Effect of Premise® 75 WSP as Perimeter Treatments on Structures Infested with *Reticulitermes flavipes* and *Coptotermes formosanus* (Isoptera: Rhinotermitidae)

by

T. Chris Keefer [1,2], Robert T. Puckett[1] & Roger E. Gold[1]

ABSTRACT

In the study described herein, 20 privately owned structures were treated with a 0.05% AI solution of imidacloprid (Premise® 75 WSP) in an attempt to control infestations of subterranean termites. Voucher specimens were collected from each structure and properly identified. Ten structures were infested with *Reticulitermes flavipes* (Kollar), and 10 structures were infested with *Coptotermes formosanus* Shiraki. Applications were made at a rate of 15 L per 3.05 m per 0.30 m of depth. All structures were inspected through 42 months post-treatment. One structure infested with *R. flavipes* required post-treatment remediation at the 9 month post-treatment inspection. Six structures (60%) infested with *C. formosanus* required post-treatment remediation, with the first activity found at 6 months.

Key Words: imidacloprid, *Reticulitermes flavipes*, *Coptotermes formosanus*

INTRODUCTION

Termites are wood-destroying insects that can cause serious damage to wooden structures, live trees, and crops (Raina *et al.* 2001). They have been described in every state in the United States except Alaska (Su *et al.* 2001, Austin *et al.* 2005). There are over 2300 termite species described in the world, 183 of which have been documented to cause damage to structures (Edwards & Mills 1986, Su & Scheffrahn 1998).

There are seven genera of subterranean termites found in North America, and of these, *Reticulitermes* is the most widespread. *Reticulitermes flavipes*, the Eastern subterranean termite, is the dominant subterranean termite species

[1]Texas A&M University, Center for Urban and Structural Entomology, College Station, TX 77843-2143, USA

[2]tckeefer@tamu.edu

found throughout the United States and is responsible for most damage to structures (Ausitn *et al.* 2005).

There are four species of *Reticulitermes* reported in Texas including; *R. flavipes, R. tibialis, R. virginicus*, and *R. hageni* (Howell *et al.* 1987). *Reticulitermes flavipes* is found throughout the state of Texas and is the dominant species in relation to structural damage. Its peak swarming times in Texas is generally from late February to early April (Furman & Gold 2002) depending on climate and elevation.

Two species of *Coptotermes* subterranean termites are reported from Texas including; *Coptotermes formosanus,* and *Coptotermes gestroi. C. formosanus* is found throughout the Gulf Coast region from Florida to Texas, and *C. gestroi* is found on peninsular Florida (Scheffrahn & Su 2005), but has also been reported from the Houston ship channel. *C. formosanus* is reported from 30 counties in Texas, and is likely to continue spreading throughout the state via movement of infested materials during intra- and interstate commerce. This termite is of concern because it causes significant damage to structures, a variety of wood products, and a number of trees species (La Fage 1987, Su & Tamashiro 1987). They have large colony sizes (relative to native subterranean termites), which can number in the millions, and exhibit voracious foraging behavior (Su & Tamashiro 1987, Su & Scheffrahn 1998, Morales-Ramos & Rojas 2001). Their presence in hurricane-prone regions of the United States Gulf Coast is noteworthy due to the damage they cause to living trees which can then fall, resulting in damage to property and injury to people during high wind events (La Fage 1987, Morales-Ramos & Rojas 2001). The peak swarming time for *C. formosanus* in Texas is generally in May through late June at dusk (Furman & Gold 2002).

Several treatment options are available for use to control subterranean termites. The goal of a termite treatment is to control termites and protect the structure (Su & Scheffrahn 1998). The strategy of a perimeter treatment is to create a complete chemical barrier, and the methods for application of termiticides are as effective today as they were 50 years ago (Gold *et al.* 1994, Gold *et al.* 1996). Soil treatments are commonly conducted by pest management professionals today to control subterranean termites, and have been since the beginning of the century (Randall & Doody 1934, Su & Scheffrahn 1998). Termiticides used in this strategy must be efficacious against all castes to be effective against subterranean termites (Gatti & Henderson 1996). Subtle differences in susceptibility to termiticides by termites have been detected even among conspecifics. Significant changes have occurred in chemicals that can be used as soil barriers against subterranean termites, and the challenge of controlling them is difficult (Raina *et al.* 2001). In the recent past, new chemical groups have been developed and introduced to the pest management industry including pyrethroids, phenylpyrazoles, chloronicotinoids and fiproles.

Termites represent a major expense (both remedially and preventatively) to structure owners worldwide and their high reproductive potential (Howard *et al.* 1982, Grace *et al.* 1989) allows them to be successful in urban areas with abundant food sources (Su & Scheffrahn 1990). The National Pest Management Association estimates the annual cost to control termites in the United States to be $5 billion (NPMA 2005). When the cost of building repair is included, cost estimates can be as high as $11 billion in the United States (Su 2002). Five species, which include *R. flavipes, R. virginicus, R. hesperus, R. tibialis* and *C. formosanus* are responsible for 90% of the dollars spent on termite control in the United States (Forshler & Lewis 1997, Austin *et al.* 2002).

Termite control and prevention requires a vast amount of knowledge in many areas as part of an integrated pest management system (Gold *et al.* 1993). It requires education in many areas other than termites, including the available products, different control tactics, tools and equipment, landscape and hydrology surrounding the structure, and building construction (Forschler & Jenkins 2000). One must also be experienced in the identification of termites. This is of major importance because different species of termites may only be susceptible to specific treatment strategies. One must also be familiar with common electrical and plumbing practices as they relate to termite entry points. Pest management professionals must also know termite biology, ecology, morphology, and habits of each species of termites. Other factors that must be considered are food sources, suitable moisture levels, and which soil types are preferred for termite survival (Suiter *et al.* 2002).

Imidacloprid 1-[(6-chloro-3-pyridinyl)methyl]-N-nitro-2-imidazolidinimine, is commonly used as a soil treatment against subterranean termites. Imidacloprid ($C_9H_{10}ClN_5O_2$) is sold under the trade name Premise® by Bayer Environmental Science (Research Triangle Park, NC).

Imidacloprid was first synthesized in 1985 (Sur & Stork 2003) and is a systemic neonicotinoid insecticide. The systemic properties allow imidacloprid to be translocated through plant vascular tissues (Jeppson 1953, Carretero *et al.* 2003). In 1996, Bayer Environmental Science introduced Premise® 75, a new formulation of imidacloprid (Potter 1997, Gahlhoff and Koehler 2001). This compound is marketed as a non-repellent termiticide (Osbrink & Lax 2003, Osbrink *et al.* 2005, Parman and Vargo 2010). It was further reported that termites that came in contact with soil treatments of imidacloprid could transfer lethal doses to other individual termites in the colony by grooming, trophallaxis, or simply by contact (Thorne and Breisch 2001, Shelton and Grace 2003, Tomalski and Vargo 2004, Parman and Vargo 2010).

Imidacloprid is a nicotinic based pesticide which is classified as a chlornicotinyl (Abbink 1991, Gahloff and Koehler 2001) and is slow acting (Matsuda *et al.* 2001, Osbrink *et al.* 2005). Imidacloprid acts as a contact and stomach poison which attacks the insect nervous system by attaching to acetylcholine binding sites, called nicotergenic receptors, on the receiving nerve cells (Abbink 1991, Ramakrishnan *et al.* 2000). Once attachment of imidacloprid occurs to the cell, the ligand-gated Na^+ cation channel is opened, the neuron continually fires and the result is death of the insect (Schroeder and Flattum 1984). It is also reported that termites that come in contact with imidacloprid treated soil cease feeding (Ramakrishnan *et al.* 2000).

Imidacloprid has also been shown to have low mammalian toxicity (Ramakrishnan *et al.* 2000). This is primarily due to the fact that mammals do not possess large numbers of nicotergenic receptors (Satelle *et al.* 1989, Ramakrishnan 2000). Imidacloprid is considered to have minimal risk as carcinogen and is classified by the United States Environmental Protection Agency (USEPA) as a "Group E" carcinogen (USEPA 1995). Imidacloprid is, however, considered highly toxic to bees when used as broad spectrum pesticide for foliar applications (Kidd and James 1994).

This research deals with imidacloprid as a control option for subterranean termites in Texas. The primary goal of this research was to determine the effectiveness of Premise® WSP 75 0.05% AI for control of *R. flavipes* and *C. formosanus* in infested structures in Texas.

MATERIALS AND METHODS

Twenty structures, 10 infested with *R. flavipes*, and 10 infested with *C. formosanus* were selected. One of the 20 structures was located in Bryan, TX and was infested with *R. flavipes*. Nine structures that were infested with *R. flavipes*, and one structure infested with *C. formosanus* were located in the Pearland, TX area. The remaining nine structures were infested with *C. formosanus* and were located in Rockport, TX. Soldiers were collected from all 20 structures and identified with termite identification keys (Scheffrahn & Hope 1996). Representative termite specimens were collected and stored in 100% ethanol from all 20 sites as voucher specimens. The structures all had monolithic slab foundations, and had not been treated for subterranean termites during the prior 12 months, as verified through an interview with property owners. A diagram of each structure was completed to include all known points of subterranean termite infestation, and all known plumbing and utility penetrations through the slab. Active termite mud tubes were documented from each structure relative to the distance of a permanent benchmark (such as the corner of the foundation). Each infested structure had a minimum of one active mud tube leading from the soil into the structure. The mud tubes were located on either an external or internal surface of each structure, and its location had to be such that it was accessible for inspection during repeated visits to the structure. If termites were eliminated after initial treatment, but then re-appeared at a later date, termites were again collected and stored in 100% ethanol. Each infested structure was inspected at 1, 2, 3, 6, 9, 12, 18, 24, 30, 36 and 42 months post-treatment.

Under the supervision of staff from the Center of Urban and Structural Entomology at Texas A&M University, all infested structures were treated by a licensed pest control company with the appropriate dilution (0.05% AI) of Premise® 75 WSP. At each of the structures, one half of the desired volume of water was first added to the tank and then the appropriate amount of Premise® 75 WSP was introduced into the tank, and the remaining volume of water was added to ensure thorough mixing of the solution. In setting up this study, the linear length for each structure to be treated was calculated prior to treatment. The mean perimeter of the 20 structures was 66.6 ±17.8 m (Table 1). The manufacturer's label for Premise 75 WSP requires that 15

Table 1. Treatment data for structures receiving a post-construction liquid application of 0.05% AI imidacloprid (Premise® 75 WSP) for control of subterranean termites.

Structure #	Treatment group	Linear m of structure (perimeter)	Liters of Premise® applied	Liters/linear m applied
1	*Reticulitermes*	54.8	333.1	6.0
2	*Reticulitermes*	57.3	283.1	4.9
3	*Reticulitermes*	57.9	283.1	4.9
4	*Reticulitermes*	55.7	242.2	4.4
5	*Reticulitermes*	60.9	272.5	4.4
6	*Reticulitermes*	86.8	492.1	5.6
7	*Reticulitermes*	74.3	386.1	5.2
8	*Reticulitermes*	65.8	340.6	5.1
9	*Reticulitermes*	55.4	253.6	4.6
10	*Reticulitermes*	92.3	507.2	5.5
Mean		66.1±13.8 a	339.4±95.1 a	5.1±0.5 a
11	*Coptotermes*	45.7	227.1	4.9
12	*Coptotermes*	78.6	670.0	8.4
13	*Coptotermes*	28.0	140.0	5.0
14	*Coptotermes*	56.0	435.3	7.7
15	*Coptotermes*	64.9	325.5	5.0
16	*Coptotermes*	62.4	454.2	7.3
17	*Coptotermes*	104.8	696.5	6.6
18	*Coptotermes*	91.7	757.0	8.2
19	*Coptotermes*	67.9	393.6	5.7
20	*Coptotermes*	61.8	427.7	6.8
Mean		66.2±21.9 a	452.7±202.4 a	6.6±1.4 a

Linear m of structure; t=0.53, df=18, P=0.61, Liters of Premise® applied; t=1.60, df=18, P=0.13, Liters/Linear m Applied; H=6.25, df=1, P=0.12. Means followed by the same letter in the same column were not significantly different at P=0.05.

L per 3.0 linear m per 0.30 m of soil depth of finished solution be applied to the soil. The mean volume of finished solution applied per structure was 396.0 ± 164.4 L (Table 1). This number included the volume of Premise 75 WSP used to treat bath traps and shower pans at each structure.

The following parameters were used for treatment of all the structures as necessary:

1. An application of a full-volume treatment of Premise® 75 WSP (15 L per 3.05 linear m per 0.30 m of depth) at 0.05% AI around the outside perimeter of the foundation wall by trenching, or by trenching and rodding to a depth of no more than 0.61 m to depth of foundations;

2. A sub-slab injection of Premise® 75 WSP at 0.05% AI extending a minimum of 0.61 to 0.91 m on either side of known infested sites at expansion

joints or cracks in slabs was made. This treatment was performed by drilling vertical through the slab and making a full-volume application (15 L per 3.05 linear m per 0.30 m of depth). All patios and sidewalks adjacent to structures were drilled on 30.48 cm centers;

3. A sub-slab injection of Premise® 75 WSP at 0.05% AI was made at or near utility penetrations with known infestations. This treatment was made by drilling vertical through the slab and making an application at a rate of 3.77 L of solution per 0.30 m^2; and

4. Premise® 75 WSP at 0.05% AI was applied at a rate of 3.77 L of finished solution per 0.30 m^2 in the exposed soil in bath traps.

Areas with any persistent or recurring termite activity were re-treated with Premise® 75WSP at 0.05% AI using the same type of application techniques as were described in the original treatments.

A flat-blade pick and 10 cm (4 in) shovel were used to dig trenches at all structures. A 189 L Continental Belton fiberglass tank (Belton, TX) having an air gap for back flow prevention, and equipped with a constant jet agitation and a HyproD-30 diaphragm pump (Italy) was used for all applicable applications. A JD-9 gun was utilized to deliver termiticides when applicable. When sub-slab injection or rodding was done, a 180° tip was used to deliver termiticide to appropriate areas.

The statistical software used to analyze the data set was, SPSS 16.0 for windows (Chicago, Il). To compare differences between structures infested with the different species of termites, a one-way analysis of variance (ANOVA) was utilized. Tukey's Honest Significant Difference test was used to separate means.

RESULTS

Only one *R. flavipes* infested test structure (10%) required re-treatment through 42 mo post-treatment study period. Active *R. flavipes* were found at structure 6 at the 9 month post-treatment inspection. The active termites were located in a base board in the kitchen, and the entry point was found near the washer plumbing area. This area was treated with 0.05% AI imidacloprid. This area had not been previously treated.

Six (60%) of the ten structures infested with *C. formosanus* required re-treatments during the 42 mo post-treatment study period. The first post-treatment termite activity in this study was found during the 6 month inspection of test structures 17 and 20. The active subterranean termites at structure 17 had re-built a mud tube on the exterior of the structure. Structure 17 was re-treated with 0.05% imidacloprid. At structure 20, *C. formosanus* swarmed out of an internal wall void near the area where one of the original pre-treatment termite mud tubes was found. This internal wall void had not been treated previously. This wall void was treated with imidacloprid foam at 0.05% AI. When the 9 month inspection at structure 20 was performed, active *C. formosanus* were found. This structure was re-treated for the second time. At the 24 month post-treatment inspection, structure 14 had active *C. formosanus* in the master bathroom, which was near an area that had active termites prior to the original treatment. Structure 14 was not re-treated at that time.

At the 30 month inspection, active *C. formosanus* were found at structures 12, 13, 14, and 18. Of these structures, 12 and 14 were treated with fipronil (0.06% AI) and were dropped from the study. Structures 13 and 18 were not re-treated at this time. In all four structures, active *C. formosanus* were found on the exterior of the structure, tunneling via a shelter tube on the slab. At 36 months post-treatment, structures 17 and 18 had active *C. formosanus* on the exterior of the structure. Structure 17 was not re-treated at that time, while structure 18 was re-treated with fipronil (0.06% AI) and was dropped from the study. At 42 months post-treatment, there were still active *C. formosanus* at structure 17. Structure 17 was then treated with fipronil (0.06% AI). A complete synopsis of inspection results is found in Fig. 1.Throughout the 42 months of inspections, six structures infested with *C. formosanus* received re-treatments with Premise® 75 WSP 0.05% AI. In all cases, there was no soil movement at the structure, and there was no evidence of remodeling or other activity that would have disrupted the treatment causing a breach in the perimeter barrier.

DISCUSSION

The results of this study indicate Premise® 75 WSP provided control of *Reticulitermes flavipes*. Only one re-treatment was necessary throughout the 42 mo of inspections on all ten of the structures included in the study. In this one incident, subterranean termites were found in the kitchen utilizing a plumbing area that had not been previously treated as a point of entry.

The efficacy of Premise® 75 WSP on *C. formosanus* was variable. There were six structures that received re-treatments. Some structures received more than one re-treatment. The re-treatment rate was 60% for these structures through 42 mo post-treatment. Formosan termite populations were more difficult to control with Premise® 75 WSP than were *Reticulitermes flavipes* (Fig. 1). These findings support the work of Su and Scheffrahn (1990) who found that *R. flavipes* are more susceptible to termiticides than *C. formosanus*.

Coptotermes spp. are considered subterranean termites, but can live above ground in carton nests. By doing so, they can continue to live and cause

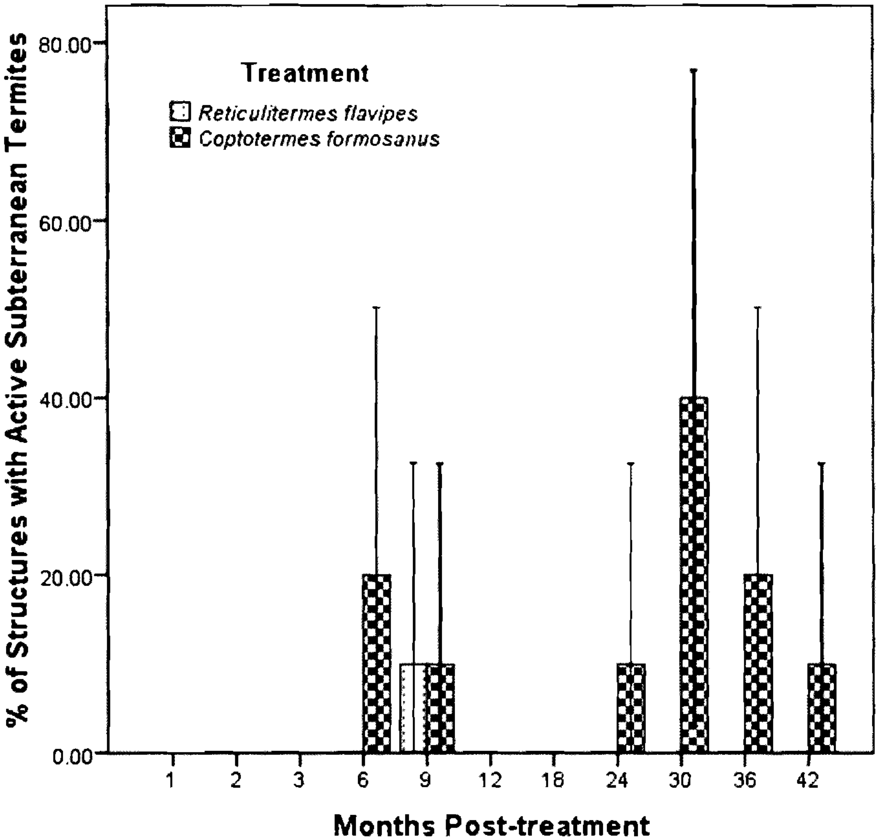

Fig. 1. Percent of structures with subterranean termite activity through time after a post-correction treatment with Premise® 75 WSP 0.05% AI.

damage even after structural treatment. The most complete treatment for a *Coptotermes* infestation would be a soil treatment along with a fumigation. However, with the advent of foam termiticides, fumigation may not always be necessary. Foam applications are done by drilling small holes into the area and applying the foam according the manufacturer's labels.

Subterranean termites will exploit any opening through the slab and foundation of a structure to gain access to the wood framing and millwork. If liquid or granular termiticides are chosen to prevent this problem, they must be applied around the perimeter of the foundation, at any openings through the slab, cracks in the slab, and joints between abutting slabs. If termiticides are applied only around the perimeter of the foundation, the structure will not be fully protected against invasion by subterranean termites. Termiticides must be applied to, and as near as possible to, known areas of infestations for maximum control.

There were no significant differences in the size of structures, nor in the amount of imidacloprid applied between the two sets of structures associated with each species of termite. The fact that *C. formosanus* was more difficult to control than *R. flavipes* was likely due to its colony size and aggression toward food sources rather than the Premise® 75 WSP treatment.

The study represents an accurate portrayal of events that occur in the real world. Field studies such as this offer a firsthand look at the problems and successes that pest management professionals can anticipate in their work. Communication with structure owners and the pest management professional was critical in these field studies and involved scheduling visits to inspect structures and travel to the structures, which were hundreds of miles away in some cases.

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