INDOOR AND OUTDOOR FORAGING LOCATIONS OF PHARAOH ANTS (HYMENOPTERA: FORMICIDAE) AND CONTROL STRATEGIES USING BAIT STATIONS

DAVID H. OI, KAREN M. VAIL, DAVID F. WILLIAMS, AND DONALD N. BIEMAN[1]
USDA-ARS MAVERL
P.O. Box 14565
Gainesville, FL 32604

[1]The Clorox Company
16218 SW 75th St.
Archer, FL 32618

ABSTRACT

While Pharaoh ants, *Monomorium pharaonis* (L.), are generally considered indoor pests, we observed these ants foraging at 51.7% of outdoor monitoring sites located on exterior wall surfaces of apartment buildings in contrast to 11.6% of indoor sites. The number of ants per infested monitoring site did not vary significantly with counts averaging from 46 to 118. Commercial bait stations containing a delayed action toxicant placed solely on the exterior walls of buildings, or outdoors, provided a 94% reduction in Pharaoh ant numbers within 1 week in contrast to a 9% reduction in untreated buildings. This was similar to the reductions from buildings treated with bait stations placed both indoors and outdoors. While a total of 3 ants were found indoors in treated apartments, indoor counts from untreated buildings also were low. Initial outdoor ant counts were 2 to 20 times higher than indoor counts, and the significant population reductions were attributed to a reduction in counts from outdoor sites.

Key Words: *Monomorium pharaonis*, pest control, toxic baits, urban pest ants, household insects, Florida.

RESUMEN

Anuque generalmente se considera que las hormigas faraónas, *Monomorium pharaonis* (L.), son plagas de puertas adentro, observamos estas hormigas en 51.7% de los sitios de monitoreo de puertas afuera sobre las superficies de paredes del exterior de edificos de apartamentos, en contraste con 11.6% de los sitios de puertas adentro. El número de hormigas por sitio de monitoreo infestado no varió significativamente, el rango de conteos siendo 46-118. Las estaciones de cebo de acción toxica retardada de preparación comercial colocadas en las paredes exteriores de los edificos, y proveyeron una reducción en números de hormigas faraónas a 94% dentro en una semana, en contrastea una reducción de 9% en edificios sin tratamiento. Eso fue similar a las reducciones en edificios tratados con estaciones de cebo colocadas afuera y adentro. Aunque un total de 3 hormigas fueron encontradas dentro de apartamentos tratados, conteos dentro de efificios no tratados tambien fueron bajos. Conteos iniciales de hormigas puertas afuera fueron entre 2-20 veces más altos que los conteos adentro, y las reducciones significantes de poblaciones se atribuyeron a una reducción en conteos de los sitios externos.

Pharaoh ants, *Monomorium pharaonis* (L.), are a major indoor pest throughout the world, often occurring in hospitals, food establishments, office buildings, and apartment complexes (Edwards 1986, Smith 1965). The use of baits impregnated with delayed action toxicants or insect growth regulators is an important strategy for the control of ants. It promotes the dissemination of the active ingredient to an entire colony (Lofgren

1986) and can reduce pesticide exposure in sensitive areas such as hospitals or food preparation areas (Edwards 1986). For Pharaoh ant control, Edwards (1986) recommended that baits be placed at foraging sites, nest locations, and adjoining areas. Labels on commercial ant baits generally suggest that stations be placed indoors, near foraging trails and possible nest sites. Bieman & Wojcik (1990) suggested the treatment of the periphery of buildings because structure-invading ants may live outdoors. Thus, the determination of nest and foraging sites is important to the success of baiting strategies for Pharaoh ant control.

In temperate areas, Pharaoh ants usually establish nests indoors (Sudd 1962, Smith 1965). In the tropics, or in areas where warm temperatures are maintained, such as refuse dumps, outdoor nests can be established (Kohn & Vlček 1986). While nest locations were not reported, Haack (1991) reported that Pharaoh ants foraged on the exterior periphery of houses in Texas during the spring and summer, when temperatures were warm and outdoor food sources were available.

In this study we document the foraging of Pharaoh ants outdoors in Florida, and compare the efficacy of placing commercial bait stations on exterior building surfaces, or outdoors, versus outdoors and indoors to control Pharaoh ants.

Materials and Methods

The study site was an apartment complex located in Alachua County, near Gainesville, Florida. A total of 12 single story buildings consisting of either 4 one-bedroom apartments (approximately 176 m^2 interior area per building) or 4 two-bedroom apartments (approximately 248 m^2 interior area per building) were used. Populations of Pharaoh ants were estimated by placing white index cards (7.5 x 6.5 cm) baited with peanut butter (approximately 1 g) at 6 locations inside and 6 locations outside each apartment. Interior card placements were in the living room on the window sill; in the kitchen on the sink counter, and on the floor near the dishwasher; in the bathroom on the basin counter, and on the floor behind the toilet; and, in the bedroom on the window sill. Exterior locations included the bottom of the front door; the top and diagonally opposite bottom of the courtyard gate; and, on top of the courtyard wall at the intersection of the courtyard and apartment walls. The remaining locations were selected from the following areas: the water spigot; the wall/air conditioning hose junction; the electric meters; and cracks in the wall where ants were observed. Exterior cards were placed on vertical surfaces with double-sided adhesive foam mounting tape. Cards were set in place between 0930 to 1200 hours EDST and were checked approximately 2 h later. Pharaoh ants were counted on both sides of each card and then shaken off at the same location from which they were collected. The presence of red imported fire ants, *Solenopsis invicta* Buren, on the baited cards also was noted. The normal pest control service was suspended for the duration of the study.

A survey was conducted on 15 September 1992 to characterize foraging locations from all buildings. Indoor and outdoor temperatures at the beginning of the survey were 27.2 and 28.6 °C, respectively. The percentage of infested cards per building and the number of ants per infested card between indoor and outdoor locations were compared by *t*-tests. In addition, the percentage of cards with ants was determined for each sampling location. The mean number of ants per infested card also was compared among locations by Ryan-Einot-Gabriel-Welsch multiple range test (SAS Institute Inc. 1988). Outdoor locations that had only 1 infested card were combined into a single category designated as "other". The bathroom basin and toilet locations also were combined to obtain homogeneous variances.

To determine the effectiveness between outdoor only and indoor plus outdoor placements of toxic bait stations in reducing Pharaoh ant populations, commercial bait stations

were assigned to the 12 buildings following a completely randomized design. Treatments consisted of Maxforce® Pharaoh Ant Killer bait stations (The Clorox Co., Oakland, California) placed indoors and outdoors; Maxforce® bait stations placed only outdoors; Pro-Control™ bait stations (Micro-Gen Equip. Corp., San Antonio, Texas) placed indoors and outdoors; and an untreated control. A total of 3 buildings were used per treatment. The Maxforce® and Pro-Control™ baits contained the delayed action toxicants hydramethylnon (0.9%) and sulfluramid (0.5%), respectively. The Pro-Control™ treatment served as a standard because its active ingredient differed from the Maxforce® treatments. Pretreatment populations were determined from the survey used in the foraging study reported above. Commercial bait stations were positioned adjacent to the bait card locations on the same day as the pretreatment survey, immediately after counts were made. For the outdoor treatments 24 bait stations were used for each building, and for the indoor plus outdoor treatments 42 to 48 stations per building were used. Bait stations were left without replacement for the duration of the study. Post-treatment populations were monitored weekly for 4 weeks (21 September through 14 October 1992) following the same procedure as the pretreatment survey. Outdoor temperatures during the population monitoring ranged from 19.4 to 33.1°C.

Pretreatment Pharaoh ant counts were either transformed to $\log_{10}(X + 1)$ to obtain homogeneous variances, or ranked, and then compared by analyses of variance. The average percent reduction in counts from the pretreatment to post-treatment counts per card per building was evaluated by analyses of variance and Tukey's HSD tests (SAS Institute Inc. 1988) for each sample date. The arcsine transformation was performed on percentages prior to analyses.

Results

Pharaoh ants were present on 51.7% (±5.0 SEM) of the cards placed outdoors for each building, which was significantly greater ($P<0.0001$; $t=6.693$; df=22) than the 11.6% (±3.3% SEM) of the cards located indoors that were infested. The average number of ants per infested card per building did not vary significantly ($P=0.725$; $t=0.356$; df=20) between outdoor (82.9 ±15.0 SEM) and indoor (75.1 ±15.8 SEM) locations. Infested cards were located most frequently (>10%) on the courtyard wall, the top of the courtyard gate, the water spigot, and the front door (Table 1). The average number of ants per card did not vary significantly among infested locations (Table 1).

Red imported fire ants were present on 8.6% (±1.1 SEM) of the outdoor cards per building over the duration of the study. The bottom of the courtyard gate accounted for 48.7% of the cards with fire ants, followed by the bottom of the front door with 12.6%. None of the indoor locations had fire ants.

All treated buildings had significantly greater ($P<0.05$) reductions in Pharaoh ant populations than the control over the 4-week period when populations were based on bait cards located both indoors and outdoors (Table 2). Differences between the outdoor only and the indoor plus outdoor commercial bait station applications were not significant (Table 2). Differences between the Maxforce® and Pro-Control™ bait stations were not significant (Table 2).

Pretreatment Pharaoh ant populations inside the apartments were from one-half to one-twentieth the level found outdoors. Ants were not detected inside any of the treated buildings following the placement of the commercial bait stations for the first 3 weeks and 3 ants were found in the fourth week. However, the reductions were not statistically different from the reductions reported for the control buildings on the first, second, and fourth weeks post-treatment. In the third week post-treatment, the control buildings had an 11.1% reduction in population, which was significantly less than the treated

TABLE 1. FREQUENCY AND AVERAGE NUMBER OF PHARAOH ANTS PER CARD AMONG LOCATIONS WHERE PHARAOH ANTS WERE PRESENT.

Card Location	Indoors vs. Outdoors	% of Cards with Ants[1]	Avg. No. Ants/Card[2]
Courtyard Wall	Outdoor	18.6	118.1
Courtyard Gate (Top)	Outdoors	14.4	57.0
Water Spigot	Outdoors	12.6	88.5
Front Door	Outdoors	10.2	100.6
Bedroom Window (Int[3])	Indoors	9.6	60.6
Air Conditioner	Outdoors	9.0	110.3
Bedroom Window (Ext[4])	Outdoors	7.2	116.8
Living Room Window	Indoors	6.6	93.6
Other	Outdoors	5.4	46.3
Courtyard Gate (Bot[5])	Outdoors	3.6	73.3
Toilet + Basin	Indoors	3.0	64.0

[1]Percentages based on a total of 167 infested cards.
[2]Averages were not significantly different ($P>0.05$) by Ryan-Einot-Gabriel-Welsch Multiple Range Test.
[3]Int, interior side of window.
[4]Ext, exterior side of the window.
[5]Bot, bottom of the gate.

buildings (Table 3). Post-treatment Pharaoh ant counts were more prevalent on the outdoor bait cards. Percent reductions on the outside of treated buildings were significantly greater than the controls for all post-treatment sample dates (Table 4). There was a gradual decline in ant populations from control buildings throughout the study (Tables 2 and 4). This resulted in diminishing differences in percent reductions between treated and control buildings.

TABLE 2. AVERAGE PERCENT REDUCTION IN PHARAOH ANT COUNTS OBTAINED INSIDE AND OUTSIDE OF APARTMENT BUILDINGS ONE TO FOUR WEEKS FOLLOWING PLACEMENT OF COMMERCIAL BAIT STATIONS INDOORS AND OUTDOORS, OR OUTDOORS ONLY. STUDY WAS CONDUCTED 15 SEPT. THROUGH 14 OCT. 1992, NEAR GAINESVILLE, FLORIDA.

Treatment (placement)	Week 0	Average Percent Reduction Inside & Outside[1]- Avg. Count[2] Week 1	Week 2	Week 3	Week 4
Maxforce (out only)	29.5	93.7 a	98.7 a	99.6 a	100 a
Maxforce (in & out)	24.3	99.6 a	98.9 a	99.8 a	99.8 a
Pro-Control (in & out)	35.0	99.8 a	99.0 a	99.9 a	100 a
Control (untreated)	22.8	8.5 b	27.0 b	43.6 b	71.3 b

[1]Averages followed by the same letter in each column are not significantly different ($P>0.05$) by Tukey's HSD test on arcsine transformed data. Untransformed percentages are presented.
[2]Average number of ants per card per building. Number of cards per building ranged from 35 to 48. Pretreatment counts are not significantly different ($F=0.97$; df=3,8; $P=0.45$) by analysis of variance on $\log_{10}(X+1)$ data.

TABLE 3. AVERAGE PERCENT REDUCTION IN PHARAOH ANT COUNTS OBTAINED INSIDE OF APARTMENT BUILDINGS ONE TO FOUR WEEKS FOLLOWING PLACEMENT OF COMMERCIAL BAIT STATIONS INDOORS AND OUTDOORS, OR OUTDOORS ONLY. STUDY WAS CONDUCTED 15 SEPT. THROUGH 14 OCT. 1992, NEAR GAINESVILLE, FLORIDA.

Treatment (placement)	Week 0	Average Percent Reduction Inside[1] Avg. Count[2] Week 1	Week 2	Week 3	Week 4
Maxforce (out only)	3.2	100 a	100 a	100 a	100 a
Maxforce (in & out)	15.1	100 a	100 a	100 a	99.7 a
Pro-Control (in & out)	6.3	100 a	100 a	100 a	100 a
Control (untreated)	8.5	70.9 a	80.5 a	11.1 b	100 a

[1]Averages followed by the same letter in each column are not significantly different ($P>0.05$) by Tukey's HSD test on arcsine transformed data. Untransformed percentages are presented.

[2]Average number of ants per card per building. Number of cards per building ranged from 18 to 24. Pretreatment counts are not significantly different ($F=1.13$; df=3,8; $P=0.39$) by analysis of variance.

DISCUSSION

In our study, Pharaoh ant foraging was more prevalent outdoors than indoors as evidenced by the higher number of infested, outdoor monitoring sites. The most frequented indoor locations were at the windows, which suggested that even indoor foraging tended toward outside locations. Foraging at windows has been attributed to the presence

TABLE 4. AVERAGE PERCENT REDUCTION IN PHARAOH ANT COUNTS OBTAINED OUTSIDE OF APARTMENT BUILDINGS ONE TO FOUR WEEKS FOLLOWING PLACEMENT OF COMMERCIAL BAIT STATIONS INDOORS AND OUTDOORS, OR OUTDOORS ONLY. STUDY WAS CONDUCTED 15 SEPT. THROUGH 14 OCT. 1992, NEAR GAINESVILLE, FLORIDA.

Treatment (placement)	Week 0	Average Percent Reduction Outside[1] Avg. Count[2] Week 1	Week 2	Week 3	Week 4
Maxforce (out only)	60.6	92.6 a	98.4 a	99.5 a	100 a
Maxforce (in & out)	33.6	99.3 a	98.1 a	99.7 a	99.9 a
Pro-Control (in & out)	62.8	99.8 a	99.1 a	99.9 a	100 a
Control (untreated)	37.3	1.5 b	20.8 b	55.9 b	63.8 b

[1]Averages followed by the same letter in each column are not significantly different ($P>0.05$) by Tukey's HSD test on arcsine transformed data. Untransformed percentages are presented.

[2]Average number of ants per card per building. Number of cards per building ranged from 17 to 24. Pretreatment counts are not significantly different ($F=0.58$; df=3,8; $P=0.64$) by analysis of variance on ranked data.

of dead insects which are often found on window sills and which serve as an important food source for Pharaoh ants (Sudd 1962). Selectively placing bait stations at potential foraging sites on the outside of buildings should increase the probability of Pharaoh ants encountering and feeding on baits when they are actively foraging outdoors.

Pharaoh ants were not found on any of the cards that had fire ants and they were probably excluded from these cards because of the aggressive foraging behavior of fire ants (Banks & Williams 1989, Baroni-Urbani & Kannowski 1974). In addition, they may have been prevented from foraging at bait stations if fire ants were foraging at the same location. Because fire ants were found predominantly at monitoring sites located near the ground, it might be advantageous to place bait stations at higher locations.

The significant reductions in Pharaoh ant populations based on all monitoring sites can be attributed to the significant reductions in ants sampled on the outside of treated buildings. The gradual increase in percent reductions from control buildings throughout the study may have reflected a seasonal decrease in foraging activity as temperatures became cooler. Kohn & Vlček (1986) reported the disappearance of Pharaoh ant colonies near the surface of refuse dumps at the onset of cooler weather in Czechoslovakia.

Indoor monitoring sites in treated buildings did not reveal reductions in Pharaoh ant populations that were consistently greater than controls because indoor counts in the controls were low. These counts averaged 4.1 (±5.9 SD) ants per monitoring card per building over the 4 week post-treatment sampling. Percent reductions in the controls for the first, second and fourth weeks post-treatment averaged 83.8% (±14.8 SD) in comparison to the 100% (±0.1 SD) reduction in treated buildings. On the third week post-treatment, when indoor population reductions in the treated buildings were significant, cool temperatures (26.6 °C falling to 20.9 °C) may have favored greater foraging activity indoors in the controls. Despite the relatively low number of ants found indoors, a majority of the Pharaoh ant trails originated from soffit areas. This suggested that the ants were nesting within the buildings with the outside foraging activity being indicative of a structural infestation.

Placing commercial bait stations indoors and outdoors was shown to be effective in controlling Pharaoh ants in houses in Texas (Haack 1991). In that study, stations were placed where ants were foraging, resulting in an average of one station being used every 9.3 to 13.9 m^2 of interior floor space and 1 station every 3 to 6.1 linear meters along the exterior perimeter of each house. We have shown that selectively placing 24 stations at potential foraging sites on exterior locations of buildings, which had perimeters of 79.3 meters (one station per 3.3 linear meters), was sufficient to provide substantial population reductions outdoors within 1 week. These reductions were comparable to buildings with stations placed both indoors (one station per 7.4 to 10.3 m^2) and outdoors (one station per 3.3 linear meters). Thus, the selective placement of bait stations only on the outside of buildings can serve as an effective control strategy when Pharaoh ants are actively foraging on the exterior of buildings. By eliminating interior treatments under these circumstances, this strategy may result in lower application costs, and reduce pesticide exposure in the indoor environment.

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POPULATION LEVELS OF *LEPTODICTYA TABIDA* (HEMIPTERA: TINGIDAE) IN FLORIDA SUGARCANE

DAVID G. HALL[1] AND OMELIO SOSA, JR.[2]
[1]Research Department,
United States Sugar Corporation, Clewiston, FL 33440

[2]United States Department of Agriculture, ARS,
Sugarcane Field Station, Canal Point, FL 33438

ABSTRACT

Three sugarcane (*Saccharum* spp.) fields in southern Florida were sampled to assess population densities of the sugarcane lace bug (*Leptodictya tabida* Herrich-Schaeffer) on leaves during 1990 - 1992. The study began several months after the bug was first discovered in Florida. A mean of 6.3 (SEM=0.51) bugs (all life stages) per leaf was observed over the entire study. Average densities per field per sample date ranged up to 74 bugs (all stages) per leaf. The bug was present from late spring through winter but exhibited a propensity for 2 annual peaks in density, one during late spring/early