EFFECTIVENESS OF A SUPERFICIAL TREATMENT USING BIFENTHRIN TO PROTECT RADIATA PINE FRAMING FROM DAMAGE BY SUBTERRANEAN AND DRYWOOD TERMITES IN INDONESIA

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ABSTRACT

Various experimental testing procedures were undertaken in Indonesia to determine the effectiveness of a patented superficial (envelope) treatment using bifenthrin to protect radiata pine framing material from damage by two species of subterranean termites (*Macrotermes gilvus* and *Coptotermes curvignathus*) and one species of drywood termite (*Cryptotermes cynocephalus*). Lengths of framing material (*Pinus radiata* sapwood) were commercially treated to the targeted retention of 0.02% m/m of bifenthrin in the outer 2 mm depth penetration zone of the material. The treated and untreated materials were subsequently cut into test specimens and exposed to *M. gilvus* in the field and a semi-laboratory trial, to *C. curvignathus* in the laboratory and a semi-laboratory trial and to *C. cynocephalus* in a laboratory trial. No supplementary treatment was performed on the exposed cut ends of the treated test specimens. The results from the trials clearly demonstrated that the superficial treatment of bifenthrin seemed effective in protecting test specimens of radiata pine framing material from significant damage by Indonesia's most notorious termite species that often causes serious economic loss to the timbers. Termites were unable to damage any of the bifenthrin-treated surfaces of test specimens. Any observed damage by termites, albeit minor, was in all cases confined to the exposed cut ends of test specimens. In contrast, attack by termites on the untreated control test specimens caused damage of the samples ranging from light to heavy.

Keywords: Envelope treatment, laboratory trial, semi-laboratory trial, field trial

I. INTRODUCTION

Termites play an important role in the recycling of waste lignocellulosic materials, e.g. forest litter. However, due to their in-discriminatory attack in nature, termites can also pose serious threats to the integrity of wood and wood products used in buildings and structures, including those for interior uses such as furniture, paper-based products, etc. Consequently, it is essential to manage infestation of buildings and structures by termites.

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Whilst no scientific data are available on the cost of prevention and remedial treatment for timber-in-service, anecdotal evidence suggests termites are disastrously notorious as major structural pests that destroy buildings in Indonesia thereby causing huge economic loss. Even the Presidential Palace in Jakarta has suffered serious damage because of infestation by termites. Despite the serious situation of this insect pest, little effort is currently directed towards minimizing damage to timber in buildings and structures throughout Indonesia. For example, the majorities of wood preservative companies are relatively inactive, although the use of non-durable timbers for building construction is steadily increasing.

Due to its climatic conditions, Indonesia has a rich termite fauna. However, only a few species have the ability to infest timber-in-service, for examples, subterranean termites *Macrotermes gilvus* Hagen (Isoptera: Termitidae) and *Coptotermes curvignathus* Holmgren (Isoptera: Rhinotermitidae), and drywood termite *Cryptotermes cynocephalus* Light (Isoptera: Kalotermitidae). These species are considered the most important pests on structural timbers in Indonesia.

Recent developments in the Australian timber preservation industry have seen the inclusion of superficial treatments (more commonly referred to envelope treatments) into the Australian Standard (Anonymous, 2005). Two insecticides (bifenthrin and permethrin) have been accepted into the standard as superficial treatments suitable only for softwood framing timbers exposed in Australian Hazard Class 2 (H2-F) (inside, aboveground) situations, south of the Tropic of Capricorn. Subsequent to the listing in the Standard, the effectiveness against termites of softwood framing timber, superficially treated with one of the approved insecticides bifenthrin was investigated in Indonesia. This paper provides results on a series of laboratory and field trials conducted to determine whether the superficial treatment was able to protect radiate pine framing timber from damage by the above-mentioned species of subterranean and drywood termites.

II. MATERIALS AND METHODS

One meter length of radiata pine (*Pinus radiata* D. Don) sapwood framing material (35 x 90 mm), superficially-treated with bifenthrin using the patented Osmose process, were supplied by CSIRO, Australia. The material had been commercially spray-treated to the targeted 0.02% m/m of bifenthrin in the outer 2 mm depth penetration zone, as specified in AS 1604.1-2005. For comparison, 1 m lengths of untreated framing materials were also supplied. The treated and untreated lengths were subsequently cut into test specimens of various dimensions appropriate to the test method being employed. No supplementary treatment was given to the exposed cut ends of the treated test specimens. Tested specimens were not artificially weathered prior to testing.

Five laboratory/field trials were conducted on the treated and untreated test specimens as follows: field trial against subterranean termites (1), two semi-laboratory trials against the subterranean termites *M. gilvus* (2) and *C. curvignathus* (3) and two laboratory trials against subterranean termite *C. curvignathus* (4) and the drywood termite *C. cynocephalus* (5). All trials conducted followed the basic principles of laboratory and field testing as cited in the ASTM D 1758 and ASTM D 3345. Five treated and five untreated replicate test specimens were prepared for each trial. At the conclusion of the trials, each treated and untreated test specimen was examined and visually rated for damage by termites using the rating systems according to the ASTM D 1758 and ASTM D 3345.

Field rating system for termites in accordance with the ASTM D 1758:

10 No attack; 1 to 2 small nibbles permitted
9 Nibbles to 3% of cross-section
8 Penetration 3 to 10% of cross-section
7 Penetration 10 to 30% of cross-section
6 Penetration 30 to 50% of cross-section
4 Penetration 50 to 75% of cross-section
0 Failure

Laboratory rating system for termites in accordance with the ASTM D 3345:

10 Sound, surface nibbles permitted
9 Light attack
7 Moderate attack with penetration
4 Heavy
0 Failure

A. The Field Trial

The field trial was conducted at a test site in Cikampek (approximately 70 km east of Jakarta). The site was known to be inhabited by numerous species of subterranean termites, particularly *M. gilvus, Microtermes* sp. and *Odontotermes javanicus* Holmgren. Each test specimen (300 mm long) was machined to provide a point at one end. Test specimens were installed randomly into the soil in the vertical position, leaving approximately 200 mm above ground-line. The distance between test specimens was 1 m. Five rubberwood (*Hevea brasiliensis*) stakes (a highly termite-susceptible species of timber) were driven into the soil around each test specimen. These rubberwood stakes were positioned in equal distance and at a radius of 250 mm from each test specimen. The rubberwood stakes were used to attract and maintain the presence of foraging termites around test specimens. The duration of the field trial was 6 months. At the conclusion of the trial, the test specimens were cleaned and assessed for damage caused by termites using the ASTM D 1758 rating system.

B. Semi-laboratory Trial Using Subterranean Termite *M. gilvus*

The trial was conducted in a test compartment of a termitarium that was confined in the laboratory. The methodology employed was similar to that described by Johnson *et al.* (1988) whereby test specimens were exposed to damage by a nest of termites collected from the field. Treated and untreated test specimens (100 mm long) were inserted vertically into the soil in alternate sequences, leaving approximately 75 mm of each test specimen exposed above the surface of the soil. The duration of the trial was 6 months. At the conclusion of the trial, test specimens were cleaned and assessed for damage caused by *M. gilvus* using the ASTM D 3345 rating system. Furthermore, numbers of termites actually foraging on each test specimen were also recorded.

C. Semi-laboratory Trial Using the Subterranean Termite *Coptotermes curvignathus*

The methodology for this trial was similar to that described for *M. gilvus* in (B) above except size of the each test specimen that was only 50 mm in length and the test duration that was only for 3 months.

D. Laboratory Trial Using *Coptotermes curvignathus*

This trial was conducted in plastic containers (65 mm in height x 135 mm in diameter). A 10 mm-thick layer of sand, wetted with distilled water according to Sornuwat *et al.* (1995), was put into each container. A test specimen (45 mm long) was then placed centrally in an upright position on the surface of the wetted sand medium. Three grams of termites (approximately 1000 individuals) comprising approximately 90% workers and 10% soldiers was employed to each container. Throughout the duration of the trial (4 weeks), containers were maintained in dark and humid conditions at ambient temperature. At the conclusion of the trial, test specimens were cleaned and rated for damage caused by *C. curvignathus* using the ASTM D 3345 rating system. Termite survival data were also observed.

E. Laboratory Trial Using the Drywood Termite *Cryptotermes cynocephalus*

The methodology for this trial was basically also similar to that described for the subterranean termite *C. curvignathus* in (D) above. However, there were three aspects being differentiated from the previous experiment. Firstly, no sand medium was placed into the plastic containers, but each test specimen was placed directly onto the inner base of the plastic container. Secondly, only 100 workers of *C. cynocephalus* were introduced into each container. Thirdly, the duration of the trial was 12 weeks. At the conclusion of the trial, test specimens were assessed for damage caused by *C. cynocephalus* using the ASTM D 3345 rating system. Termite survival data were also obtained.

III. RESULTS AND DISCUSSION

A. Field and Semi-laboratory Trials

Results of the field and semi-laboratory trials are summarized in Tables 1 and 2. The results showed that the bifenthrin-treated test specimens were either superficially damaged by termites (i.e. nibbles/grazing) or sound (rating of 10; no damage) (Figure 1). Noteworthy was that any damage to the treated or untreated test specimens in the field trial was caused solely by *M. gilvus*. In all cases, damage caused by termites was confined to the cut ends that exposed the untreated cores of the superficially-treated test specimens (Figure 2). Surfaces of test specimens that were superficially-treated with bifenthrin sustained no damage. In contrast, damage sustained by the untreated control test specimens ranged from light (rating of 9; light attack) to totally destroyed (rating of 0; failure). At the conclusions of the field and semi-laboratory trials, there appeared to be a positive correlation between damage sustained and the numbers of foraging termites in contact with test specimens (Tables 1 and 2). This observation was most likely indicative of the well-known repellent effect of bifenthrin on termites. The results of the field and semi-laboratory trials have clearly demonstrated that the superficial treatment of bifenthrin protected test specimens of radiata pine framing material from significant damage by two of Indonesia's most economically important species of subterranean termites, i.e., *C. curvignathus* and *M. gilvus.*

Figure 1. Test specimens after exposure to termites in the field trial for 6 months (Left: untreated test specimen infested by *M. gilvus*; Right: treated test specimen remained sound).

Table 1. Mean[a] of damage rating, termite survival and termite contact with treated and untreated control test specimens at the conclusion of the field and semi-laboratory trials against *M. gilvus*

		Macrotermes gilvus	
	Treatment	Field	Semi-laboratory
Damage rating[b]	0% (Control)	2.4 ± 2.3	8.6 ± 1.4
	0.02% m/m	9.6 ± 0.5[d]	10 ± 0.0
Termite contact[c]	0% (Control)	>300	0 ± 0.0*
	0.02% m/m	0 ± 0.0	0 ± 0.0

[a] Means of five replicate test specimens.
[b] Damage ratings based upon ASTM D 3345.
[c] Numbers of foraging termites in contact with test specimen at the conclusion of the trial.
[d] Damage confined to the exposed cut ends of treated test specimens.
* Termites were not present at the conclusion of the trial.

Figure 2. Slight damage to the exposed cut end of a bifenthrin-treated test specimen during the semi-laboratory trial with *C. curvignathus*.

Table 2. Mean[a] of damage rating, termite survival (%) and termite contact with treated and untreated control test specimens at the conclusion of the laboratory and semi-laboratory trials against *C. curvignathus*

		Coptotermes curvignathus	
	Treatment	Laboratory	Semi-laboratory
Damage rating[b]	0% (Control)	7 ± 0.0	5.5 ± 1.7
	0.02% m/m	9.8 ± 0.5[d]	9.8 ± 0.5[d]
Termite survival (%)	0% (Control)	91.0 ± 3.0	
	0.02% m/m	11.9 ± 9.9	
Termite contact[c]	0% (Control)		11.5 ± 11.6
	0.02% m/m		2.8 ± 3.8

[a] Means of five replicate test specimens.
[b] Damage ratings based upon ASTM D 1758 and ASTM D 3345.
[c] Numbers of foraging termites in contact with test specimen at the conclusion of the trial.
[d] Damage confined to the exposed cut ends of treated test specimens.

B. Laboratory Trials

Results of the laboratory trials against the subterranean termite *C. curvignathus* and the drywood termite *C. cynocephalus* are provided in Tables 2 and 3, respectively. These data have again demonstrated that termites were unable to damage test specimens of radiata pine framing material that were superficially treated with bifenthrin. When the test specimens were exposed to *C. curvignathus* and *C. cynocephalus*, the mean damage ratings for treated test specimens were 9.8 and 10 (sound), respectively (Tables 2 and 3). Surface nibbling by *C. curvignathus* was found only on the exposed cut ends of some of the treated specimens. In contrast, mean damage ratings for the untreated control test specimens were 7 (moderate damage) and 5.2 (heavy to moderate damage), respectively.

Meanwhile, mean of termite survival for *C. curvignathus* and *C. cynocephalus* employed on the treated samples at the conclusion of the laboratory trials was 11.9% and 0%, respectively (Tables 2 and 3). In contrast, when the termites were employed on the untreated test specimens, mean termite survival for *C. curvignathus* and *C. cynocephalus* was very high, reaching 91.0% and 89.0%, respectively.

Results of the two laboratory trials (*C. curvignathus* and *C. cynocephalus*) supported those obtained from the field and semi-laboratory trials (*C. curvignathus* and *M. gilvus*). Furthermore, the results have shown that the superficial treatment of bifenthrin clearly protected test specimens of radiata pine framing material from damage by two subterranean termite species, *C. curvignathus* and *M. gilvus* and a drywood termite species *C. cynocephalus*, the most economically important species of termites in Indonesia.

Table 3. Mean[a] of damage rating and termite survival at the conclusion of the laboratory trial with the drywood termite *C. cynocephalus*

Cryptotermes cynocephalus		
	Treatment	Laboratory
Damage rating[b]	0% (Control)	5.2 ± 1.7
	0.02% m/m	10 ± 0.0
Termite survival (%)	0% (Control)	89 ± 14.7
	0.02% m/m	0 ± 0.0

[a] Means of five replicate test specimens.
[b]Damage ratings based upon ASTM D 3345.

These results are in line with those of previous investigations using other pyrethroid preservatives, i.e. deltamethrin and permethrin (Peters and Creffield, 2004). Effectiveness of superficial treatment can not only be achieved using preservative treatment but also using certain coating material, even though it is only effective against bostrychid wood borer beetle, *Heterobostrychus aequalis* (Sukartana, 2008). However, the superficial treatment will be only effective if the timbers are still really sound, which is no hidden (initial) insect attack inside the timber before the treatment is applied because such insect attack may probably develop further since this part is not penetrated by the preservative treatment.

Repellent effect, nonetheless, will play an important role for the superficial treatment effectiveness, so the exposed cut ends or any parts that are still untreated will not be grasped by the termite coming from outside. This treatment method may also reduce using preservative because penetrating the whole part of timber with the toxic chemical is not necessary.

IV. CONCLUSION

A superficial treatment that is also called envelope treatment using befenthrin for radiata pine timber seems effective against subterranean termites, *M. gilvus* and *C. curvignathus,* and drywood termite, *C. cynocephalus*. Any initial termite attack on the exposed cut ends that are not penetrated by the toxic chemical does not develop further because of the repellent effect, and therefore, supplementary treatment on that area is not necessary.

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