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Alternative Control Strategies for Ants Around Homes[1]

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ABSTRACT Recent research in urban ant control provides some new opportunities for developing alternative pest management strategies. Current control of urban pest ants relies heavily on broadcast spraying of residual insecticides. However, recent findings suggest that a combination of ant repellents, baits, and exclusion techniques may be equally effective and offer a safer alternative. Low-toxicity pesticides and nonchemical methods would significantly reduce the risk of exposure to pesticides, as well as serve as a model for ant control based on an environmentally safe approach.

KEY WORDS Ant repellents, ant baits, IGRs, boric acid, nonchemical pest control

These are challenging times for research and development of innovative techniques in the management of household pests, particularly with regard to strategies that reduce risk of pesticide exposure. A trend toward the use of low-toxicity pest control continues into the 21st century. Consequently, we are looking at more judicious use of pesticides in the future through precise, target-specific treatments. In this spirit of low-toxicity pest control, we address some breakthroughs in ant control research that may offer alternative strategies for controlling ants around homes.

In a recent national survey in the United States, ants were considered by homeowners to be a more serious household pest than cockroaches (Whitmore et al. 1992). To control ants, many pest control operators rely heavily on insecticide sprays (Klotz et al. 1995). For example, barrier sprays or perimeter treatments have been and are currently a common method of ant control (Haack & Granovsky 1990). As a result, as much as 10 gallons of insecticide solution is sometimes applied per 1,000 ft^2 around a structure to prevent the entry of ants. Such a strategy does not eliminate or suppress ants but is intended to form a barrier to prevent access into a structure. Achieving this end is difficult because any small gaps or breaks in the barrier are potential passageways. In addition, perimeter sprays are usually broad-spectrum

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insecticides that kill many of the beneficial insects present around homes and may result in secondary pest outbreaks (Smith et al. 1996).

In contrast to the traditional approach of using sprays, there is a resurgence in the use of baits for controlling ants. Baits are fairly target specific and use ess insecticide. In comparison with chemical barriers, baits offer distinct advantages. First, very little insecticide is required, and the toxicant can be contained within a bait station. Consequently, baits are safer for the environment than a chemical barrier. Second, baits eliminate the necessity of finding the nest, usually a labor-intensive procedure because of the cryptic nesting habits of many pest ants. And third, baits capitalize on the social behavior of ants, whereby scout ants recruit nestmates to a newly discovered bait, and these recruited ants return to a nest to share the bait with the rest of the colony.

The objective of this paper is to summarize our research results on barrier treatments, bait development, and nonchemical techniques in light of their potential use as alternative strategies for ant control. First, we address a possible alternative to broad-spectrum insecticides—using ant repellents formulated for barrier or perimeter sprays. Second, we describe our research on low-toxicity bait toxicants for ant control. And third, we briefly discuss some nonchemical methods for ant control, such as exclusion. Although labor-intensive, we believe these nonchemical techniques could be as effective as chemical control.

Ant repellents. Chemical signals dominate the communication systems of social insects such as ants (Wilson 1971). For example, the Argentine ant, *Linepithema humile* (Mayr) (= *Iridomyrmex humilis*), produces a trail pheromone from the sternal gland (Wilson & Pavan 1959). Over evolutionary time, ants, other insects, and plants have developed chemical methods of defending themselves against ant attack (Hölldobler & Wilson 1990). We may be able to exploit these same chemical defenses in management of pest ants. Progress in the use of repellents in pest ant management has gone farthest in agriculture, where research has focused primarily on plant protection (Shorey et al. 1992, 1993, 1996). For example, repellents applied in a band around the trunks of citrus trees can prevent Argentine ants from tending honeydew-producing homopterans. Candidate chemicals are placed on cotton twine or rubber tubing and then wrapped around tree trunks; the number of ants crossing this potential barrier is counted to evaluate a compound's repellency (Shorey et al. 1992). In Table 1 the efficacy of the repellent farnesol with the barrier Stickem is evaluated against a Lorsban (chorpyrifos) spray. Farnesol-Stickem remains effective as a barrier for 5 mo. Other carriers for repellents have been investigated, but the best so far has been Stickem Special (Seabright, Emeryville, California), which shows some repellency of its own (Table 1) (Shorey et al., unpublished data).

To identify potential repellents, food sources may be set out in a laboratory foraging arena and surrounded by each chemical compound to be evaluated as barriers to foraging ants (Shorey et al. 1996). In this type of assay, farnesol provides an effective barrier against Argentine ants.

Repellents may have a place in urban settings for management of ants in orchard or shade trees around homes, and in sensitive areas such as hospitals,

Table 1. Mean number[a] (95% confidence interval) of Argentine ants per minute climbing lemon trees in Ventura County, California (1994).

Treatment[b]	April	May	July	Sept.
Franesol-Stickem band	0	0	1 (0–[illegible])	0
Stickem-only band	1 (0–3)	6 (2–14)	5 (2–[illegible])	2 (0–8)
Lorsban-boom (broadcast spray)	1 (0–3)	1 (0–3)	8 (2–[illegible])	4 (1–13)
Lorsban-back pack (trunk + 2-m radius on soil surface spray	0	0	1 (0–[illegible])	6 (1–21)
Untreated	21 (7–57)	23 (11–45)	5 (2–12)	59 (52–67)

[a]Original data were transformed to In(x+1) for analysis and determination of 95% confidence intervals. Numbers presented here are transformed back to the original scale.
[b]Six replicates, 25 trees/plot (≈0.10 ha each). Each tree observed for 2 min at each sampling date, counting numbers of ants proceeding both up and down. Data from Shorey, H. H., R. G. Gerber & P. A. Phillips, unpublished.

animal rearing facilities, computer equipment, vending machines, and food processing and storage facilities. If repellents could be formulated in sprays for perimeter treatments, they would be an ideal way to pestproof homes prone to ant infestation. Or, used in concert with baits, repellents might alleviate the immediate problem of ants entering a house while allowing time for slower-acting baits to take effect on the outside.

Low-toxicity baits—Insect growth regulators (IGRs) and boric acid

A bait consists of four components (Cherrett & Lewis 1974): an attractant, usually a food or pheromone that enhances the probability that the bait will be accepted and readily picked up (Peregrine 1973); a palatable carrier that gives the physical structure or matrix to the bait; a toxicant that should be nonrepellent and delayed in action, effective over at least a 10-fold dosage range (Stringer et al. 1964); and other materials added for reasons of formulation, such as emulsifiers or antimicrobial agents. Each of these components must be developed and tested in combination for efficacy.

This manuscript focuses on the toxicant component of a bait and discusses low-toxicity alternatives for controlling ants by examining two compounds that have potential in this respect.

Insect growth regulators. Juvenile hormone analogs (juvenoids) and chitin synthesis inhibitors have low mammalian toxicity (Staal 1975) and have been used effectively in ant control. Their current use is focused primarily on control of the red imported fire ant, *Solenopsis invicta* Buren. The use of IGRs should be expanded to include other urban pest ants, such as has been done with methoprene against Pharaoh ants, *Monomorium pharaonis* (L.) (Edwards 1986). Methoprene was available for commercial use for Pharaoh ant control but is no longer marketed.

Contrary to popular belief, IGRs are just as effective as metabolic inhibitors (Williams 1994). In field tests with fire ants, the juvenoids fenoxycarb and pyriproxyfen and the chitin synthesis inhibitor teflubenzuron were compared with the metabolic inhibitors hydramethylnon and sulfluramid, and the reduction in the population index after 6–10 wk was similar for all five compounds (Table 2).

More recent work in the laboratory has shown similar success with IGRs for control of Pharaoh ants (Williams & Vail 1993, Vail & Williams 1995). Large colonies were exposed to 0.5% fenoxycarb, methoprene, or pyriproxyfen. In comparison with the control, all of these IGRs had a significant impact on worker numbers. As in the field studies with fire ants, after 6 wk the colonies exposed to fenoxycarb and pyriproxyfen showed significant reduction in worker numbers. Methoprene took a little longer to show effects.

In field tests with concentrations of pryriproxyfen (0.25%, 0.5%, and 1.0%) at housing complexes infested with Pharaoh ants, significant reductions in foraging ants were attained (Vail et al. 1996). All concentrations reduced the foraging population almost to zero after 12 wk. In fact, the 0.25% pyriproxyfen treatment reduced foraging population 85.5% by 2.5 wk after the second treatment.

Insect growth regulators affect various stages in an ant's life cycle (Banks 1990). In the case of pyriproxyfen against Pharaoh ants, it interferes with larval and pupal development, the reproductive physiology of the queen, and has a possible toxic effect on adult ants (Vail & Williams 1995).

Insect growth regulators could be important tools in an urban pest management strategy: used first in a baiting program to penetrate the entire colony and then followed by faster-acting insecticides or baits to reduce the immediate problem of foraging ants (Vail et al. 1996).

David H. Oi (Auburn University, personal communication) discovered in laboratory tests that metabolic inhibitors were not spread as widely into a population as IGRs. In controlling a Pharaoh ant colony with multiple nests, a bait with a metabolic inhibitor usually affects only the nests closest to the bait, whereas a bait with an IGR eventually eliminated all of the nests.

Boric acid. Boric acid is another bait toxicant that, at low doses, has low mammalian toxicity (Quarles 1992) and exhibits delayed action (Klotz & Moss 1996). Boric acid has been used in ant baits for over 100 yr (Quarles 1993, Riley 1889, Rust 1986), but our research indicates that it has probably been misused (Klotz et al. 1997). For example, doses of ≥5% boric acid are common in currently used ant baits. Our research has shown that at low doses (≤1%), boric acid shows delayed toxicity (Table 3) whereas higher doses (≥5%) are faster acting but not as readily consumed (Fig. 1). Here is a classic case of "less is better" in pest control.

Baits shift the emphasis in pest control from a treatment strategy based on applying gallons of pesticide solutions to make an impervious barrier to a strategy that exploits the social behavior of the insect to effect control.

Table 2. Field efficacy of bait toxicants against *Solenopsis invicta*.

Chemical[a]	Mode of action[b]	Active ingredient (g/ha)	% Reduction in population index after weeks indicated[c] 6–10	>20
Fenoxycarb	IGR	6.2–25.1	94	92
Hydramethylnon	MI	4.2–10.4	86	79
Pyriproxyfen	IGR	5.3–24.5	83	87
Sulfuramid	MI	6.7–10.1	93	79
Teflubenzuron	IGR	0.051–0.2	77	–[d]

[a]All baits were formulated in a soybean oil-pregel defatted corn grit mixture containing the active ingredient.
[b]MI, metabolic inhibitor; IGR, insect growth regulator.
[c]See Lofgren & Williams (1982) for an explanation of the method of determining the population index. Percentages are means of the population index.
[d]Data not recorded for this period. Data from D. F. Williams (1994).

However, a control program for household pests should not rely on only one strategy such as baits but also should be supplemented with nonchemical techniques.

An effective nonchemical technique for ant control is pest-proofing or exclusion, i.e., finding out where the ants are getting into a structure and then sealing that point of entry. In their natural habitat, foraging ants prefer to follow preexisting edges and other structural features in the environment to and from their nest (Klotz & Reid 1992). This natural behavior predisposes ants to travel along the structural guidelines that are provided in the urban environment, such as wires, pipes, and conduits. Therefore, an effective strategy for preventing ant entry should include pest-proofing the points where utility lines enter a structure.

Guideline orientation also has important implications for chemical control strategies. Insecticides should be applied along guidelines to optimize their efficacy as well as to reduce the amount used. Dust is an excellent formulation for this purpose. Ants readily pick up dusts that are lightly applied to their trailways. Ideally, dusts should be applied during construction when there is easy access to wall voids. They also can be applied for remedial treatment by using a power duster (Hansen & Akre 1993). In this technique, all of the switch plates within a structure are removed and dust is then injected behind the switch boxes with a power duster to spread both laterally and vertically in the wall voids. This procedure thoroughly treats all the utility lines in the void space that the ants could use as runways.

Table 3. The LT_{50}s of *Camponotus floridanus* (Buckley) workers fed boric acid bait.

Conc. molar (%)	LT_{50} (95% CL) days	Slope ± SE	No. of ants	Chi square	*P*
0.02 (0.13)	9.7 (8.1–13.3)	2.87 (± 0.47)	110	7.3	0.06
0.04 (0.25)	4.5 (4.3–4.8)	5.26 (± 0.38)	110	9.7	0.08
0.06 (0.38)	5.1 (4.8–5.5)	3.90 (± 0.32)	110	7.5	0.19
0.08 (0.50)	4.2 (3.9–4.5)	3.80 (± 0.28)	110	10.8	0.06
0.10 (0.63)	3.1 (2.8–3.3)	3.54 (± 0.24)	110	8.3	0.08
0.15 (0.94)	3.3 (3.0–3.5)	3.62 (± 0.30)	70	7.1	0.21
0.20 (1.25)	2.8 (2.5–3.0)	2.71 (± 0.20)	110	7.5	0.18
0.25 (1.56)	2.5 (2.3–2.7)	3.62 (± 0.27)	80	3.2	0.67
0.30 (1.88)	3.1 (2.8–3.4)	2.67 (± 0.22)	90	0.7	0.98
0.35 (2.19)	2.4 (2.1–2.6)	3.21 (± 0.25)	80	10.0	0.08
0.50 (3.13)	1.5 (1.2–1.7)	2.83 (± 0.31)	60	2.4	0.67

Data from Klotz & Moss (1996).

Future development of alternative strategies for household ant control depends on the commitment of both industry and academia to support research on innovative techniques that would significantly reduce the risk of exposure to pesticides and offer an environmentally safe alternative for ant control.

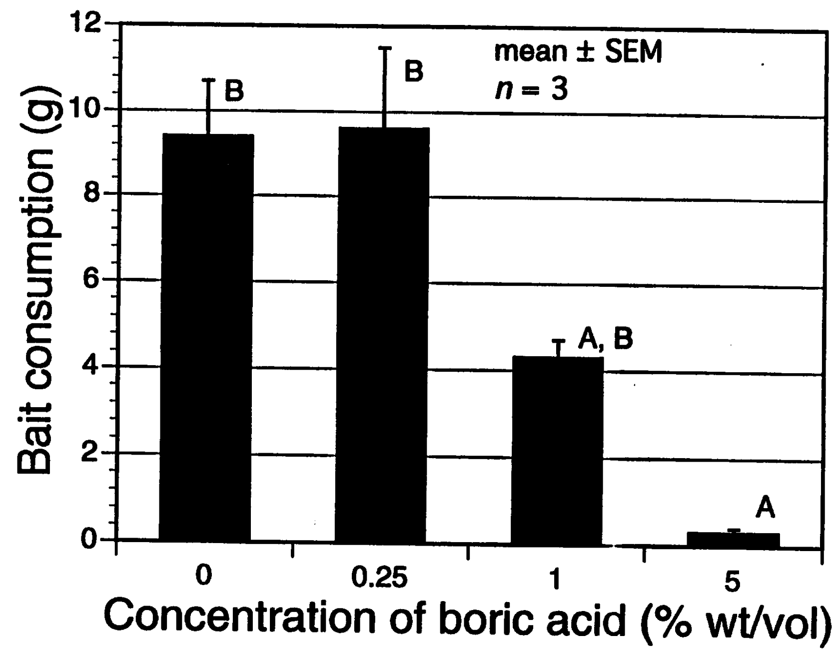

Fig. 1. Consumption of boric acid in 10% sucrose-water solutions by *S. invicta* colonies in 24 h. Consumption was significantly different by ANOVA ($F = 14.7$; df = 3, 8; $P = 0.0013$) for the various concentrations of boric acid. Means followed by the same letter are not significantly different ($P \le 0.05$; Scheffe's F test). Data from Klotz et al. (1997).

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