# Rate of Removal of Fenoxycarb (Logic®) Fire Ant Bait by Red Imported Fire Ants (Hymenoptera: Formicidae) from Treated Pastures[1]

J. Scott Ferguson, Alan J. Hosmer[2] and Michael E. Green

Ciba Corporation
7145 58th Avenue
Vero Beach, FL 32967 U.S.A.

J. Entomol. Sci. 31(1): 20-32 (January 1996)

**ABSTRACT** Field studies were conducted in Vero Beach, FL, in November 1993 and 1994 to determine the rate of removal of Logic® fire ant bait by red imported fire ants, *Solenopsis invicta* Buren, from treated improved pastures of bahiagrass, *Paspalum notatum* Fluegge. Logic® fire ant bait was applied at the maximum label rate of 1.68 kg/ha (16.8 g ai/ha). In 1993, fire ants had removed approximately 35% of the granules by 4 h after application and about 67% by 12 h. By 24 h, 82% had been removed. By the last count (48 h after application) about 95% had been removed. In 1994, the granules were removed slightly faster, with about 60% removed by 4 h and 92% by 24 h after application. Nearly 97% of the granules had been removed by the last count (30 h after application). In 1993, several mounds of the ant, *Dorymyrmex bureni* Trager, were found in the test area while in 1994 only red imported fire ant mounds were present. The results indicate that Logic® fire ant bait is found and harvested very rapidly by fire ant workers under favorable foraging conditions and that a dose which will provide effective population reduction can be obtained in 12 to 24 h after application at 1.68 kg/ha. Additionally, with its low use rate, specificity to certain insects and rapid removal by fire ants, Logic® fire ant bait when used according to label poses minimal risk to non-target organisms.

**KEY WORDS** Red imported fire ants, *Solenopsis invicta*, Logic® fire ant bait, fenoxycarb, foraging

The red imported fire ant, *Solenopsis invicta* Buren, was introduced into the United States over 50 years ago at Mobile, AL (Lofgren et al. 1975). Since then it has spread throughout the southern states from Texas to Florida and now occupies almost the entire southeastern United States (Porter 1993). Generally, red imported fire ants become one of the dominant ant species in infested areas (Wilson et al. 1971). In addition to being a threat to agriculture and livestock (Apperson and Adams 1983), humans are affected by the stinging and biting behavior of fire ants (Drees and Vinson 1991). The increasing incidence of the polygynous form raises the potential for greater economic and environmental damage resulting from mound densities that are two to three times larger than

[1] Accepted for publication 26 July 1995.
[2] Address: Ciba Corporation, 410 Swing Road, Greensboro, NC 27409.

those of the monogyne form (Porter 1992, 1993). Due to their ability to sting repeatedly and attack in large numbers, it is often justified to control or maintain fire ant population density at tolerable levels, especially in high use areas such as parks and yards. For fire ant control over large areas the most economically feasible and environmentally least damaging treatment is the use of toxic baits (Williams 1983). Such baits, composed of a liquid food attractant and a soluble toxicant incorporated or sprayed onto a granular carrier, have been used for fire ant control since 1962 (Lofgren et al. 1975). Effective fire ant control with such baits is dependent upon the toxicant having sufficient delayed toxicity to allow time for the worker ants to harvest the bait and distribute it via trophallaxis to other colony members (Stringer et al. 1964). Death of the colony is contingent upon death of the queen (Lofgren and Williams 1982).

Fenoxycarb (Logic®, Ciba Corporation, Greensboro, NC) is a chemical with a carbamate moiety that exhibits insect growth regulator activity against a variety of insects, including red imported fire ants (Banks et al. 1988). Unlike the N-ethyl and N-methyl carbamates, fenoxycarb does not inhibit cholinesterase. Banks et al. (1983) found that fenoxycarb caused alteration in egg laying and brood development, eventually leading to death in most treated colonies. In further studies, Banks et al. (1988) determined that the reduction in colony size with fenoxycarb treatment was due to: (1) lethality to developing immatures, (2) inhibition of egg production by the queen, and (3) a shift in caste differentiation from worker to sexual forms. In their field studies, Banks et al. (1988) reported that fenoxycarb eliminated approximately 60% of the colonies and reduced total ant population indices by 67 to 99% within 12 to 13 wks after treatment. In another field study, Williams et al. (1991) reported 94 and 99% reduction in ant population indices at 12 and 18 wks after fenoxycarb treatment, respectively. The first fenoxycarb registration was obtained from the U. S. Environmental Protection Agency in 1985.

Logic® fire ant bait is formulated by dissolving fenoxycarb in once-refined soybean oil which is then impregnated on pregel defatted corn grit, with a final concentration of 1.01% (wt:wt) of fenoxycarb (Ciba Corp., Greensboro, NC). For fire ant control, the granules are broadcast at a rate of 1.12-1.68 kg product/ha, or 11.2-16.8 g actual fenoxycarb/ha. Because these granules degrade readily in the environment, especially in the presence of moisture, there is a concern that the bait may disappear before fire ants had an opportunity to harvest a dose of fenoxycarb sufficient to eventually kill the colony. Also, the rate of bait removal and consumption of the active ingredient plays an important role in the environmental fate and potential ecological effects of fenoxycarb. Rapid removal minimizes the likelihood of non-target organism exposure. Fenoxycarb exhibits low toxicity to birds, fish and mammals, and even short-term but high exposures to invertebrates elicit mild responses. However, long-term laboratory exposures produce dramatic effects on growth and reproduction of certain aquatic invertebrates (A. Hosmer, unpubl. data).

The purpose of this study was to determine the rate of removal of fenoxycarb fire ant bait by red imported fire ants after normal application to improved pasture areas under Florida conditions.

## Materials and Methods

All field research was conducted at the Ciba Vero Beach Research Center, Vero Beach, FL. In 1993 and 1994, single test plots of 50 × 76 m were established in an improved pasture of bahiagrass (*Paspalum notatum* Fluegge). Each test plot was divided into three contiguous subplots of 46 × 6 m which were centered within the test area such that 15 m of treated border surrounded the test plot (Fig. 1). Ten sampling stations (approximately 0.1 $m^2$ each) were located 4.6 m apart on each of two transects positioned longitudinally within the subplots; the transects were 2 m apart in each subplot. In the treatment of the data, each transect was considered a replicate and thus there were six replicates per test. Prior to the tests the pasture was mowed to a height of 5 cm using a tractor-mounted lawn mower equipped with a vacuum to remove as much of the clippings as possible.

Due to the difficulty in evaluating the efficacy of chemicals that do not kill directly but instead affect reproduction and development (e.g., fenoxycarb), Lofgren and Williams (1982) modified the colony rating method of Harlan et al. (1981). This technique classifies fire ant colonies (mounds) into categories based on the estimated numbers of workers per colony and whether or not worker brood is present. Colonies without worker brood are placed in category 1 to 5 and those with brood in category 6 to 10 (Table 1). The population index for a plot is calculated by multiplying the number of colonies in each category by the weighting factor of that category. All visible mounds within and adjacent to the test areas were opened with a shovel and evaluated using this method as an indicator of fire ant activity prior to test initiation.

To aid in locating the granules, Uvitex OB® dye (Ciba Ltd., Basel, Switzerland) at 0.03% (wt:wt) was incorporated into the soybean oil of a standard Logic® fire ant bait formulation to cause the granules to fluoresce under UV light. For the counts in the field, a hand-held battery-operated UV light source (Blak-Ray® Model ML-49 366 nm, UVP Inc., San Gabriel, CA) was held just above the surface of the ground and the flourescing granules counted. For sampling during daylight hours, a cardboard box (1 × 1 × 1m) draped with black plastic was used to exclude daylight while observations and counts were made. Counts of granules were scheduled to be conducted at each sampling station along each transect immediately after application (0 h), and then at 4, 12, 24, 30 and 48 h after application. The Uvitex-treated Logic® granules were applied at the maximum label rate of 1.68 kg/ha with a Herd GT-77 granular applicator (Herd Seeder Co., Inc., Logansport, IN) at 0900 h Eastern Standard Time (EST) on 3 November 1993 and at 1000 h EST on 22 November 1994.

Due to the abundance of red imported fire ants throughout the entire test area, an untreated control (i.e., an area where Logic® granules would not be harvested by fire ants and thus allow the observation of granule deterioration by environmental factors) was not possible. Instead, three reference trays (900 $cm^2$ each) containing field soil planted with bahiagrass were established outdoors near the test area and elevated to exclude fire ant foraging. Sixteen Uvitex-treated Logic® granules were placed in each tray. Granule counts were made at 0, 4, and 24 h after application.

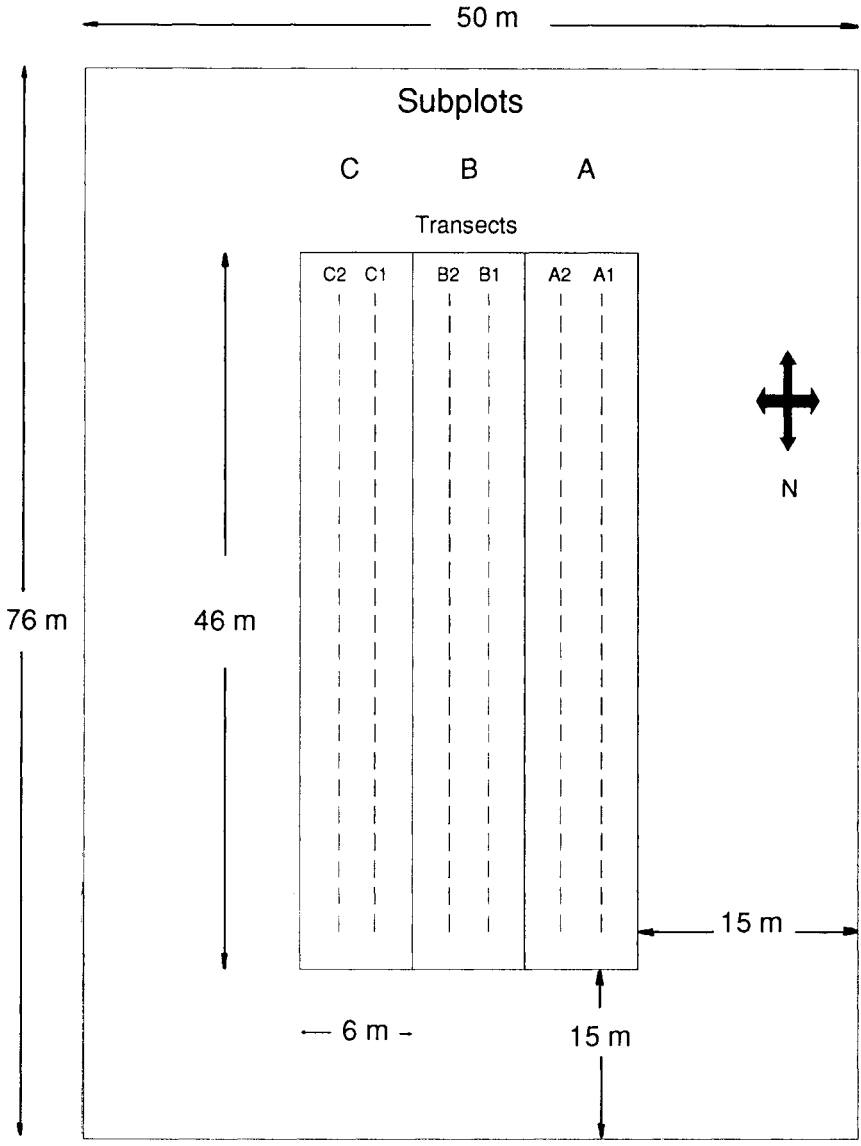


Fig. 1. Experimental plot design for Logic® fire ant bait removal study.

**Table 1. Standardized rating system for evaluating efficacy of insecticides against fire ants (from Lofgren and Williams, 1982).**

| Estimated no. of worker ants | Colonies | | | |
|---|---|---|---|---|
| | Without worker brood | | With worker brood | |
| | Category | Weighting factor | Category | Weighting factor |
| <100 | 1 | 1 | 6 | 5 |
| 100 - 1,000 | 2 | 2 | 7 | 10 |
| 1,000 - 10,000 | 3 | 3 | 8 | 15 |
| 10,000 - 50,000 | 4 | 4 | 9 | 20 |
| >50,000 | 5 | 5 | 10 | 25 |

Weather records (air temperature, wind, rainfall and pan evaporation) for the study periods were obtained from a NOAA weather station located approximately 8 km from the test site. Additionally, the occurrence of rainfall was recorded at the test site.

## Results

Prior to the bait removal studies, a choice test was conducted in the field in which red imported fire ants showed no preference between Uvitex-treated and standard Logic® (J. S. Ferguson, unpubl.). In 1993, subplots A and B each contained six red imported fire ant mounds while ten were located in subplot C (Fig. 2). An additional nine mounds were located outside of the test plot but within the treated area. Mound ratings ranged from 6 to 10 indicating that all surveyed mounds contained worker brood and an estimated <100 workers (rating 6) to >50,000 workers (rating 10). The population indices (number mounds × weighting factor) were 150, 115 and 220 for subplots A, B and C, respectively. An attempt was made to identify all mounds within the test area, however, it was recognized that small, inconspicuous mounds were not included. The initial granule count was made at 1 h postapplication (instead of the planned immediately after application due to an equipment problem) and ranged from 23 granules/transect to 100 granules/transect, with a mean of 71.0 granules found (Fig. 3). At the 4-h postapplication count, the number of granules found ranged from 11 to 80 granules/transect with a mean of 49.3. Figures for the percent granules removed were calculated by designating the initial count as the total number of granules applied and then using the formula:

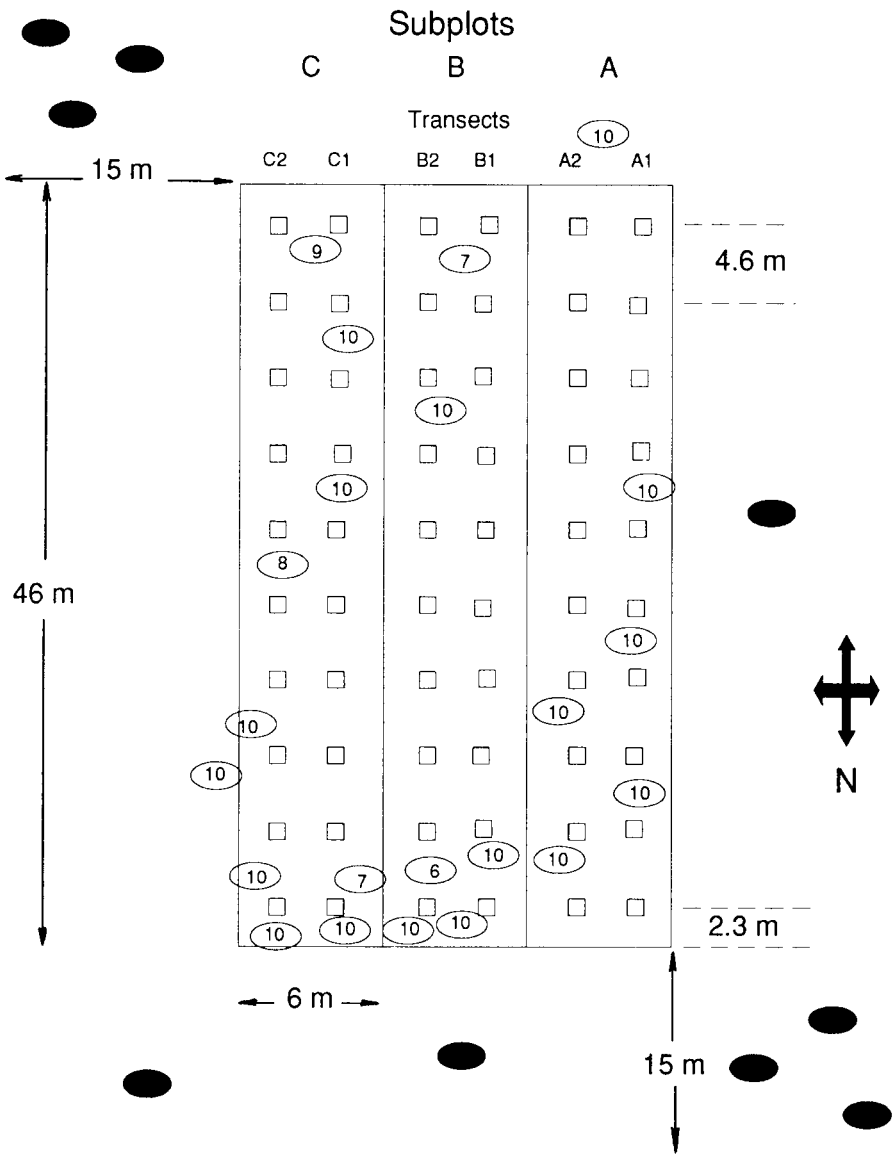


Fig. 2. Experimental test plot diagram, 1993. Open ovals represent red imported fire ant mounds within test plot; number indicates mound rating (after Lofgren and Williams 1982). Solid ovals represent red imported fire ant mounds outside of test plot but within the treated area. Small squares represent sampling stations along transects.

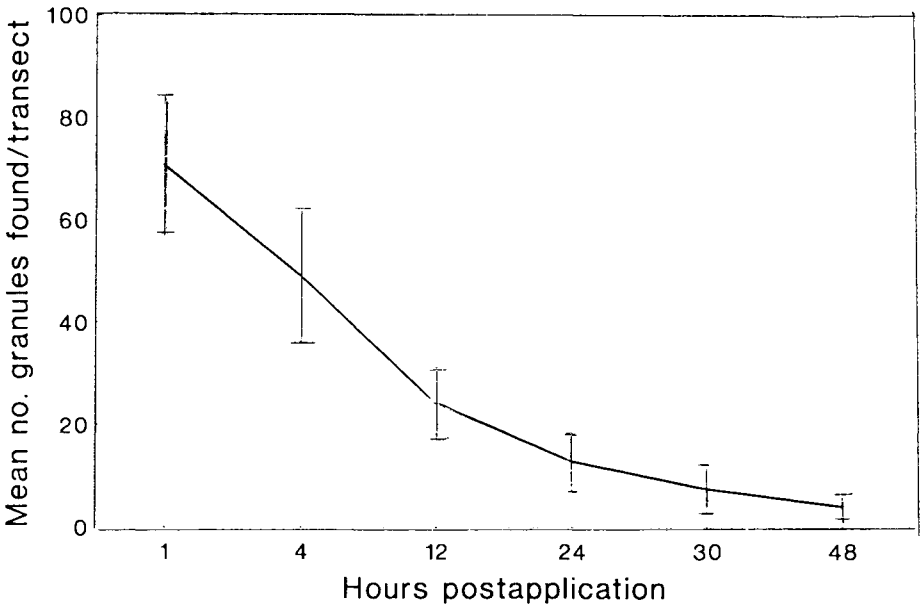


Fig. 3. Number of Logic® fire ant bait granules found per transect at hours postapplication, 1993.

$$[(G_t\text{-}G_x) \div G_t] \times 100\%$$

where $G_t$ is the mean number of granules found per transect at the initial count and $G_x$ is the mean number of granules found per transect at time x. Thus, by the 4 h postapplication count 34.5% of the granules had been removed (Fig. 4). Foraging proceeded rapidly, with 82.0% of the granules removed by 24 h and almost 95% by 48 h postapplication. During the test period air temperature ranged from 9°C to 29°C and 0.5 mm rain fell between the 12 and 24 h counts.

One hundred percent of the granules placed in each of the three reference trays were found at the 0, 4 and 24 h counts, indicating that granules did not disintegrate (at least through 24 h) under these environmental conditions and that grandules could be successfully located after application to vegetation.

In 1994, there were fewer mounds in the test area, with three, six and eight in subplots A, B and C, respectively (Fig. 5). However, 25 mounds were located out of the test plot but within the treated area. Mound ratings ranged from 8 to 10, with population indices of 75, 125 and 180 for subplots A, B and C, respectively. The initial granule count was made immediately after application and ranged from 68 to 187 granules/transect, with a mean of 119.2 granules found (Fig. 6). At the 4-h postapplication count, the number of granules found ranged from 32 to 69 granules/transect, with a mean of 48.0, thus 59.7% of the

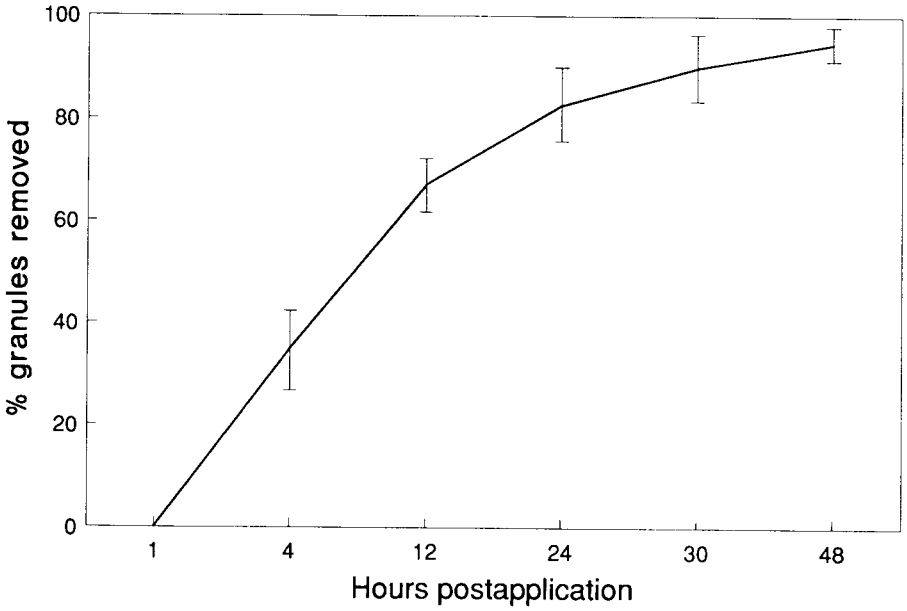


Fig. 4. Percent Logic® fire ant bait granules removed by hours postapplication, 1993.

granules had been removed (Fig. 7). By 12 h post application 72% of the granules had been removed, with 92% removed by 24 h and almost 97% removed by 30 h. Because of the low numbers of granules found at the 30-h count (a range of 0 to 8 granules/transect, with a mean of 4.0), no additional counts were made. Air temperatures ranged from 18°C to 29°C while soil temperature at 2 cm ranged from 24°C to 30°C during the test period. No rainfall occurred.

## Discussion

The Uvitex-treated Logic® fire ant bait was rapidly collected by red imported fire ant workers. Foraging began immediately after application, as at the 0-h count in 1994 (and at the 1-h count in 1993) ants were observed at a number of sampling stations carrying fluorescing granules. The variability in granule counts between sampling stations and transects was probably due in part to the uneven terrain, resulting in a nonuniform distribution of granules by the granular applicator (due to the tractor bouncing), and the nonuniform distribution of mounds within the subplots. In 1993, the initial granule count was made at 1-h posttreatment instead of immediately after application. Additionally, the initial count required approximately half an hour to complete.

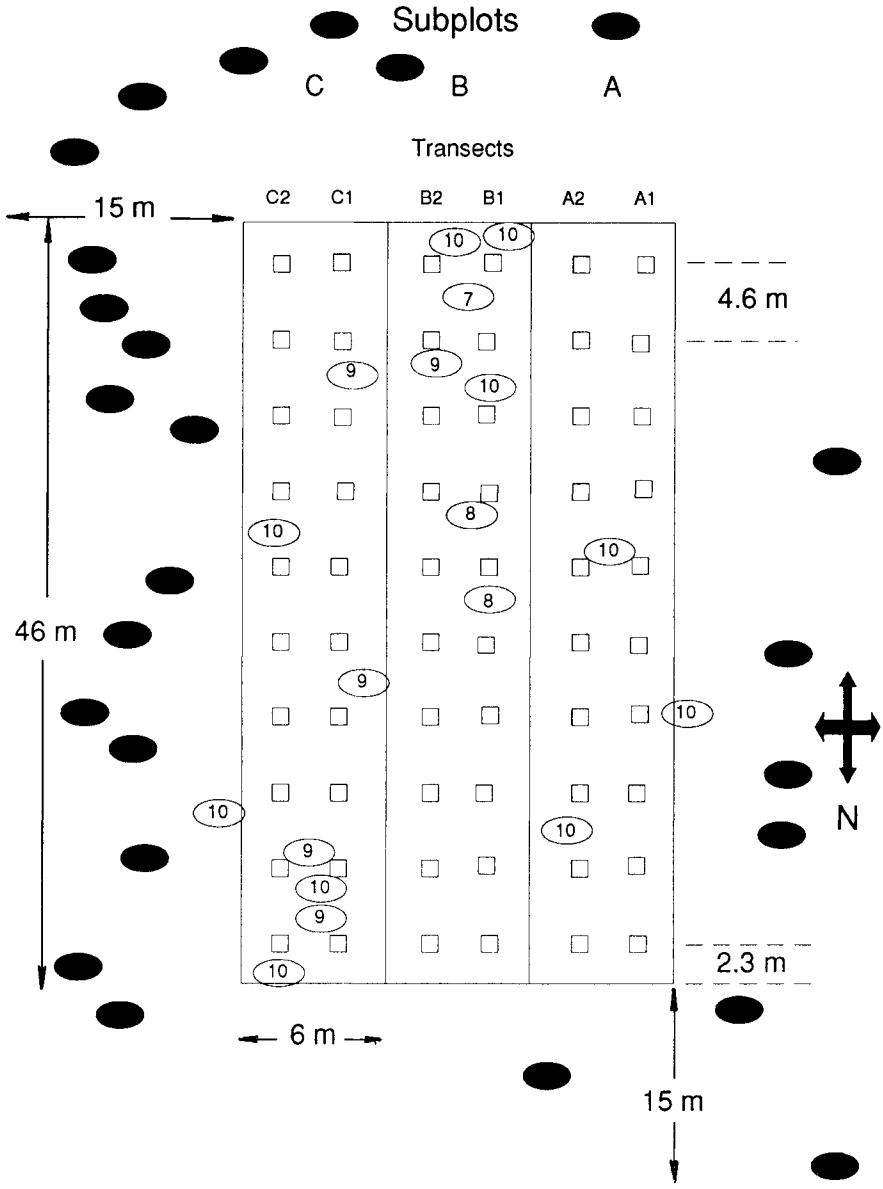


Fig. 5. Experimental test plot diagram, 1994. Open ovals represent red imported fire ant mounds within test plot; number indicates mound rating (after Lofgren and Williams 1982). Solid ovals represent red imported fire mounds outside of test plot but within the treated areas. Small squares represent sampling stations long transects.

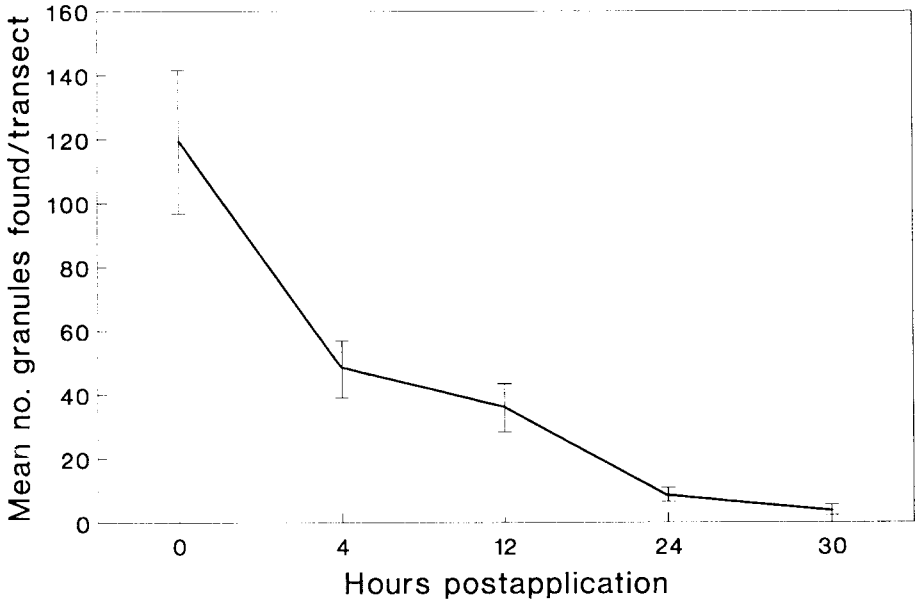


Fig. 6. Number of Logic® fire ant bait granules found per transect at hours post-application, 1994.

Removal of the granules by fire ants began quickly and was actually observed during this first sampling (and in subsequent samplings). Thus the rate of foraging in 1993 was underestimated because this initial activity was not captured. This underestimation probably accounts in part for the difference in the percent bait removed in 1993 versus 1994. For example, by the 4-h count in 1994, approximately 60% of the bait had been removed compared to about 35% in the 1993 test. At the 12-h count the percentages were quite similar between years (67% in 1993; 72% in 1994), but at subsequent counts there was an increased percentage of bait removed in 1994 versus 1993. By the 30-h count in 1994 almost 97% of the bait had been removed whereas in the 1993 test 95% was removed by 48 h. Despite the variation it is clear that the bait was discovered almost immediately after application and was removed rapidly.

In 1993 there were a few colonies of the ant, *Dorymyrmex bureni* Trager (identification by T. Lockley), scattered throughout the test area. This species is commonly found in Florida and can reportedly coexist in close proximity to red imported fire ant mounds without disruption (T. Lockely, pers. comm.). Given the small numbers in the test area, it is doubtful that *D. bureni* had a measurable impact on bait removal. This species was not observed at any time carrying granules. Apperson and Powell (1984) stated that the use of foraging tunnels by red imported fire ants enables workers to be rapidly recruited after food sources are discovered. In their study red imported fire ants were never

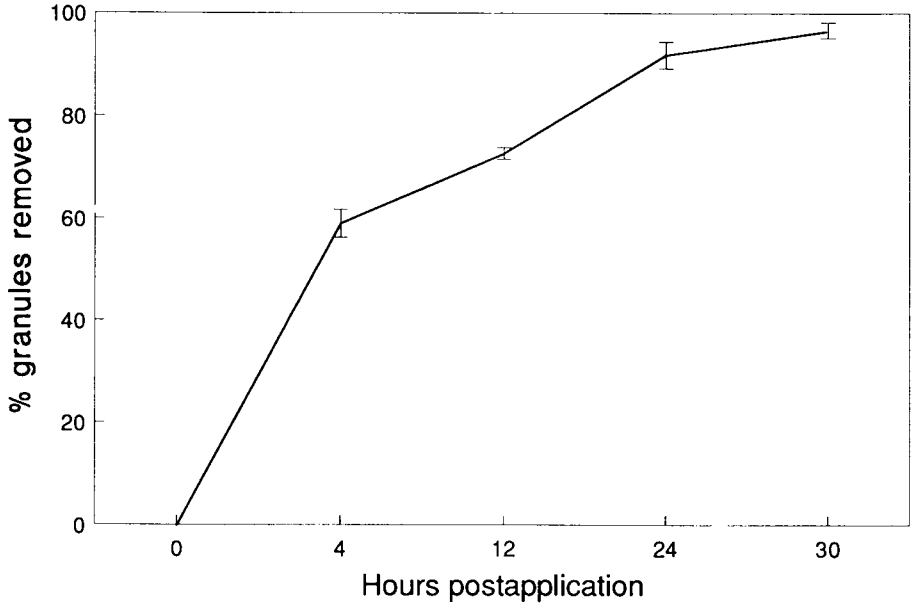


Fig. 7. Percent Logic® fire ant bait granules removed by hours postapplication, 1994.

found to occur with other ants on the bait. In a study by Baroni-Urbani and Kannowski (1974), red imported fire ants first discovered >90% of the baits placed away from its mound but eventually exploited 100% of the baits after displacing other ant species. There were no observed colonies of *D. bureni* or any other ant species in the test area in 1994. Given the density of red imported fire ant mounds in the test area, their high level of activity, the observations of workers carrying flourescing granules and the apparent absence of other ant species competing for the bait, it can be concluded that in this study the Logic® fire ant bait was removed solely by red imported fire ants.

Porter and Tschinkel (1987) reported that soil temperature at 2 cm was the best single predictor of red imported fire ant foraging rates, with foraging occurring between 15°C and 43°C, however, maximum foraging occurred between 22°C and 36°C. Season also had an effect on foraging but most of this effect was apparently due to seasonal variation in soil temperature at 2 cm. In our study soil temperatures at 2 cm, which were recorded in 1994 only, ranged from 24°C to 30°C - optimum temperatures for red imported fire ant foraging. In Florida, fire ant mounds are most conspicuous and activity is most noticeable in the late-summer and fall, due to warm temperatures and abundant rainfall (which results in increased mound height due to wet soil conditions). Given the rapid bait removal by fire ants under these conditions, the late-summer or fall may be the optimum time to initiate a control program. Collins (1992) reported that a single fall application of Logic® fire ant bait was more effective than a

single spring application, however, two applications/year (spring/fall or fall/spring) maintained population suppression longer than a single application. Additionally, delaying the bait application until after the spring mating flights would allow red imported fire ants and non-target ants to kill newly-mated queens in their foraging territories (Wojcik 1992).

In this study, red imported fire ants removed 67 to 72% of the bait within 12 h after application and 82 to 92% within 24 h. The maximum label rate of 1.68 kg/ha, or 16.8 g ai/ha (Logic® fire ant bait is formulated as a 1.0% ai material), was applied. Thus, in the 12 h after application fire ants had removed 11.08 to 11.76 g ai/ha and 13.78 to 15.62 g ai/ha by 24 h. Several studies have reported effective red imported fire ant population reduction with Logic® at the low label rate of 1.12 kg/ha or 11.2 g ai/ha (Williams et al. 1991, 1988, Banks et al. 1983, 1986). Therefore, under favorable foraging conditions it can be assumed that a dose which will provide effective population reduction can be obtained in 12 to 24 h after application at 1.68 kg/ha. Applications of baits at optimum foraging times lessens the chances of other ant species feeding on the bait (Williams 1986). Furthermore, several studies have reported that Logic® fire ant bait had no effect on non-target ants (Wojcik and Williams 1991, 1992, L. Thompson, unpubl. data). With its low use rate, specificity to certain insects, low mammalian and avian toxicity and rapid removal from the soil surface by red imported fire ants, Logic® fire ant bait when used according to label poses little or no risk to non-target organisms. Rapid removal of the bait also minimizes the potential exposure to aquatic invertebrates. Applicators are better able to predict short-term weather conditions and avoid periods of likely rainfall and resultant runoff to aquatic habitats.

## References Cited

**Apperson, C. S. and C. T. Adams. 1983.** Medical and agricultural importance of red imported fire ants. Florida Entomol. 66: 121-126.

**Apperson, C. S. and E. E. Powell. 1984.** Foraging activity of ants (Hymenoptera: Formicidae) in a pasture inhabited by the red imported fire ant. Florida Entomol. 67: 383-392.

**Banks, W. A. 1986.** Insect growth regulators for control of the imported fire ant, Pp. 387-398. *In* C. S. Lofgren and R. K. Vander Meer [eds.], Fire ants and leaf-cutting ants: biology and management. Westview, Boulder, CO.

**Banks, W. A., L. R. Miles and D. P. Harlan. 1983.** The effects of insect growth regulators and their potential as control agents for imported fire ants (Hymenoptera: Formicidae). Florida Entomol. 66: 172-181.

**Banks, W. A., D. F. Williams and C. S. Lofgren. 1988.** Effectiveness of fenoxycarb for control for red imported fire ants (Hymenoptera: Formicidae). J. Econ. Entomol. 81: 83-87.

**Baroni-Urbani, C. and P. B. Kannowski. 1974.** Patterns in the red imported fire ant settlement of a Louisiana pasture: some demographic parameters, interspecific competition and food sharing. Environ. Entomol. 3: 755-760.

**Collins, H. L. 1992.** Management of imported fire ant populations in commercial grass sod. Proc. 1992 Imported Fire Ant Conf. 50-58.

**Drees, B. M. and S. B. Vinson. 1991.** Fire ants and their management. Texas Agric. Ext. Serv. Bull. B-1536. 18 p.

**Harlan, D. P., W. A. Banks, H. L. Collins and C. E. Stringer. 1981.** Large area tests of AC 217300 bait for control of imported fire ants in Alabama, Louisiana and Texas. Southwest. Entomol. 6: 150-157.

**Lofgren, C. S. and D. F. Williams. 1982.** Avermectin $B_1a$: highly potent inhibitor of reproduction by queens of the red imported fire ant (Hymenoptera: Formicidae). J. Econ. Entomol. 75: 798-803.

**Lofgren, C. S., W. A. Banks and B. M. Glancey. 1975.** Biology and control of imported fire ants. Annu. Rev. Entomol. 20: 1-30.

**Porter, S. D. 1992.** Frequency and distribution of polygyne fire ants (Hymenoptera: Formicidae) in Florida. Florida Entomol. 75: 248-257.

**1993.** Stability of polygyne and monogyne fire ant populations (Hymenoptera: Formicidae: *Solenopsis invicta*) in the United States. J. Econ. Entomol. 86: 1344-1347.

**Porter, S. D. and W. R. Tschinkel. 1987.** Foraging in *Solenopsis invicta* (Hymenoptera: Formicidae): effects of weather and season. Environ. Entomol. 16: 802-808.

**Stringer, C. E. Jr., C. S. Lofgren and F. J. Bartlett. 1964.** Imported fire ant toxic bait studies: evaluation of toxicants. J. Econ. Entomol. 57: 941-945.

**Williams, D. F. 1983.** The development of toxic baits for the control of the imported fire ant. Florida Entomol. 66: 162-172.

**1986.** Chemical baits: specificity and effects on other ant species, Pp. 378-386. *In* C. S. Lofgren and R. K. Vander Meer [eds.], Fire ants and leaf-cutting ants: biology and management. Westview, Boulder, CO.

**Williams, D. F., W. A. Banks, R. K. Vander Meer and C. S. Lofgren. 1991.** Red imported fire ant (Hymenoptera: Formicidae) control with a corn grit bait of fenoxycarb without soybean oil. J. Econ. Entomol. 84: 814-817.

**Wilson, N. L., J. H. Dillier and G. P. Markin. 1971.** Foraging territories of imported fire ants. Ann. Entomol. Soc. Am. 64: 660-665.

**Wojcik, D. P. 1992.** The effects on non-target ants of pre- and post-mating flight toxicant applications for fire ant control. Proc. 1992 Imported Fire Ant Conf. 124-136.

**Wojcik, D. P. and R. S. Patterson. 1991.** Studies of bait toxicants on red imported fire ants and non-target ants in South Florida, 1989-1991. Proc. 1991 Imported Fire Ant Conf. 69-72.