, such as plant leaves, and penetrate into the soil to the depths of tunnels and nest galleries in order to produce a lethal effect on the exposed ants, but we did not know the depth

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TABLE 1. MEAN NUMBER (±SE)[1] OF *PHEIDOLE MEGACEPHALA* WORKERS FEEDING ON AN OIL/PROTEIN BAIT, PRE-TREATMENT AND 1, 3, 7, 14, 21, AND 28 D AFTER EXPOSURE TO 7 TREATMENTS IN A FIELD BIOASSAY (MAR 2007).

Treatments	Type[2]	Days before exposure		Days after exposure					
		11	0	1	3	7	14	21	28
AdvionB	B	115.9 ± 11.6 bc	90.1 ± 8.1 cd	2.0 ± 0.8 c	1.0 ± 0.5 c	9.3 ± 2.7 d	44.4 ± 9.6 cd	88.3 ± 9.1 cd	82.0 ± 22.7 bc
SiestaB	B	130.9 ± 12.1 b	115.4 ± 12.9 bc	1.5 ± 0.5 c	2.7 ± 1.1 c	16.9 ± 6.4 d	44.7 ± 12.6 bcd	112.3 ± 14.1 bc	139.9 ± 17.8 a
MaxForceB	B	85.7 ± 21.5 c	169.9 ± 16.1 a	62.4 ± 9.6 b	32.9 ± 13.6 c	48.4 ± 9.7 c	65.6 ± 8.2 bc	67.3 ± 8.8 d	38.8 ± 10.7 c
ControlB	B	119.5 ± 23.5 bc	158.2 ± 25.9 ab	131.3 ± 17.6 a	157.7 ± 23.7 a	147.2 ± 18.6 a	107.3 ± 16.3 a	142.7 ± 22.5 b	128.1 ± 24.5 ab
ArenaR	R	179.4 ± 13.9 a	176.5 ± 11.9 a	17.9 ± 3.8 c	14.3 ± 2.1 c	48.8 ± 9.3 c	34.3 ± 7.3 de	135.8 ± 10.7 b	178.5 ± 18.8 a
TransportR	R	151.8 ± 13.8 ab	181.1 ± 18.1 a	10.1 ± 9.6 c	8.4 ± 5.6 c	5.6 ± 5.4 d	10.8 ± 4.8 e	24.8 ± 15.5 bc	153.6 ± 24.6 a
ControlR	R	81.0 ± 6.7 c	68.6 ± 10.3 d	58.2 ± 4.9 b	88.9 ± 11 b	109.2 ± 7.1 b	73.7 ± 9.5 b	186.9 ± 20 a	165.8 ± 11.9 a
Treatment Effects Statistics									
F		4.9	8.3	29.5	26.8	31.2	9.0	6.5	6.5
df		6,63	6,63	6,63	6,63	6,63	6,63	6,63	6,63
P		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

[1]Means followed by the same letter within a column are not significantly different (LSD test at $\alpha = 0.05$; $n = 10$).
[2]B = granular bait, R = residual product applied as an aqueous spray.

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of the tunnels at each location throughout our plots. Our applications of residual products at best penetrated only to about a depth 1-2 cm, and leaf cover may have prevented reaching even that depth. That would mean that ants would need to crawl over the surface and over leaves of plants to obtain a lethal exposure, unless rains after the initial product applications carried active ingredients to depths that would reach subterranean ants and in high enough concentration for lethal effect, or by transfer effect.

In this experiment, neither of the residual products had a significant effect on ant numbers beyond 2 weeks. Applying these (or other) residual products with a higher volume of water will allow better soil penetration which could significantly improve efficacy against this soil-dwelling species.

Two of the bait products, AdvionB and SiestaB, performed more efficaciously during the first 2 weeks, but MaxforceB provided the most control up to 4 weeks. Most likely this is explained by ant foragers picking up the bait and carrying it down into nest areas after which the toxicants were diffused throughout the colony by trophallaxis.

In future tests with these and other products, researchers should consider using higher water volumes for residual products, and the use of bait stations to protect baits from rain and sunlight. Amdro in bait stations performed well in tests against BHA done by Taniguchi et al. (2003, 2005, 2006) in Hawaii. The use of a product such as Extinguish (0.365% hydramethylnon and 0.250 % S-methoprene, Wellmark International, Schaumburg, IL), could provide a longer-lasting control due to the additional IGR.

The BHA population at our location seems to have displaced the red imported fire ants (RIFA) (*Solenopsis invicta* Buren) that are ubiquitous on the FLREC property except in places where BHA are nesting. Only rover ants (*Brachymyrmex* spp.) and pyramid ants (*Dorymyrmex* spp.) are found nesting near the BHA. It is unlikely that the presence of these ants would have a significant effect on these tests.

ACKNOWLEDGMENT

We thank Arysta LifeScience North America Corp. and FMC for financial support.

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