A Fluid Bait for Remedial Control of Subterranean Termites

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ABSTRACT A fluid bait, comprising α-cellulose and fine-ground phagostimulants (Summon Preferred Food Source) impregnated with 0.5% hexaflumuron (AI wt/wt) and mixed with 1% methylcel solution to yield 10% dry weight, was injected into simulated foraging galleries of *Coptotermes formosanus* Shiraki and *Reticulitermes virginicus* (Banks) for a laboratory efficacy evaluation. Six weeks after the injection, mortalities for both species exceeded 90%, and all termites died by the eight wk. The fluid bait can be applied internally through a small drill hole in a tight spot with any surface contour and may bypass many problems associated with the AG system that has to be installed externally on the walls or wood surface. When injected into an active gallery of termites in a structure, a tree, or in soil, the fluid baits may be fed immediately by termites to achieve the colony elimination.

KEY WORDS above-ground bait, Isoptera, Rhinotermitidae, Formosan subterranean termite, *C. formosanus*

Introduction

There are two general types of termite bait products on the market for subterranean termite control. One type is the in-ground (IG) system, which is installed in the soil surrounding a structure to intercept foraging termites. The IG bait system is used for both preventive and remedial control, and it may take weeks and sometime months for termites to find the IG stations (Su et al. 1995). Another type of bait system, often referred to as an above-ground (AG) bait, is intended for remedial control only, and is designed to be placed over active termite infestations so that termites may come into bait stations to feed on baits (Su et al. 1997). An AG bait system usually comprises a bait box with one open side mounted on a wall that is infested with termites. Baits are placed in contact with termites in the box before it is closed with a lid. Because this arrangement allows termites to enter the AG station for immediate bait consumption, it can bypass the interception time needed for an IG system. Field studies with commercial AG system demonstrated elimination of all detectable activities of subterranean termites (Weissling and Thoms 1999, Lee 2002). One requirement for a successful termite control with an AG system is to completely seal the station to prevent air flow that may discourage termites from entering the station. Placement of the rigid AG bait box on uneven surfaces without creating a gap, however, can be challenging. When an incomplete sealing of an AG box leaves gaps, these must be completely sealed off with tape, caulk, or other means to encourage termite entry into the AG box.

Another problem with the current AG bait system is that it can be unsightly and intrusive because the AG stations are usually installed in a house visible to residents, who dislike to be reminded of the presence of termites (Su et al. 2012). Moreover, it is not always possible to install the bulky AG station over an active termite infestation in a tight spot where no room is available to accommodate the AG box. There is a need to devise a novel method to replace the current AG system to apply baits for remedial control of subterranean termites.

This article describes a fluid bait that can be injected into voids containing or connected to termite foraging galleries in walls, floors, or any other parts of a structure or trees. Application of fluid baits into galleries with active termites will result in immediate bait consumption and reduce the time required for baits to achieve the control. Results of a laboratory evaluation study of fluid bait against subterranean termites are reported in this article.

Materials and Methods

Efficacy of fluid bait was tested in an arena composed of a stack of five spruce (*Picea* sp.) boards (each 30 by 9 by 0.4 cm thick) covered with a transparent acrylic sheet (30 by 9 by 0.2 cm thick) and tightly secured with eight screws (Fig. 1). Large washers were placed beneath the screw heads to prevent damaging the acrylic sheet. A 0.5-cm-wide main tunnel (0.5 cm in depth; Fig. 1a) was precut at the center of the upper two boards through the entire 30-cm length with four branch tunnels (3 cm in length; Fig. 1b) emerging alternately on both sides at 51° from the main tunnel. The tunnel pattern simulates subterranean termite galleries, as described by Su et al.

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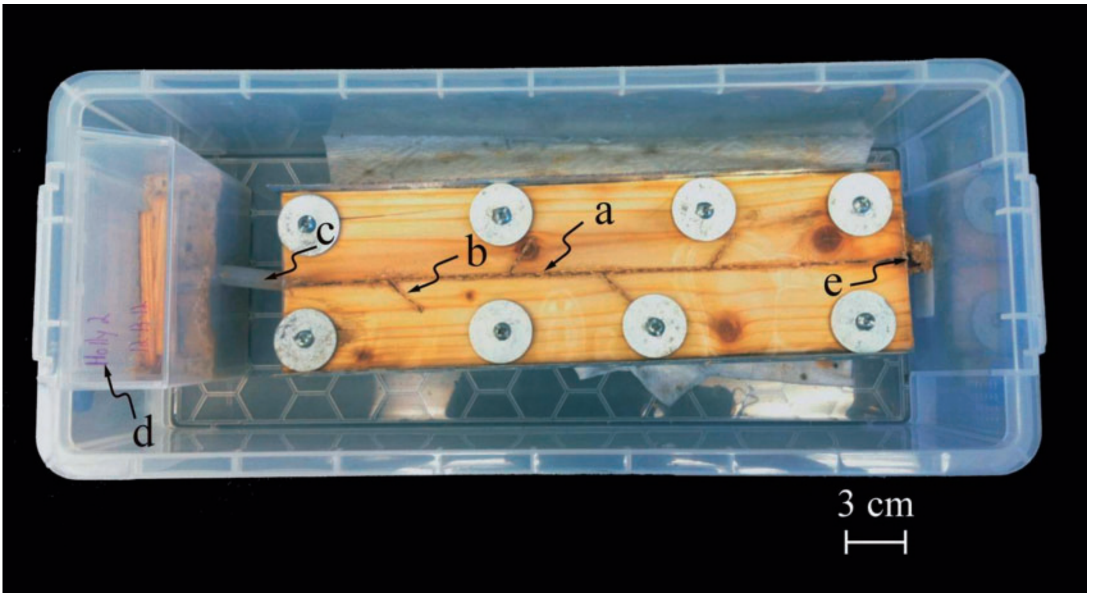

Fig. 1. A simulated foraging arena to test the efficacy of fluid bait against subterranean termites. (a) Main tunnel; (b) branch tunnel; (c) Tygon tubing; (d) hinged-lid plastic container with moisten sand and termites; and (e) wooden plug.

(2004). One end of the main tunnel was connected with a piece of Tygon tubing (5 by 0.5 cm internal diameter; Fig. 1c) to a hinged-lid plastic container (4 by 10.5 by 11.5 cm; Fig. 1d) filled to a depth of 5 cm with moistened sand. The other end of the main tunnel was capped with a wooden plug (Fig. 1e). The arena–container assembly was placed in a large plastic box (42 by 17 by 12 cm) provisioned with moistened paper at the bottom. The test was done for two subterranean termite species, the Formosan subterranean termite, *Coptotermes formosanus* Shiraki, and the native subterranean termite, *Reticulitermes virginicus* (Banks). Two hundred fifty workers (plus 25 soldiers for *C. formosanus*, and 3 soldiers for *R. virginicus*) were placed in the hinged-lid plastic container to allow them to move into the artificial tunnels through the Tygon tubing (Fig. 1c). *C. formosanus* termites were collected from five field colonies (three from New Orleans, LA, two from Broward County, FL) for testing. Termites of *R. virginicus* collected from three field colonies in Broward County, FL, plus one colony that has been maintained in the laboratory for >2 yr were used. Colony origin was used as the replicate, totaling five and four replicates for *C. formosanus* and *R. virginicus*, respectively. The entire assembly was covered with a plastic lid to maintain moisture, and kept at 25 ± 1°C.

The feed medium comprised 90% α-cellulose and 10% fine-ground Summon Preferred Food Source (FMC corp., Princeton, NJ), which was impregnated with 0.5% hexaflumuron (AI wt/wt) and homogeneously mixed with a 1% methylcel/H_2O solution to yield a 10% dry weight feed medium in the fluid bait formulation. The commercial product Summon is known to increase termite feeding (Cornelius and Lax 2005), and a preliminary study showed that it stimulated feeding even at 10% in the bait matrix. For this study, 98% technical grade hexaflumuron (Ruina International Co., Henan, China) was used.

Control bait formulations were also prepared using acetone-treated feed medium, i.e., 90% α-cellulose and 10% fine-ground Summon impregnated with acetone. Two weeks after placing termites in the arena, the wooden plug at the opposite end of the Tygon tubing connection was removed and ~5–10 g of the fluid bait were injected into the main tunnel by using a syringe (0.3 cm in diameter and 5 cm in length). The injected quantity usually resulted in filling ~10–15 cm of the main tunnels with fluid baits.

Fifteen experimental units each were prepared for both treated and untreated control for *C. formosanus*, totaling 30 units. For *R. virginicus*, 12 experimental units each were prepared for both treated and untreated control, totaling 24 units. The experimental units were kept at 25 ± 1°C. At 4, 6, and 8 wk posttreatment, each replicate of treated and untreated control was disassembled to count the number of surviving workers. Moribund termites were excluded from survival count. Percent mortalities were transformed to log (x + 1) and subjected to Student's *t*-test to detect the significant difference ($\alpha = 0.05$) between treated and untreated control groups separately at 4, 6, and 8 wk for each species (SAS Institute 1985, Cary, NC).

Results and Discussion

Two weeks after being introduced into the arena, termites extensively fed on wood by expanding the provided tunnels. Termites were present in most of the tunnels when fluid baits were injected at one end (Fig. 1e), and some were trapped in the injected baits, but most were able to free themselves the following

Table 1. Mean mortalities (% ±SE) of termites 4, 6, and 8 wk after feeding on fluid baits treated with 0.5% hexaflumuron in laboratory arenas

Weeks	*C. formosanus*		*R. virginicus*	
	Control	Treated	Control	Treated
4	15.4 ± 0.7a	36.1 ± 3.8b	17.4 ± 1.7a	73.2 ± 3.4b
6	19.4 ± 1.4a	94.6 ± 3.9b	23.7 ± 2.9a	92.6 ± 6.0b
8	16.7 ± 1.9a	100.0 ± 0.0b	17.2 ± 2.4a	100.0 ± 0.0b

For each combination of termite species and sampling time (week), means with the same letter are not significantly different ($\alpha = 0.05$) according to Student's *t*-test (SAS Institute 1985).

day when the wood absorbed substantial amount of liquid and the feed medium was more solidified. During the initial week after injecting the fluid bait into the arena, termites moved the feed medium throughout the tunnel system, and by the third week, some workers in treated arenas began to show symptoms of hexaflumuron effects, i.e., marbled coloration with sluggish movement. At the fourth week, dead workers were found in the tunnels of treated arenas, and mortalities were ~36 and ~73% for *C. formosanus* and *R. virginicus*, respectively, which were significantly higher than untreated control groups (Table 1). The timing of the appearance of these symptoms and mortality was similar to the laboratory study with hexaflumuron baits (Su and Scheffrahn 1993). By the sixth week, mortalities for both species exceeded 90%. Control mortality of one *R. virginicus* colony exceeded 30% at 8 wk and data of this colony was excluded from the analysis. Mortalities of treated units for both termite species at 8 wk were 100% (Table 1).

The results showed that the fluid bait being injected at one part of the tunnel system can be spread to the rest of the experiment unit to cause 90–100% mortality 6–8 wk later. As demonstrated in previous laboratory and field studies (Su and Scheffrahn 1993, Su 1994, Su et al. 1995), the 6–8 wk latent effect of hexaflumuron is long enough to enable termites to spread the AI-impregnated feed medium amongst termites of a colony, resulting in the elimination of field colonies that may extend up to 100 m. Because the fluid bait can be applied internally through a small drill hole in a tight spot with any surface contour, it may bypass many problems associated with the AG system that has to be installed externally on the walls or wood surface. When injected into an active gallery of termites in a structure, a tree or in soil, termites in the active sites should be able to carry the fluid baits to feed the nestmates, leading to the elimination of a termite colony. Studies are underway to evaluate the efficacy of fluid baits against field colonies of subterranean termites.

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