Efficacy of Localized Chemical Treatments for *Cryptotermes brevis* (Isoptera: Kalotermitidae) in Naturally Infested Lumber

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Abstract. Localized injection of insecticides into termite galleries in infested wood represents an alternative to whole-structure fumigation for drywood termite control. The efficacy of this method is limited, however, by the use of repellant insecticides and the difficulty of locating drywood termite colonies. The present study addressed both issues by the use of an experimental acoustic emissions (AE) detector to assist in location of termite infestations in naturally infested shipping pallets, and application of the non-repellant insecticide spinosad (Dow AgroSciences). Chlorpyrifos 0.5% aerosol, 15% aqueous disodium octaborate tetrahydrate (DOT), resmethrin 0.25% aerosol, distilled water (control) and two treatments of 0.5% spinosad suspension concentrate (one with the injection site based on visual evidence and the other on acoustic evidence) were injected into boards in hardwood shipping pallets naturally infested with the drywood termite *Cryptotermes brevis* Walker. Termite mortality was greatest with spinosad treatments, although variability was high due to the continued difficulty of identifying and treating all separate areas of infestation in the boards.

Key words: West Indian drywood termite, drywood termite control, spinosad, chlorpyrifos, disodium octaborate tetrahydrate

Introduction

Drywood termites (Isoptera: Kalotermitidae) are cryptic economic pests, living within seasoned wood in service in structures. In Hawaii, and all of the tropical through southern temperate regions of the globe, drywood termites are second only to subterranean termites (Rhinotermitidae) in terms of the damage caused to residential structures, and the need to apply control methods. Drywood termite control currently relies heavily upon structural fumigation, in which the structure is sealed and a lethal gas injected and retained for approximately 24 hours. Although effective, fumigation is a rather extreme and disruptive form of residential pest control, leading to a great deal of research interest in other control options that might be less expensive, less disruptive to the homeowner, and less lethal to non-target organisms, including people.

Alternatives to fumigation currently include: extremes of temperature (Woodrow and Grace 1998; Lewis and Haverty 1996), the use of microwaves (Lewis and Haverty 1996), preventative applications of residual insecticides to the wood surface (Scheffrahn et al. 1998), and injection of insecticide into the termite galleries in the infested wood, often referred to as "drill and treat" (Scheffrahn et al. 1997). Localized injection of insecticide into the wood is the most economical and popular alternative (Lewis 2003).

The principle complicating factor in the use of localized treatments is the cryptic nature of drywood termites. Many contact insecticides are repellent, and termites elsewhere in the gallery system and not immediately exposed to the injection are thus not exposed to a sufficient quantity of the insecticide for control. Theoretically, a non-repellant insecticide might require fewer injection points (drill holes) and cause greater mortality throughout the drywood termite colony. Spinosad (Dow AgroSciences), a natural fermentation product, is a possible candidate for such use (Scheffrahn et al. 1997). In laboratory simulations with man-made termite galleries, and using acoustic emissions (AE) evidence to detect termite presence in field trials, it has been demonstrated that drywood termites will forage through areas of the gallery system treated with spinosad, resulting in greater termite mortality and longer-term efficacy than conventional insecticide treatments (Scheffrahn et al. 1997, Scheffrahn et al. 1998, Ferster et al. 2001).

The present paper was prepared for a special symposium of the Pacific Entomology Conference in February 2005, and represents a summary of work discussed in greater detail by Woodrow et al. (2006).

Materials and Methods

A unique aspect of this study was the use of naturally termite-infested hardwood shipping pellets, since previous work (e.g., Scheffrahn et al. 1997) has relied either upon man-made galleries for laboratory investigations, or indirect measurement of efficacy in structural lumber in the field by detecting the sound vibrations (acoustic emissions, or AE) given off by termite feeding. The use of naturally infested pallets allowed us to dissect the wood at the conclusion of the study and directly count living and dead (indicated by head capsules) termites. These methods are described in detail by Woodrow et al. (2006).

Hardwood shipping pallets (3-5 per treatment) naturally infested by *Cryptotermes brevis* Walker were randomly assigned to injected insecticide treatments: chlorpyrifos 0.5% aerosol, 15% aqueous disodium octaborate tetrahydrate (DOT), resmethrin 0.25% aerosol, distilled water (control) and two treatments of 0.5% spinosad suspension concentrate: one in which injection points (one per each infested board within each pallet) were based solely on visual inspection of the pallets, and the second in which an experimental acoustic emissions (AE) detector provided by Dow AgroSciences was used to determine points of greatest termite activity for insecticide injection into each infested board. Injection points for the other insecticides were selected using the AE detector to determine the points of greatest termite activity. Insecticides were either provided by Dow AgroSciences, or obtained commercially. Resmethrin (0.25% aerosol) was included in the study since this repellent insecticide is the active ingredient in several retail insecticides used by home owners for drywood termite control in Hawaii.

We analyzed for treatment effects on pallets using both AE evidence (emission counts) and a termite mortality at the conclusion of the study. One year after treatment, final AE readings were taken, and the pallets were dissected to determine the connections among termite colonies (gallery systems) in each pallet, and termite mortality as measured by the ratio of dead (indicated by the presence of head capsules) to live termites. AE readings, and the relationship to actual mortality counts are described by Woodrow et al. (2006).

Differences in termite mortality, both among whole pallets and among "sectional aggregates" (SA) were determined by the general linear models procedure (PROC GLM) and the Tukey-Kramer means separation test (SAS Institute 1997). SAs represented individual termite colonies, or gallery systems that were not connected to other gallery systems (as determined by dissection of the wood), within each pallet.

Results and Discussion

Among 28 pallets included in the study there were 381 boards and 1514 individual monitoring sections with an average of 13.6 boards and 54 sections, per pallet, respectively.

Table 1. Percentage mortality of *Cryptotermes brevis* in whole hardwood shipping pallets or sectional aggregates (representing individual termite colonies) within those pallets 12 months after insecticide treatment by injection.

	Whole pallets		Sectional aggregates[a, b]	
Treatment	n	Mean % ± SEM	n	Mean % ± SEM
Chlorpyrifos aerosol	3	33.2 ± 23.7 ab	3	33.3 ± 23.7 abc
Spinosad sc	5	58.7 ± 18.5 a	8	71.9 ± 14.3A
Spinosad sc (visual)	5	53.5 ± 20.0 a	10	48.3 ± 15.0 a
DOT	5	30.4 ± 17.9 ab	4	47.6 ± 22.8AB
Resmethrin aerosol	5	18.1 ± 5.1 b	11	35.9 ± 10.8 bc
Water (control)	5	6.8 ± 4.3 b	6	5.2 ± 3.8 c
F		1.70		16.67
df		5, 22		5, 39
P		0.176		<0.0001

[a]Sectional aggregates are mutually independent groups of board sections, connected by termite galleries, which were delineated after pallets were disassembled; only those that were treated were included in this analysis.
[b]Grouped according to Tukey-Kramer means separation test (SAS Institute 1997).
[c]DOT= Disodium octaborate tetrahydrate

During breakdown of the pallets 12 months after treatment, we observed a number of gallery connections between boards and were able to delineate 90 mutually independent sectional aggregates (SA), or independent gallery systems. Inspection indicated that some SAs were missed during the treatment phase of the study and thus not treated due to lack of AE evidence. This demonstrates that it is very easy to overlook and not treat an individual drywood termite colony when performing a commercial treatment, even when a tool such as the AE detector is employed as an aid to the usual visual inspection.

Liquid insecticide dilutions were injected into 108 individual monitoring sites amounting to a total of 2433 ml of liquid applied with an average of 86.9 ml/pallet or 22.5-ml/ injection. Upon breakdown, 17,222 living termites were collected along with 9306 dead termites. Based on total termite mortality within each pallet, none of the insecticidal treatments resulted in significant termite mortality. However, when SAs (individual termite colonies) were analyzed as independent samples, while excluding those SAs that were “missed” and not treated, significant model effects were found (Table 1). Individual means comparisons indicated that both of the spinosad treatments were significantly different from the controls, while the remaining treatments were intermediate in their effects, but did not differ statistically from the controls.

Our results support the use of spinosad as a localized treatment for drywood termite infestation; although even with this insecticide, a maximum of 72% mortality was achieved within 12 months within the treated termite gallery systems (SAs). Due to the non-repellant nature of spinosad, it is possible that termite mortality within the exposed colonies would continue to increase over time.

The weakness of all localized insecticide injections was clearly site selection, i.e., locating all active drywood termite colonies and injecting the insecticide into each of them. Use of the experimental AE detector did not necessarily improve accuracy over visual inspection alone (Woodrow et al. 2006). In current commercial "drill and treat" drywood termite control situations, pest control professionals drill a pattern of injection holes across each board suspected of infestation at fairly close intervals (e.g., 12 inches), in order to treat as many termite gallery systems as possible. Although our results do not indicate that localized treatment, even with an effective non-repellant toxicant such as spinosad, can currently replace whole-structure fumigation (or heat treatment), such treatments certainly are effective at reducing termite populations in the colonies that are actually treated, and are appropriate for use when the extent of the drywood termite infestation can be accurately deliminated.

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