Control of a Natural Infestation of the Pharaoh Ant (Hymenoptera: Formicidae) with a Corn Grit Bait of Fenoxycarb

DAVID F. WILLIAMS AND KAREN M. VAIL

Medical and Veterinary Entomological Research Laboratory, USDA–ARS, Gainesville, FL 32604

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ABSTRACT The insect growth regulator fenoxycarb was very effective against a natural infestation of the Pharaoh ant, *Monomorium pharaonis* (L.). A large building (7,841 m^2) containing four separate wings was used to evaluate two concentrations of fenoxycarb (0.5 and 1%) in oil on a corn grit bait. Raid Max Ant Bait was used as a standard for comparative purposes. A separate wing was used for each treatment. One wing received no bait and functioned as a control. Our study demonstrated that 0.5% fenoxycarb in peanut butter oil was more effective than a 1% fenoxycarb bait and Raid Max Ant Bait; this treatment completely eliminated the ants <6 wk after treatment. Reinfestation in the 0.5% fenoxycarb-treated wing occurred 24 wk after treatment and only at two sites in the area treated. Although Raid Max eliminated the ants <6 wk after treatment, reinfestation occurred at 12 and 14 wk after treatment. Raid Max baits were applied again at 12 and 14 wk; no ants were detected in this wing after the 14-wk treatment.

KEY WORDS *Monomorium pharaonis*, Pharaoh ant, fenoxycarb

THE PHARAOH ANT, *Monomorium pharaonis* (L.), is found worldwide (Wheeler 1910) and is a major indoor pest in most parts of the world (Edwards 1986). Infestations are especially troublesome in large office buildings and apartment complexes, factories, food establishments, and hospitals (Edwards 1986).

Control strategies for *M. pharaonis* have included baits containing chlordecone (Beatson 1968), boric acid (Newton 1980), *Bacillis thuringiensis* (Vankova et al. 1975), chemosterilants (Berndt & Nitschmann 1977), and methoprene (Edwards 1975). Other strategies consisted of killing worker ants that had collected on baits (Bellevoye 1889, Riley 1889) and using pyrethrum (Lintner 1895) and inorganic and organic insecticides (Rogers & Herrick 1953, Morgan & Price 1954, Papworth 1958).

Because insecticidal sprays and dusts generally do not result in complete elimination of an infestation, using toxic baits is the control method of choice (Edwards 1986). Because sprays and dusts mainly affect foraging workers, the majority of the colony survives treatment (Edwards 1986). A single colony can contain many queens; this favors the survival of the colony if only a few queens are affected by a treatment. However, only a few workers and brood are needed to perpetuate a colony, i.e., as few as 5 workers and ≈50 pieces of brood (Vail & Williams, in press) can effectively start a new colony. Therefore, to eliminate a colony completely, a toxicant must be distributed to all members. Distribution can be accomplished by using a bait. In addition, *M. pharaonis* can relocate rapidly in a building without coming into contact with a spray or dust because their nests generally are found in interior walls and spaces.

Fenoxycarb (Ciba-Geigy, Greensboro, NC), an ethyl carbamate chemical that exhibits insect growth regulator (juvenile hormone) activity against several insects (Dorn et al. 1981, Masner et al. 1981, El-Gazzer et al. 1986), including the imported fire ant, *Solenopsis invicta* Buren (Banks et al. 1983), has shown excellent efficacy against laboratory colonies of *M. pharaonis* (Williams 1990, Williams & Vail 1993). In these laboratory studies, Pharaoh ant brood declined and egg production by queens ceased or was reduced when colonies were fed fenoxycarb in peanut butter oil. Our study was done to evaluate the efficacy of a corn grit carrier formulation of fenoxycarb in peanut butter oil for controlling a natural infestation of *M. pharaonis*.

Materials and Methods

The study was conducted in a Bachelor Officers' Quarters building at the U.S. Naval Air Station, Jacksonville, FL. The building (≈7,841 m^2) is a two-level structure built in 1948 and designed with four separate wings designated as

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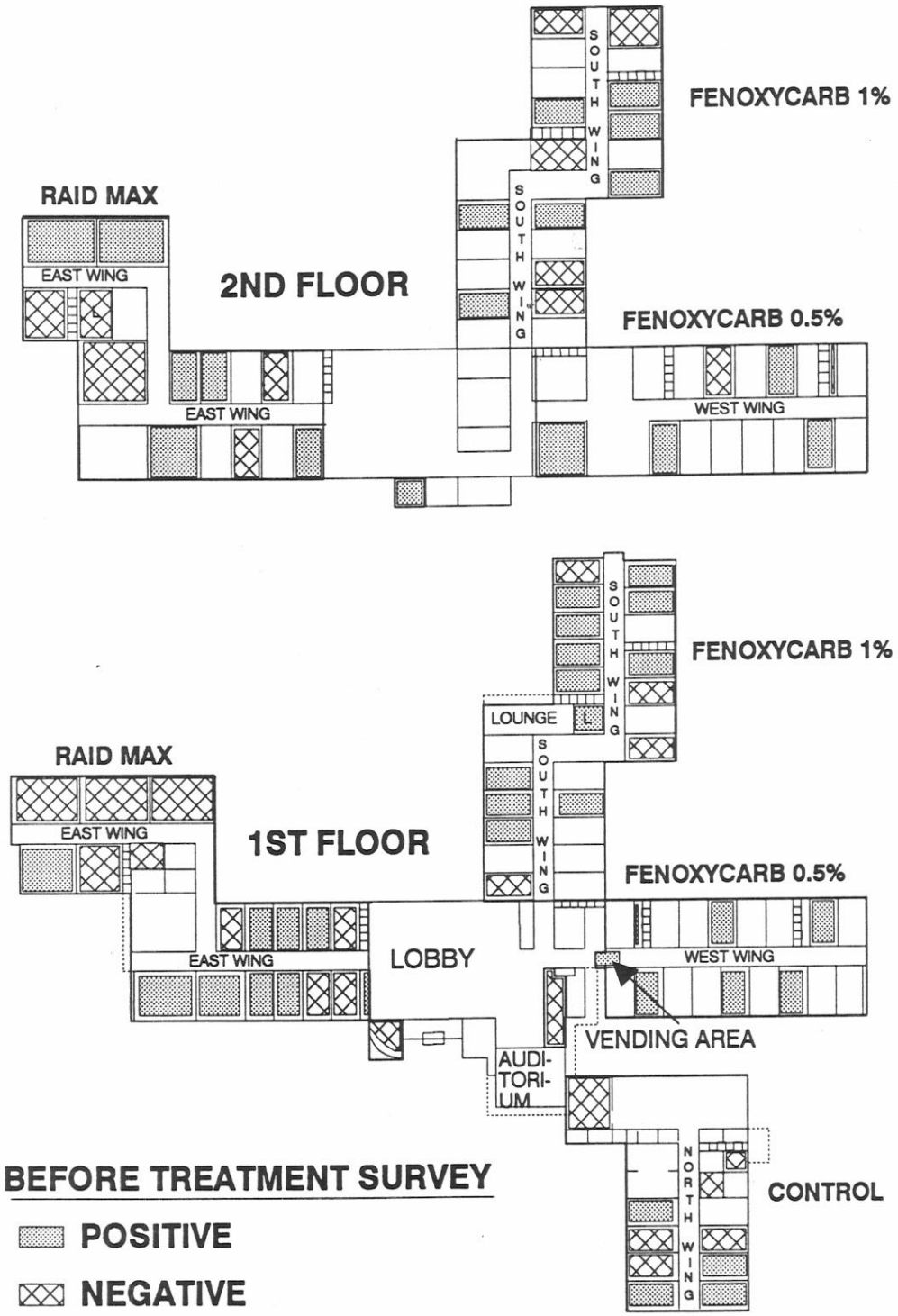

Fig. 1. Schematic of the Jacksonville Naval Air Station Bachelor Officers' Quarters, indicating results for the initial (before treatment) survey.

north, south, east, and west. Each wing was used for a separate treatment (Figs. 1–4). An initial (before treatment) survey of the *M. pharaonis* population was conducted by placing ≈1 g peanut butter on white index cards (3.8 by 6.4 cm) throughout rooms in the building. Survey cards were placed in 69% of the apartments (usually consisting of a living room, bathroom, and bed-

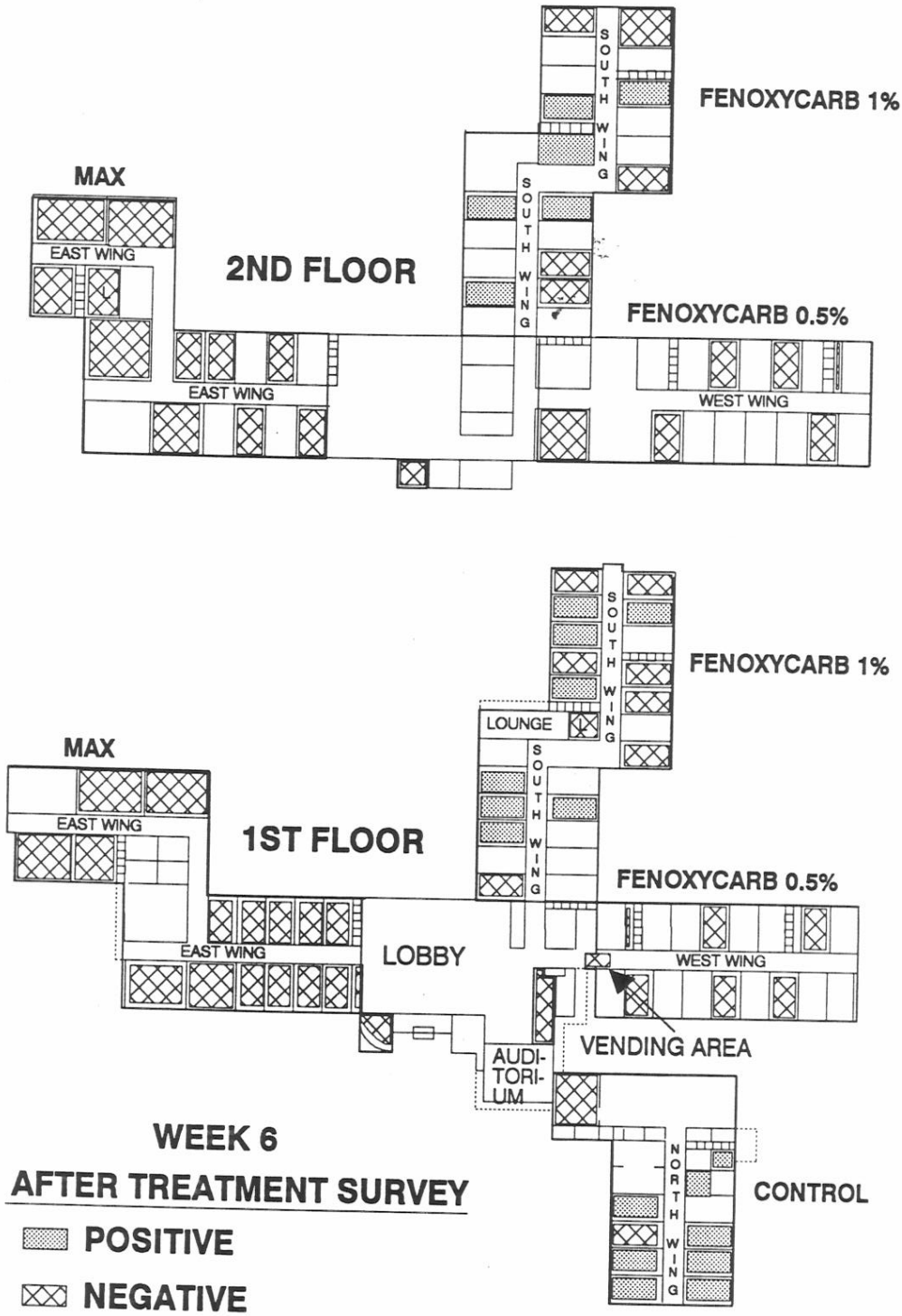

Fig. 2. Schematic of the Jacksonville Naval Air Station Bachelor Officers' Quarters, indicating survey results for 6 wk after treatment (no ants found in wings treated with 0.5% fenoxycarb and Raid Max Ant Bait).

room) and in other areas such as the lobby, kitchens, laundries, lounge areas, and offices. Normally, six cards were placed in each apartment (usually two in the living room, bathroom, and bedroom). The window sills were used for card locations in the living room and bedroom of each apartment. In the bathroom, both cards were placed on the floor under the sink and next to the

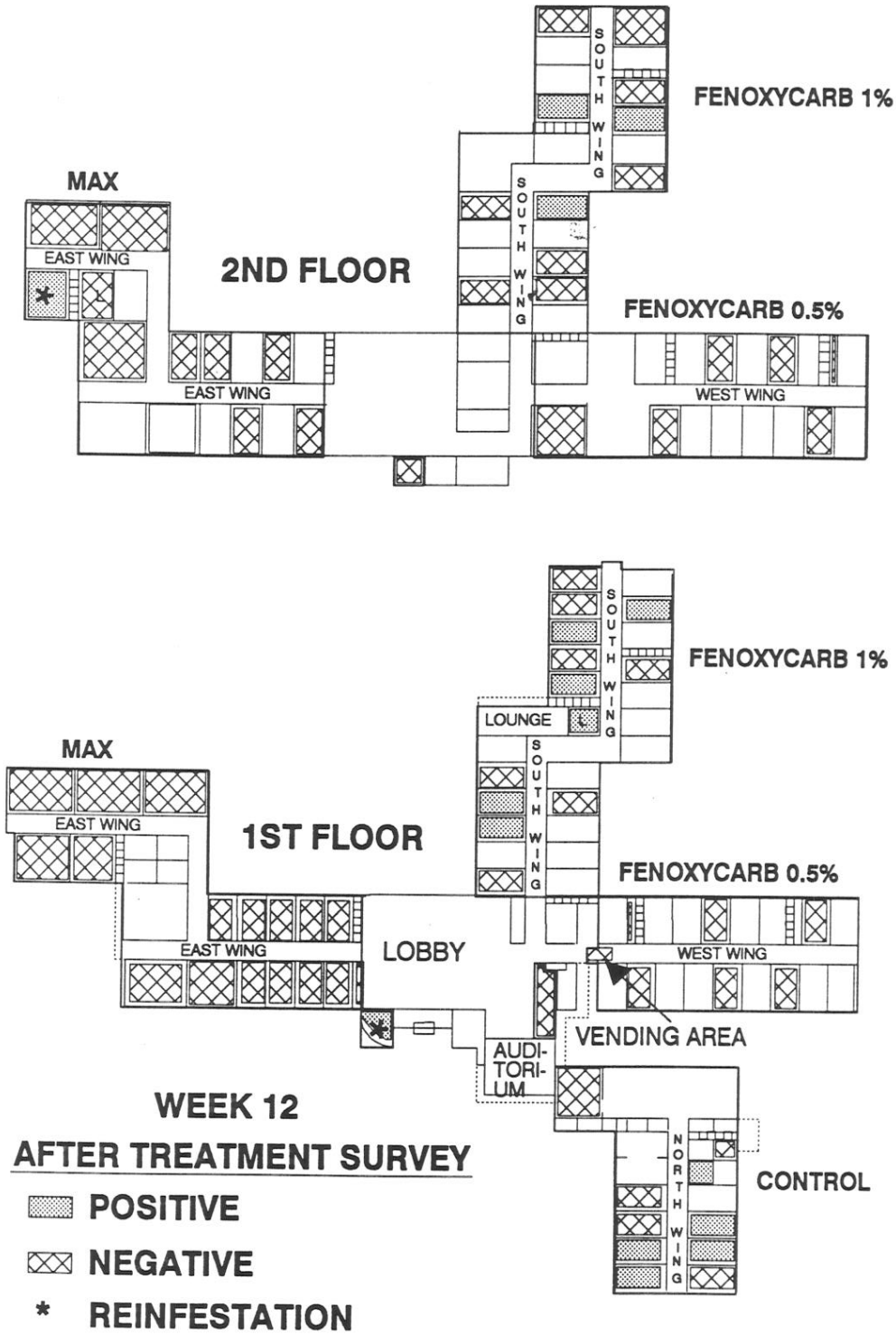

Fig. 3. Schematic of the Jacksonville Naval Air Station Bachelor Officers' Quarters, indicating survey results for 12 wk after treatment (reinfestation of the wing treated with Raid Max Ant Bait).

radiator pipes. All cards were placed between 1000 and 1200 hours and left undisturbed for 2–2.5 h, after which the number of worker ants on each card was counted and recorded. Immediately after the initial survey, all routine pest control treatments to the building were halted

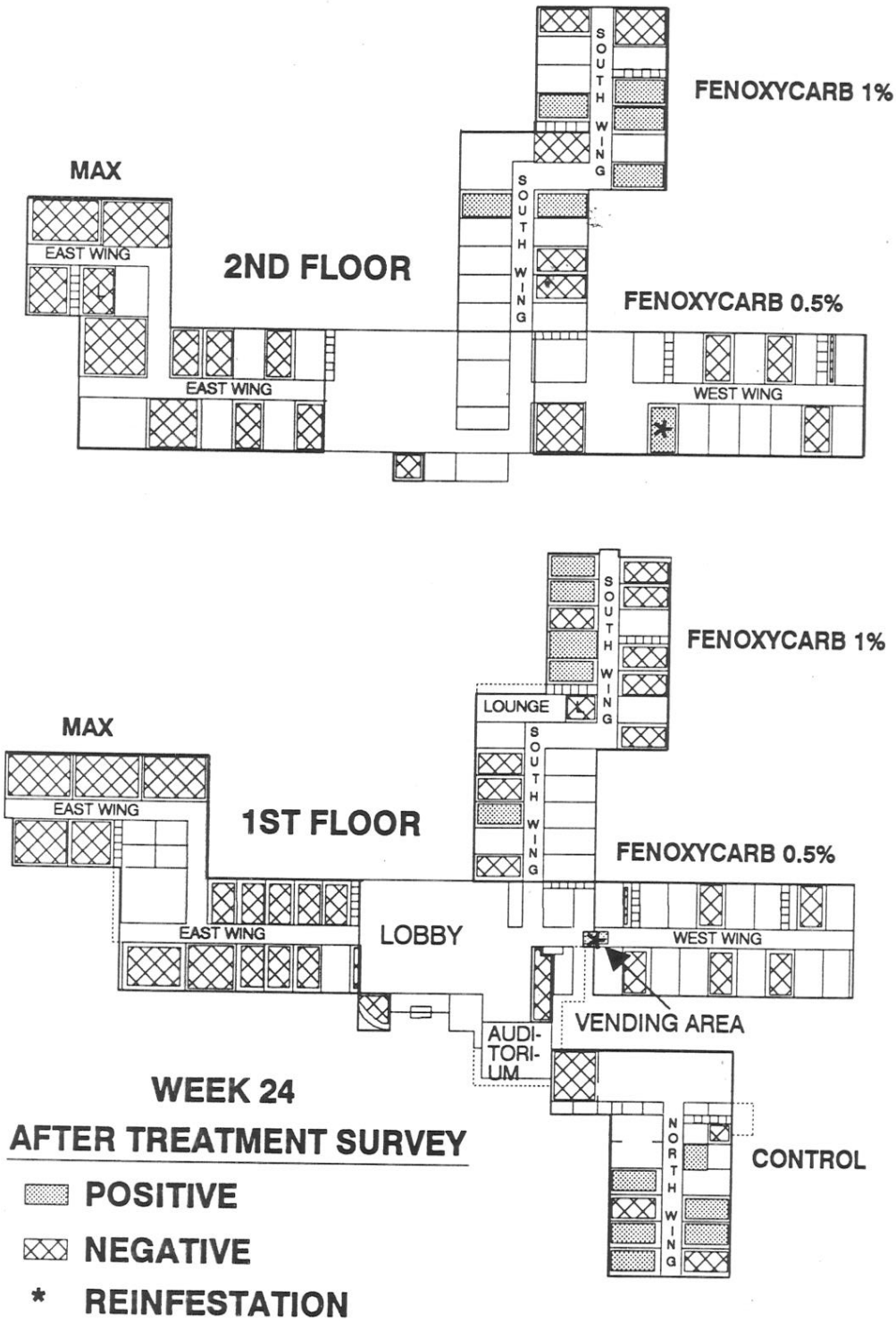

Fig. 4. Schematic of the Jacksonville Naval Air Station Bachelor Officers' Quarters, indicating survey results for 24 wk after treatment (reinfestation of the 0.5% fenoxycarb-treated wing).

for the duration of the study to prevent interference of the evaluations.

The three bait treatments were two levels of fenoxycarb (1.0 and 0.5% [wt:wt]) concentrations in peanut butter oil and were applied to a corn grit carrier (30% by weight) and a commercially available bait, Raid Max Ant Bait (S.C. Johnson & Son, Racine, WI), prepackaged in plastic bait

stations containing 0.5% AI of sulfluramid in 2 g of total bait. To test the concentration of fenoxycarb and not the amount of active ingredient, 2 g of the 0.5% bait and 1 g of the 1.0% bait were used.

Bait stations for the fenoxycarb treatments consisted of a round petri dish (50 mm diam by 9 mm height) with nine holes in the lid. After the baits were poured into the dish, the edges were sealed with a drop of methylene chloride. The 0.5% concentration was selected because of excellent results obtained in laboratory evaluations (Williams & Vail 1993). The 1.0% concentration of fenoxycarb, which was slightly less effective than the 0.25% concentration in laboratory evaluations, also was selected because it was already available in the commercial bait, Logic (CIBA-GEIGY, Greensboro, NC), used for fire ants.

Baits were applied to all apartments 1 wk after the initial survey. The applications were as follows: 1.0% fenoxycarb in the south wing (≈2,787 m^2 floor space), which contained 40 apartments (each apartment ≈49 m^2); 0.5% fenoxycarb in the west wing (≈2,040 m^2), which contained 32 apartments; Raid Max Ant Bait stations in the east wing (≈2,319 m^2), which contained 31 apartments; the north wing (≈412 m^2), which contained eight apartments, was used as an untreated control. The lobby, which served to separate the wings, was ≈258 m^2. Bait applications were made once per week for 2 wk. Baits were removed 1 wk after application. Three baits were placed per apartment. The window sills were used for baits in the living room and bedroom. The third bait was placed on the floor of the bathroom by the radiator pipes. Baits were also placed in the lounges, laundries, and offices.

Treatment efficacy was determined by comparing the worker ant population (mean number of ants per card per room) of the wings. Surveys using peanut butter on index cards were done at 2, 4, 6, 8, 12, 14, 16, 20, and 24 wk after the second treatment. Survey cards were placed in the same locations as the initial survey cards. Two additional bait treatments with the Raid Max Ant Bait stations were applied at 12 and 14 wk to the east wing because of a small reinfestation.

Mean number of ants per card per room was the dependent variable used in the general linear models (GLM) analysis (SAS Institute 1988). We are aware that the ant populations in one room may not be independent of ant populations in the nearby rooms. In fact, one wing may represent one supercolony (workers move freely from one nest to another). However, we are fairly confident that treatments of fenoxycarb, Raid Max, and control were applied to separate populations as indicated in the Results and Discussion section. The Ryan-Einot-Gabriel-Welsch Q test (SAS Institute 1988) was used for separation of means at $P = 0.05$.

Results and Discussion

The Pharaoh ant infestation was extensive, as indicated in the initial (before treatment) survey results (Fig. 1). Pharaoh ants were found in >75% of the rooms surveyed. The mean number of ants per card per room was not significantly different in any of the treatments before the baits were applied (Table 1). The results indicated that 0.5% fenoxycarb in peanut butter oil applied to an extruded corn grit gave the best control, eliminating all ants within 6 wk after treatment (Fig. 2; Table 1). Reinfestation occurred at 24 wk after bait application (Fig. 4) and then only at two sites in the treated area. These sites were close to the south wing and near or in the vending-machine area (Fig. 4). Studies of Pharaoh ant foraging at the site have indicated a maximum foraging distance of 45 m and a mean foraging distance of 16.2 m (Vail & Williams, in press), which indicated that Pharaoh ants were capable of reinfesting the 0.5% treated wing from the south wing. Ants may have also been introduced from infested candy and other products in the vending machines. It is unlikely that ants from the north wing (control wing) infested the west wing or any of the other wings because ants were never detected in the western portion of the lobby where the north wing is attached to the rest of the building. In addition, an auditorium separated the living quarters of the control wing (where high numbers of ants were found) from the rest of the building (Figs. 1–4).

The treatment using 1.0% fenoxycarb, although not as effective as the 0.5% treatment (Figs. 2–4; Table 1), was significantly different from the control for all dates except for the initial survey and 12 and 14 wk after bait application (Fig. 3; Table 1). The difference between the two fenoxycarb concentrations appeared to be related to an antifeedant effect of the higher concentration because fewer Pharaoh ant workers fed on the 1% baits compared with lower concentrations of fenoxycarb baits in the laboratory (Williams & Vail 1993).

Although Raid Max reduced ant numbers more quickly than the other treatments (Table 1), complete reduction did not occur until week 6. However, ants were detected in this treatment during weeks 12 (Fig. 3) and 14. At this time, more Raid Max baits were applied. No ants were found in this wing after week 14. The reappearance of Pharaoh ants in the east wing may have occurred because stomach poisons work quickly (faster than IGRs) and the workers feeding on the Raid Max Ant Bait may have died before distributing the insecticide to the entire colony. Therefore, some queens or brood and a few workers may have survived, allowing the worker force to increase to a level that was detectable with our monitoring technique at week 12.

Table 1. Mean number of Pharaoh ants per card per room for each treatment

Treatment	No. ants/card/room, $\bar{x}$ ± SEM[a]			
Week	0	2	4	6
Control	33.3 ± 14.43	76.9 ± 30.5a	120.6 ± 48.07a	134.2 ± 43.81a
0.5% Fenoxycarb	30.8 ± 11.76	8.8 ± 3.47b	8.4 ± 7.42b	0.0 ± 0.00b
1.0% Fenoxycarb	16.9 ± 3.48	8.6 ± 2.43b	19.7 ± 5.96b	18.0 ± 4.81b
Raid Max Ant Bait	14.3 ± 3.71	0.2 ± 0.18b	2.8 ± 2.78b	0.0 ± 0.00b
df	3, 76	3, 73	3, 62	3, 74
F	1.92	14:26	10.4	21.66
P	0.1327	0.0001	0.0001	0.0001
Week	8	12	14	16
Control	136.7 ± 48.69a	14.6 ± 8.05a	4.8 ± 4.71a	78.2 ± 23.30a
0.5% Fenoxycarb	0.0 ± 0.00b	0.0 ± 0.00b	0.0 ± 0.00a	0.0 ± 0.00b
1.0% Fenoxycarb	9.9 ± 4.24b	5.8 ± 2.24ab	6.9 ± 2.02a	7.0 ± 2.43b
Raid Max Ant Bait	0.0 ± 0.00b	3.1 ± 3.03ab	0.1 ± 0.06a	0.0 ± 0.00b
df	3, 74	3, 72	3, 76	3, 74
F	18.57	1.98	4.62	26.8
P	0.0001	0.1246	0.0051	0.0001
Week	20	24		
Control	37.6 ± 24.81a	63.1 ± 23.69a		
0.5% Fenoxycarb	0.0 ± 0.00b	0.7 ± 0.50b		
1.0% Fenoxycarb	0.9 ± 0.60b	6.0 ± 2.17b		
Raid Max Ant Bait	0.0 ± 0.00b	0.0 ± 0.00b		
df	3, 74	3, 73		
F	6.14	16.8		
P	0.0009	0.0001		

[a] Within a column, means followed by the same letter are not significantly different ($P > 0.05$; Ryan-Einot-Gabriel-Welsch Q test [SAS Institute 1988]).

The control population increased through the first 8 wk; however, a dramatic decline was evident at 12 and 14 wk. Although we have no evidence to explain such a decline, the following scenario seems plausible. As the populations continued to escalate, residents became unnerved by the high numbers of ants present in their rooms and sprayed an over-the-counter insecticide in an attempt to control the ants. This would explain the decline followed by an increase in numbers of ants because only foragers would be killed by the contact insecticide and the number of ants would soon increase as new workers eclosed.

Edwards & Clark (1978) reported control of the Pharaoh ant with the IGR methoprene in a 15,236-m^2 hospital; Wilson & Booth (1981) reported control of this species using methoprene in a 21,030-m^2 hospital. Although the facility we used to evaluate fenoxycarb for the control of the Pharaoh ant was not as large, our results indicate that fenoxycarb formulated in a bait can control a large infestation of the Pharaoh ant. The most effective concentration in peanut butter oil was 0.5%. Higher concentrations evaluated in the laboratory were repellent; however, concentrations <0.5% (such as 0.25%) were not tested in the field and may provide as good as or better control than 0.5%. Only additional studies can determine this supposition.

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