# FIELD EVALUATION OF PERIMETER TREATMENTS FOR PHARAOH ANT (HYMENOPTERA: FORMICIDAE) CONTROL

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ABSTRACT

Four types of exterior perimeter treatments for the control of Pharaoh ants, *Monomorium pharaonis* (L.), in houses were compared. Treatment with a granular bait containing hydramethylnon, a delayed-action toxicant, resulted in a 95% reduction in foraging activity 1 and 4 weeks after treatment. Houses treated with either an insecticidal residual spray, insecticide granules, or a granular bait containing a contact insecticide, had an average increase of 22% in foraging activity. Foraging by Pharaoh ants on a delayed-action toxicant bait applied solely to the exterior periphery of houses controlled Pharaoh ant colonies located inside the structure. Exterior perimeter baiting for Pharaoh ants could reduce indoor insecticide applications.

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

RESUMEN

Fueron comparados cuatro tipos de tratamientos de perímetro exterior para el control de la hormiga faraón, *Monomorium pharaonis* (L.) dentro de casas. Un cebo granular conteniendo hydramethylnon, un tóxico de acción retardada, produjo un 95% de reducción de la actividad forrajera una y cuatro semanas después del tratamiento. Las casas tratadas con aspersiones de un insecticida resisdual, gránulos de insecticida o un cebo granular conteniendo un insecticida de contacto tuvieron un incremento promedio del 22% en la actividad forrajera. El forrajeo de las hormigas faraón sobre un tóxico de acción retartdada aplicado solamente a la periferia de las casas controló las colonias localizadas dentro de la estructura. El uso de cebos exteriores para las hormigas faraón podría reducir las aplicaciones de insecticidas al interior de las casas.

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Bait stations containing an attractant mixed with toxicants or insect growth regulators have been used successfully for Pharaoh ant, *Monomorium pharaonis* (L.), control (Edwards 1986, Haack 1991, Williams & Vail 1993, Oi et al. 1994). Because Pharaoh ants have generally been considered indoor pests, the recommended placement of these stations is usually indoors. However, Pharaoh ants have been reported to nest outdoors in warm areas (Kohn & Vlček 1986) and have been observed to forage on exterior wall surfaces and the outside periphery of buildings (Oi et al. 1994, Vail & Williams 1993, Haack 1991). Placement of bait stations at outdoor foraging sites has reduced Pharaoh ant populations inside and outside of buildings (Oi et al. 1994, Haack 1991, K. M. V. & D. F. W. unpublished data). Insecticidal residual sprays, granules, or bait formulations that kill on contact also are registered for ant control. Applications to the exterior walls and periphery of buildings with these types of treatments are designed to prevent ants from entering structures. Granular ant baits that contain a delayed-action toxicant or insect growth regulator have been developed to control imported fire ants (Williams 1994). These types of bait scattered around the periphery of buildings may be useful for Pharaoh ant control. The objective of this study was to compare the efficacy of exterior perimeter applications of an insecticidal residual spray, a granular contact insecticide, a granular bait containing a contact insecticide, and a granular bait containing a delayed-action toxicant in reducing the presence of Pharaoh ants.

## MATERIALS AND METHODS

The study was conducted from 2 August through 30 September 1993 with 15 single story homes located in Port Richey, Florida. Pharaoh ant counts were obtained by placing index cards (7.6 × 6.4 cm), baited with peanut butter (1-2 cc), inside and outside of each structure. Interior bait card sites usually included all window sills, kitchen counters and floors, bathroom counters and lights, washing machines and water heaters in utility rooms, fuse boxes, and any other sites where ants were trailing. An average of 16.2 (±2.2 SD) bait cards, ranging from 12 to 19 per house, were used. Exterior bait cards were placed off the ground to deter fire ants from foraging on the peanut butter. Bait cards were positioned at each corner of the house, along any wire, pole, or crack, and near water spigots, air conditioners, meters, lights, mailboxes, doors, and other sites where ants were foraging on the exterior structure of the houses. The number of exterior placements ranged from 15 to 22, with an average of 17.2 (±1.3 SD) baits per house. Approximately 2 to 3 h after bait card placement, the number of ants on each card was determined by visual counts. After counting, the ants were tapped off the card at that monitoring site.

A treatment was applied to each house three days after the initial bait card counts were completed. Treatments were replicated three times on houses that had an average (±SD) perimeter length of 57 ± 3.8 m (187 ± 12.5 ft). A granular bait containing 0.97% hydramethylnon, a delayed-action toxicant (The Clorox Co., Pleasanton, California), was applied at a rate of 283.5 g per 92.9 $m^2$ (10 oz. per 1,000 $ft^2$) in a 0.6 m (2 ft) band around the perimeter of each house. Additional bait (12.4 ± 9.2 g) was sprinkled on all outdoor window sills and other outdoor locations where Pharaoh ants were foraging. Thus, an average total of 117.1 (±7.5) g hydramethylnon granular bait was applied per house. Another granular bait containing a contact insecticide, 2% propoxur (Baygon 2% Bait Insecticide, Miles Inc., Kansas City, Missouri), was applied in the same manner as the hydramethylnon bait but at the label rate of 113 g per 92.9 $m^2$ (4 oz per 1,000 $ft^2$) in a 0.6 m band. An average of 40.7 (±1.5) g was applied in a perimeter band plus 19.5 (±6.6) g at active foraging sites and window sills for an average total of 60.2 (±5.7) g per house. A granular contact insecticide containing 2% diazinon (Ortho Diazinon Granules, Chevron Chemical Co., San Ramon, California) was applied at the label rate of 454 g per 18.6 $m^2$ (1 lb per 200 $ft^2$) as a barrier treatment. Granules were sprinkled along the perimeter of the house in a 1.5 m (5 ft) band and watered in. A mean of 2,016.4 (±528.3) g of the diazinon granules was applied per house. A residual spray of cyfluthrin (Tempo 20 WP, Miles Inc., Kansas City, MO) also was applied as a barrier treatment. All soffits, windows, doors and foundation bases were treated at the label rate of 19 g Tempo 20 WP per 3.8 liters (1 gal) water per 92.9 $m^2$ (1,000 $ft^2$). An average of 1.56 (±0.3) liters of spray was applied per house. For the controls, 46 g of pregel defatted corn grit was applied in a 0.6 m (2 ft) swath around the perimeter of each house (4.4 oz per 1,000 $ft^2$).

TABLE 1. AVERAGE PERCENT REDUCTION IN PHARAOH ANT COUNTS PER MONITORING SITE LOCATED INDOORS AND OUTDOORS OF HOUSES THAT RECEIVED EXTERIOR PERIMETER TREATMENTS ON 5 AUG. 1993, IN PORT RICHEY, FLORIDA.

| Treatment (AI) | N[1] | Location | No. of Ants Pretreat. | Average (±SE) Percent Reduction in Ants per Monitoring Site | | |
|---|---|---|---|---|---|---|
| | | | | Week 1 | Week 4 | Week 8 |
| Contact granular bait (propoxur) | 2 | In | 35.3 | -28.3 | -109.1 | —[2] |
| | | | (24.1) | (86.5) | (139.0) | |
| | | Out | 66.4 | 13.3 | -102.5 | — |
| | | | (30.9) | (69.1) | (72.5) | |
| | | In + Out | 52.5 | -14.1 | -93.0 | — |
| | | | (26.4) | (71.8) | (91.3) | |
| Granular contact insecticide (diazinon) | 2 | In | 30.0 | -50.0 | 28.4 | — |
| | | | (0.6) | (2.5) | (22.5) | |
| | | Out | 89.4 | -79.8 | -9.2 | — |
| | | | (58.3) | (17.4) | (72.9) | |
| | | In + Out | 60.6 | -69.3 | 10.7 | — |
| | | | (29.7) | (11.5) | (50.4) | |
| Residual spray (cyfluthrin) | 2 | In | 41.0 | -66.5 | 61.6 | — |
| | | | (3.2) | (65.2) | (21.6) | |
| | | Out | 74.5 | 50.6 | 4.2 | — |
| | | | (31.4) | (37.1) | (78.7) | |
| | | In + Out | 58.6 | 10.9 | 22.7 | — |
| | | | (18.1) | (35.2) | (60.4) | |
| Delayed-action granular bait (hydramethylnon) | 3 | In | 75.2 ns[3] | 100.0*[4] | 6.2 ns | 13.9 ns |
| | | | (47.1) | (0.0) | (93.8) | (86.0) |
| | | Out | 53.5 ns | 99.2* | 96.8* | 96.2 ns |
| | | | (17.4) | (0.8) | (3.2) | (2.0) |
| | | In + Out | 64.5 ns | 99.2* | 89.8* | 90.7 ns |
| | | | (32.7) | (0.8) | (10.3) | (8.5) |
| Control (corn grit) | 3 | In | 22.6 ns | -13.4* | -44.9 ns | 60.6 ns |
| | | | (5.6) | (29.4) | (97.1) | (8.1) |
| | | Out | 36.0 ns | -65.3* | -432.9* | 51.1 ns |

[1]Number of houses sampled per treatment, with 12 to 22 monitoring sites per indoor or outdoor location.

[2]Test terminated after week 4 because of complaints.

[3]Pretreatment ant counts were not significantly different ($P \le 0.05$) between the delayed-action granular bait and the control for the same sampling locations using $t$-tests.

[4]Percent reductions followed by a "*" were significantly different ($P \le 0.05$) by $t$-tests between the delayed-action granular bait and control treatments for the same sampling location and week. Nonsignificant reductions are followed by "ns". Negative percentage reductions were set to zero for analysis; negative reductions are presented. Statistical tests were not conducted on the other treatments due to insufficient replication.

TABLE 1. (CONTINUED) AVERAGE PERCENT REDUCTION IN PHARAOH ANT COUNTS PER MONITORING SITE LOCATED INDOORS AND OUTDOORS OF HOUSES THAT RECEIVED EXTERIOR PERIMETER TREATMENTS ON 5 AUG. 1993, IN PORT RICHEY,

| Treatment (AI) | N[1] | Location | No. of Ants Pretreat. | Average (±SE) Percent Reduction in Ants per Monitoring Site | | |
|---|---|---|---|---|---|---|
| | | | | Week 1 | Week 4 | Week 8 |
| | | | (15.3) | (68.8) | (288.8) | (25.1) |
| | | In + Out | 29.3 ns | -19.7* | -184.2* | 62.1 ns |
| | | | (9.8) | (19.3) | (74.7) | (9.5) |

[1]Number of houses sampled per treatment, with 12 to 22 monitoring sites per indoor or outdoor location.
[2]Test terminated after week 4 because of complaints.
[3]Pretreatment ant counts were not significantly different ($P \leq 0.05$) between the delayed-action granular bait and the control for the same sampling locations using *t*-tests.
[4]Percent reductions followed by a "*" were significantly different ($P \leq 0.05$) by *t*-tests between the delayed-action granular bait and control treatments for the same sampling location and week. Nonsignificant reductions are followed by "ns". Negative percentage reductions were set to zero for analysis; negative reductions are presented. Statistical tests were not conducted on the other treatments due to insufficient replication.

Treatment evaluations were based on percentage reduction in counts per bait card per house and average number of Pharaoh ants per card per house 1, 4, and 8 weeks after treatment. Infestation levels also were characterized by percent frequency distribution of bait card counts grouped in intervals of 50 ants. Percentage reductions and average number of ants for the separate and combined indoor and outdoor sampling locations between the hydramethylnon bait and the control were compared by *t*-tests (SAS Institute 1988) for each sample date. Negative percentage reductions were set to zero, and count data were $\log_{10}(x + 1)$ or $\sqrt{(x + 0.5)}$ transformed, when necessary, to stabilize variances. During the study it was determined that one house in each of the remaining treatments was treated for ants or cockroaches and had to be removed from the study. Therefore, these treatments were excluded from statistical testing because of insufficient replication. In addition, because of complaints from some residents, all houses that received applications of propoxur, diazinon, or cyfluthrin were treated for Pharaoh ants after the fourth week of sampling and were no longer used in the study.

## RESULTS AND DISCUSSION

Percentage reductions and ant counts for the indoor locations allowed for evaluation of the exterior perimeter treatments based on presence of Pharaoh ants indoors, which, for ant control, is an important concern for pest control operators. For indoor samples, percentage reductions from the hydramethylnon bait were significantly greater ($t$=6.88, df=2, $P$=0.0205) than the control on week 1. However on week 4, only a 6.2% reduction was recorded for the hydramethylnon bait which was not significantly different from the control (Table 1). The low reduction was attributed to the presence of 120 ants at one site, or 2% of the monitoring sites, in contrast to the controls where 13 sites, or 37%, had ants (Figs. 1 and 2). The number of ants also were significantly lower on week 1, but not on week 4 (Table 2). On week 8, percentage reductions from the hydramethylnon and control did not differ significantly for both locations (Table 1). However, the hydramethylnon treatment had significantly lower ($t$=4.0358, df=4, $P$=0.0157) ant counts than the controls (Table 2). The number of ants

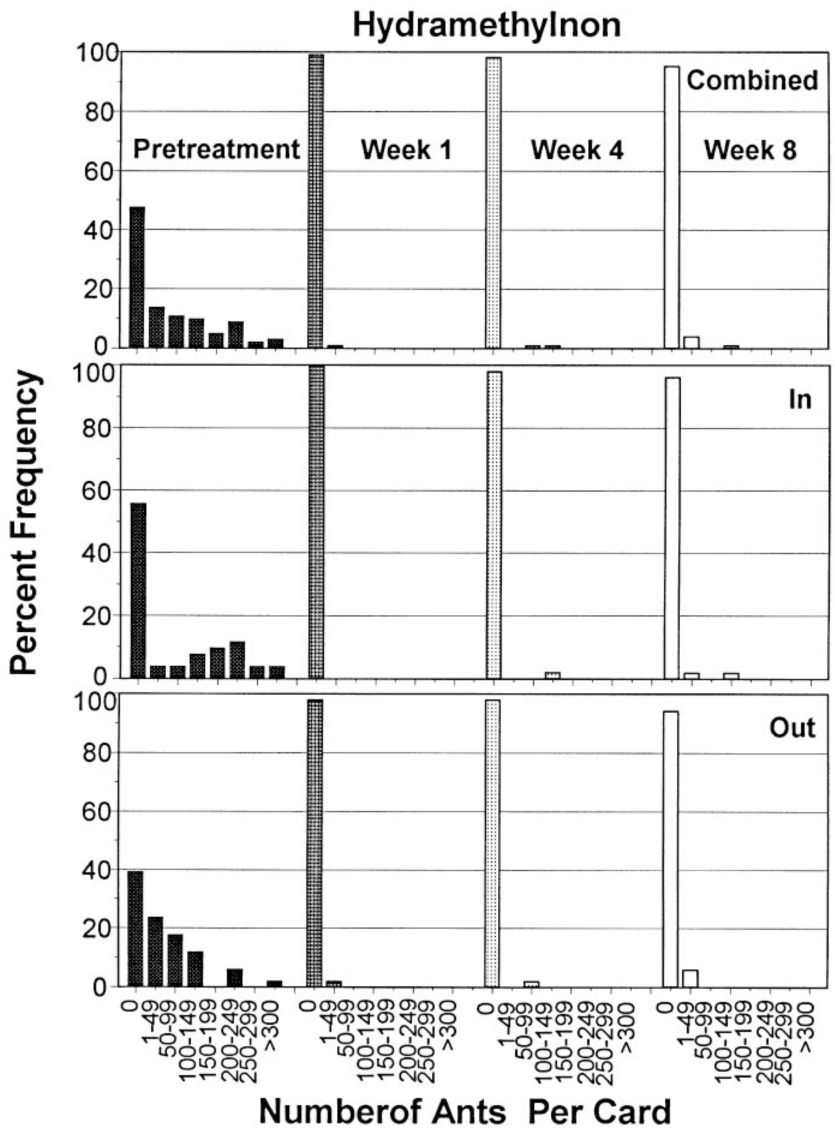


Figure 1. Percent frequency distributions of bait cards with Pharaoh ant counts grouped in intervals of 50 ants from the combined indoor plus outdoor, indoor only, and outdoor only sampling sites from houses treated with a delayed-action toxicant (hydramethylnon) bait.

in the controls declined on this date, perhaps as a result of less foraging activity due to cooler temperatures. Temperatures during sampling on week 8 were 22 to 27°C, while on the previous dates a minimum of 31°C was recorded outdoors.

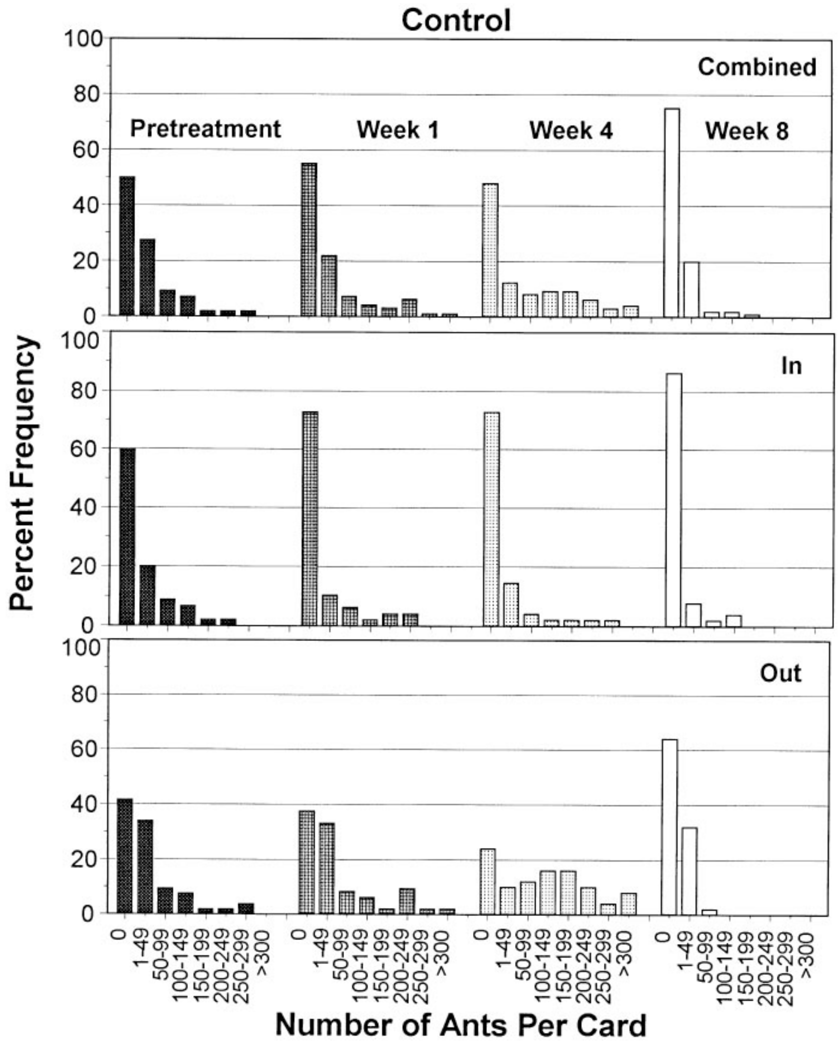


Figure 2. Percent frequency distributions of bait cards with Pharaoh ant counts grouped in intervals of 50 ants from the combined indoor plus outdoor, indoor only, and outdoor only sampling sites from control houses.

Indoor percentage reductions from the propoxur, diazinon, and cyfluthrin treatments did not exceed 62% (Table 1) on weeks 1 and 4. In general, foraging activity increased inside of the houses treated 1 week after treatment as indicated by a mean percent reduction of -48.3% (±19.2 SD) and average counts per card per house which ranged from 24 to 70 (Table 2). On week 4 activity was lower, but still present.

Separate monitoring of Pharaoh ants indoors and outdoors reflected the effect of the exterior treatments on Pharaoh ant activity. Before treatments were applied, Pharaoh ant activity was more prevalent outdoors than indoors (Figs. 1-5). After treat-

TABLE 2. AVERAGE NUMBER OF PHARAOH ANTS PER MONITORING SITE LOCATED INDOORS AND OUTDOORS FROM HOUSES THAT RECEIVED EXTERIOR PERIMETER TREATMENTS ON 5 AUG. 1993, IN PORT RICHEY, FLORIDA.

| Treatment (AI) | N[1] | Location | Average (±SE) No. of Ants per Monitoring Site | | | |
|---|---|---|---|---|---|---|
| | | | Pretreat. | Week 1 | Week 4 | Week 8 |
| Contact granular bait (propoxur) | 2 | In | 35.3 | 24.5 | 40.4 | — |
| | | | (24.1) | (0.3) | (1.5) | |
| | | Out | 66.4 | 53.9 | 111.9 | — |
| | | | (30.9) | (10.9) | (14.4) | |
| | | In + Out | 52.5 | 40.9 | 77.2 | — |
| | | | (26.4) | (7.6) | (3.0) | |
| Granular contact insecticide (diazinon) | 2 | In | 30.0 | 45.1 | 21.6 | — |
| | | | (0.6) | (1.6) | (7.2) | |
| | | Out | 89.4 | 171.0 | 55.2 | — |
| | | | (58.3) | (120.4) | (1.6) | |
| | | In + Out | 60.6 | 106.1 | 39.2 | — |
| | | | (29.7) | (57.3) | (4.0) | |
| Residual spray (cyfluthrin) | 2 | In | 41.0 | 70.3 | 16.4 | — |
| | | | (3.2) | (32.0) | (10.1) | |
| | | Out | 74.5 | 48.5 | 96.0 | — |
| | | | (31.4) | (43.2) | (88.7) | |
| | | In + Out | 42.5 | 58.6 | 56.2 | — |
| | | | (19.2) | (36.8) | (49.4) | |
| Delayed-action granular bait (hydramethylnon) | 3 | In | 75.2 ns[2] | 0.0*[2] | 2.2 ns | 2.1* |
| | | | (47.1) | (0.0) | (2.2) | (2.0) |
| | | Out | 53.5 ns | 0.2* | 0.9* | 2.0* |
| | | | (17.4) | (0.2) | (0.9) | (1.2) |
| | | In + Out | 64.5 ns | 0.1* | 1.6* | 2.0* |
| | | | (32.7) | (0.1) | (1.6) | (1.2) |
| Control (corn grit) | 3 | In | 22.6 ns | 24.1* | 22.7 ns | 8.1* |
| | | | (5.6) | (6.8) | (10.6) | (0.7) |
| | | Out | 36.0 ns | 47.9* | 113.9* | 11.2* |
| | | | (15.3) | (24.0) | (10.0) | (2.2) |

[1]Number of houses sampled per treatment, 12 to 22 monitoring cards per indoor or outdoor location.

[2]Averages from the delayed-action granular bait and control treatments for the same sampling location and week that were significantly different ($P \leq 0.05$) by *t*-tests are followed by "*". Nonsignificant reductions are followed by "ns". When necessary, analyses were conducted on $\log_{10}(x + 1)$ and $\sqrt{(x + 0.5)}$ transformed data. Nontransformed averages are presented. Statistical tests were not conducted on the other treatments due to insufficient replication.

TABLE 2. (CONTINUED) AVERAGE NUMBER OF PHARAOH ANTS PER MONITORING SITE LOCATED INDOORS AND OUTDOORS FROM HOUSES THAT RECEIVED EXTERIOR PERIMETER TREATMENTS ON 5 AUG. 1993, IN PORT RICHEY, FLORIDA.

| Treatment (AI) | N[1] | Location | Average (±SE) No. of Ants per Monitoring Site | | | |
|---|---|---|---|---|---|---|
| | | | Pretreat. | Week 1 | Week 4 | Week 8 |
| | | In + Out | 29.3 ns<br>(9.8) | 36.1*<br>(15.5) | 69.0*<br>(3.1) | 9.6*<br>(1.5) |

[1]Number of houses sampled per treatment, 12 to 22 monitoring cards per indoor or outdoor location.

[2]Averages from the delayed-action granular bait and control treatments for the same sampling location and week that were significantly different ($P \leq 0.05$) by *t*-tests are followed by "*". Nonsignificant reductions are followed by "ns". When necessary, analyses were conducted on $\log_{10}(x + 1)$ and $\sqrt{(x + 0.5)}$ transformed data. Nontransformed averages are presented. Statistical tests were not conducted on the other treatments due to insufficient replication.

ments were applied, significant percentage reductions and average ant counts both indoors and outdoors were indicative of a reduction in Pharaoh ant populations. Over weeks 1 and 4 in the hydramethylnon treated houses, average indoor and outdoor percentage reductions were 63.1 (±66.3 SD) and 98.0 (±1.7 SD), respectively. On average, less than 3 ants were counted from either location (Table 2). In contrast, the control and diazinon treated houses had increased activity in both locations (Table 1), and counts averaged 52.2 (±42.8 SD) and 73.3 (±66.7 SD), respectively. Thus there was little or no control with the diazinon treatment. In the propoxur treatment, activity decreased 13% outdoors, but also increased 28% indoors one week after treatment and continued to increase indoors and outdoors on week 4 (Table 1). The average ant count for propoxur was 57.7 (±38.1 SD) (Table 2). For cyfluthrin, activity decreased by 51% outdoors but increased 67% indoors one week after application. This trend was reversed on week 4, with an outdoor percentage reduction of 4% and an indoor reduction of 62% (Table 1). A similar pattern was recorded with ant counts (Table 2). This suggested that Pharaoh ant activity in the propoxur and cyfluthrin treatments temporarily moved indoors.

Combining indoor and outdoor sampling sites allowed for evaluation of treatment effects on Pharaoh ant activity, regardless of sampling location. Over weeks 1 and 4, percentage reductions and counts of ants averaged -53.6% (±55.8 SD) and 59.1 (±26.7 SD) for propoxur; -29.3% (±56.6 SD) and 72.7 (±47.3 SD) for diazinon; 16.8% (±8.3 SD) and 57.4 (±1.7 SD) for cyfluthrin; and 94.5% (±6.7 SD) and 0.9 (±1.1 SD) for hydramethylnon. Average percentage reduction in the control was -102.0% (±116.3 SD) and 52.6 (±23.3 SD) ants per card.

Of the perimeter treatments that were applied, the hydramethylnon granular bait was the most effective. The delayed mortality caused by hydramethylnon makes it an ideal toxicant for ant control because it allows time for the toxicant to be spread throughout the colony (Stringer et al. 1964). While the perimeter application of cyfluthrin is often used to exclude arthropods from structures, it is not recommended for Pharaoh ant control because of the potential for causing colony fragmentation and movement if the entire colony is not treated. Our results concurred with this premise because there was an increase in ant counts indoors and a decrease outdoors in the cyfluthrin treated houses 1 week after treatment (Table 2). The diazinon granules and propoxur bait also were not effective. These treatments cause mortality on contact, and as a result only foraging ants would be exposed to the insecticide. Since foragers generally comprise less than 25% of the worker population in ant colonies (Porter &

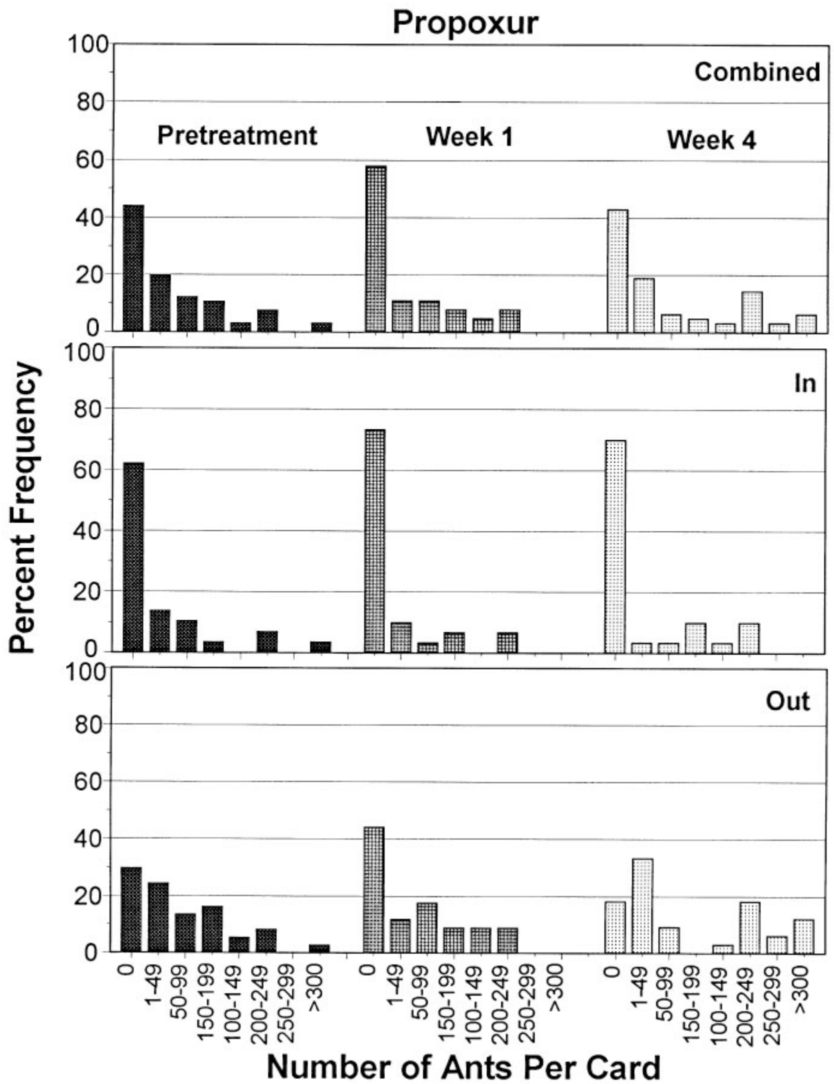


Figure 3. Percent frequency distributions of bait cards with Pharaoh ant counts grouped in intervals of 50 ants from the combined indoor plus outdoor, indoor only, and outdoor only sampling sites from houses treated with a bait containing a contact insecticide (propoxur).

Jorgensen 1981, K. M. V. unpublished data), most of the colony would not be treated. Instead of finding and directly treating or removing an entire colony, baiting with a delayed-action toxicant is probably the most practical method to control a structural infestation of Pharaoh ants.

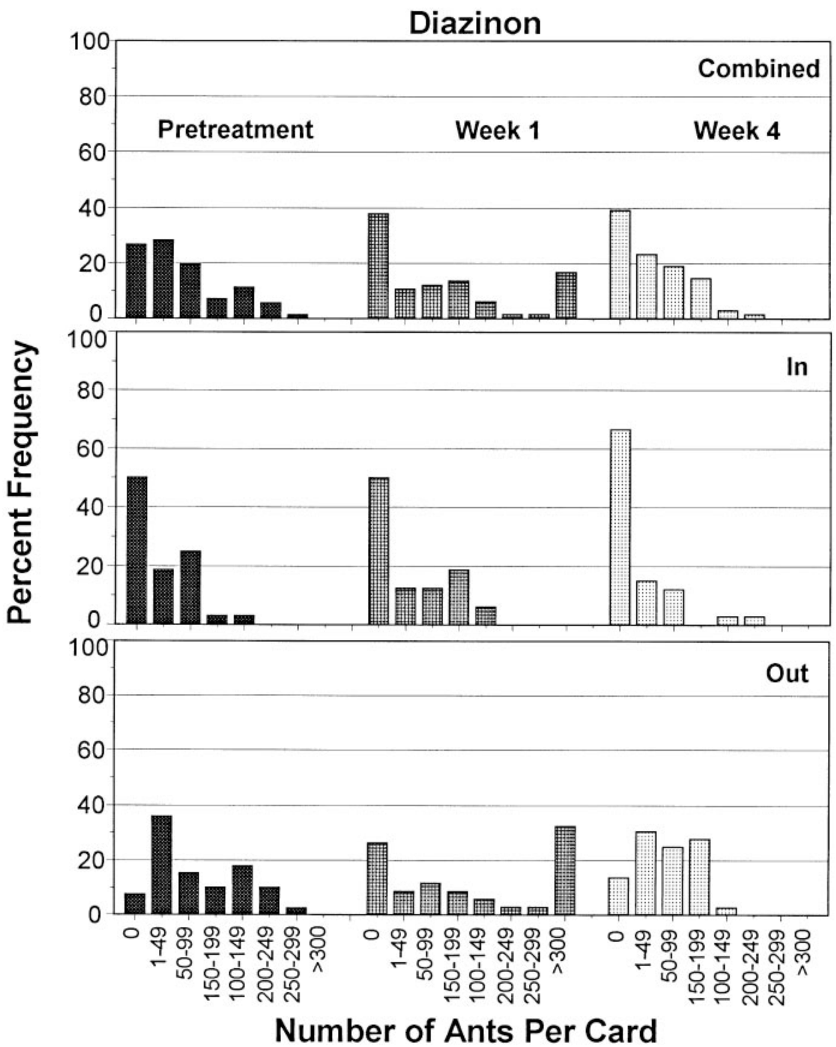


Figure 4. Percent frequency distributions of bait cards with Pharaoh ant counts grouped in intervals of 50 ants from the combined indoor plus outdoor, indoor only, and outdoor only sampling sites from houses treated with diazinon granules.

Most baits registered for use against Pharaoh ants are dispensed in containerized stations or are applied indoors in protected areas. Using baits outdoors has been effective in reducing Pharaoh ant populations (Haack 1991, Oi et al. 1994). Bait stations containing delayed-action toxicants placed along the perimeter of apartment buildings also were useful in reducing Argentine ant populations and complaints from residents (Forschler & Evans 1994). Stations provide protection and prolong the availability of baits to ants. They generally have been placed at specific distance intervals (Haack 1991, Forschler & Evans 1994) or at known, or potential, foraging sites

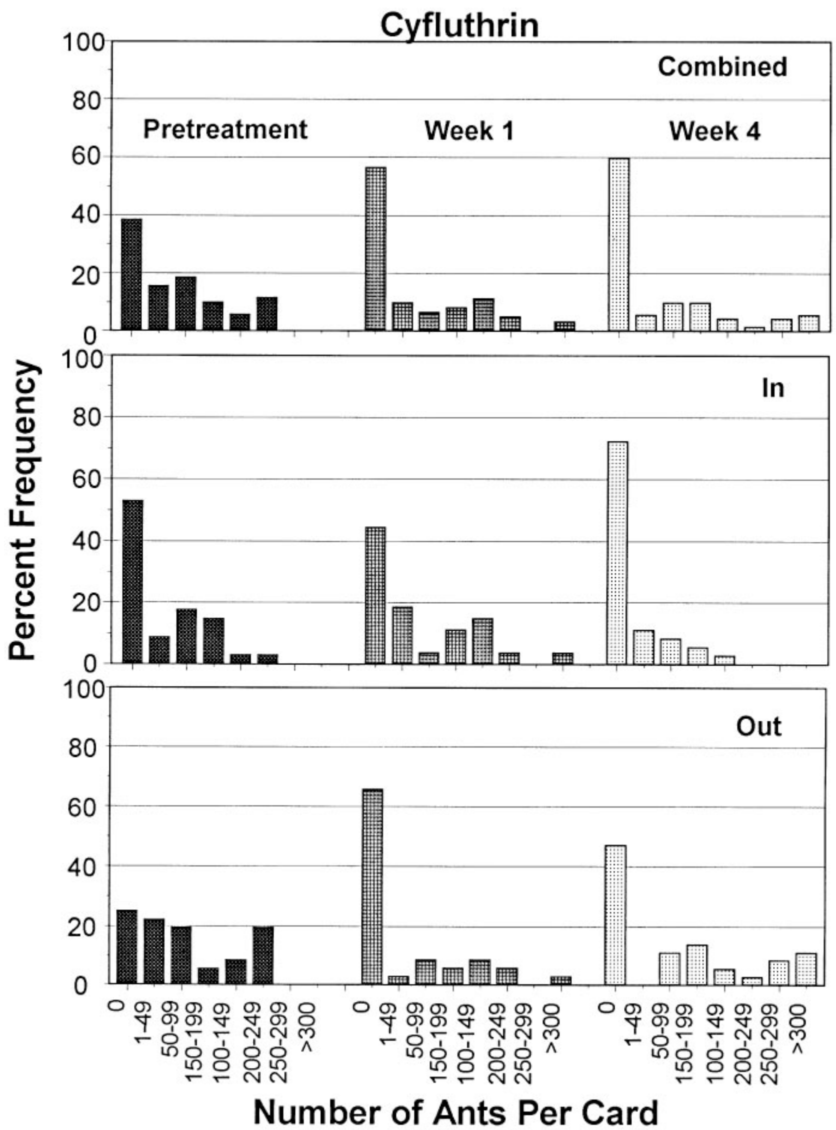


Figure 5. Percent frequency distributions of bait cards with Pharaoh ant counts grouped in intervals of 50 ants from the combined indoor plus outdoor, indoor only, and outdoor only sampling sites from houses treated with a residual spray (cyfluthrin).

(Oi et al. 1994). Application of a delayed toxicant bait formulation that could be scattered around the exterior periphery of a building would be easier to use than placing and removing bait stations. Since a scattered bait could be dispensed over a larger area, the probability that ants would find and forage on the bait should increase. Potential drawbacks of a scattered bait would be possible exposure to rain, which may make the bait unpalatable, photodegradation of the active ingredient (Vander Meer et al. 1982), and exposure to non-target organisms. However, if baits are applied when and where ants are actively foraging, these constraints should be minimized.

Among the various exterior perimeter treatments used in this study, only the bait treatment that contained a delayed-action toxicant provided Pharaoh ant control. Even though Pharaoh ant colonies were located inside structures, exterior foraging by these ants allowed application of this bait solely to the exterior periphery of houses to be an effective control method. Formulations that improve the convenience of using exterior perimeter baiting as a strategy for Pharaoh ant control could reduce the application of insecticides inside of buildings and homes.

## Acknowledgments

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