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by

J. Kenneth Grace and Robin T. Yamamoto

Department of Entomology
University of Hawaii
Honolulu, Hawaii 96822-2271
USA

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S - 114 86 Stockholm
Sweden

Sequential Exposure of Borate Treated Douglas-fir to Multiple Formosan Subterranean Termite Colonies in a 40-Week Field Test[1]

J. K. Grace and R. T. Yamamoto

Department of Entomology, University of Hawaii, Honolulu, HI 96822-2271, USA

ABSTRACT

Douglas-fir boards (ca. 74.5 g) pressure-treated with disodium octaborate tetrahydrate (DOT) to retentions of 0 (controls), 0.88, 1.23, 1.60, or 2.10% (weight/weight) DOT were sequentially exposed to four active field colonies of Formosan subterranean termites, *Coptotermes formosanus* Shiraki (Isoptera: Rhinotermitidae), in an above-ground field test. Samples were placed in contact with each colony for 10 weeks, with oven-dry weight losses determined between exposures, for a total termite exposure period of 40 weeks. Feeding activity differed among termite colonies, with the control wood samples having mean weight losses of 1.3 - 15.1% of their initial weight during each individual 10-week termite exposure. The two lower borate retentions (0.88 and 1.23% DOT) were virtually equal in efficacy, with mean wood weight losses during each individual 10-week exposure ranging from 1.2 - 4.6%. Feeding was negligible at the two higher borate retentions, with mean wood weight losses from termite feeding during each 10-week period ranging from 0.7 - 1.3% with 1.60% DOT, and 0.3 - 0.9% with 2.10% DOT. Total cumulative wood weight losses over the 40 week exposure were: 10.2% (0.88% DOT), 8.7% (1.23% DOT), 3.6% (1.60% DOT), and 2.4% (2.10% DOT).

KEYWORDS: *Coptotermes formosanus*, wood preservative, termite control, Rhinotermitidae, Isoptera

1 INTRODUCTION

Douglas-fir (*Pseudotsuga menziesii* [Mirb.] Franco) lumber, pressure-treated with various wood preservatives, is used extensively in building construction in western North America and Hawaii (Wilcox 1984). In Hawaii, termites (Isoptera) are generally more destructive than decay fungi to wood in service, and the most destructive termite species is the Formosan subterranean termite, *Coptotermes formosanus* Shiraki (Family Rhinotermitidae). Recently, disodium octaborate tetrahydrate (DOT, as TIM-BOR®) has become available in Hawaii as a pressure treatment for Douglas-fir (Anonymous 1991). Lumber stamped with the HI-BOR® quality mark has a minimum retention of 1.1% DOT (1.32% BAE, or Boric Acid Equivalents) by weight in an 0.6-inch assay zone (M.J. Manning, pers. commun.).

A previous 23-week field test established that a cross-sectional retention of 0.85% DOT (1.02% BAE) was sufficient to restrict wood weight loss from termite feeding to less than 3% of the initial weight (Grace et al. 1992). These results raised the question of whether this very minor feeding could be further minimized by treatment to even higher DOT retentions; that is, whether any retention of DOT was sufficient to guarantee that minor cosmetic damage would not occur. We also wished to determine whether repeated termite invasions over the life of a structure and attempts to feed on the treated wood by different Formosan subterranean termite colonies could lead to greater cumulative damage to the wood.

[1]Research results reported here have been submitted for publication in a refereed journal.

In the present study, Douglas-fir lumber pressure-treated to cross-sectional retentions from 0.88-2.10% DOT (1.06-2.52% BAE) was exposed sequentially to three separate *C. formosanus* field colonies, and twice to the first termite colony, for a total of four sequential 10-week field tests. We used a rigorous field test protocol, in which the wood samples were placed directly into active termite feeding sites within traps established to monitor and collect termites from each of these colonies (Tamashiro et al. 1973; Grace et al. 1992).

2 MATERIALS AND METHODS

Douglas-fir heartwood samples measuring 3.5 by 3.5 by 0.75 inches (weighing about 74.5 g) were pressure impregnated with DOT (TIM-BOR®, United States Borax and Chemical Corporation, Los Angeles, Calif.) by a modified full-cell process (M.J. Manning, pers. commun.). DOT retentions were determined by weight gain, and confirmed by ashing selected samples, extracting the residue, and using inductively coupled plasma (ICP) spectroscopy to determine boron in solution (M.J. Manning, pers. commun.). Four wood samples each were pressure-impregnated to retentions of 0.88, 1.23, 1.60, or 2.10% DOT.

Four sequential 10-week above-ground field tests (total 40-week exposure) were conducted using Formosan subterranean termite colonies located on the Manoa campus of the University of Hawaii, and at the Poamoho Experiment Station near Waialua on the island of Oahu, Hawaii. Wood samples were oven-dried (90°C for 72 hours) before and after each termite exposure to determine weight losses from termite feeding. Each wood sample was placed over the open end of a rectangular box (termite trap) constructed of untreated Douglas-fir and placed on the soil surface, protected by a covered 5-gallon metal can with the bottom removed. This trap design was first described by Tamashiro et al. (1973) as a means of collecting termites, and has been used in field evaluations of ACZA (Tamashiro et al. 1988) and DOT (Grace et al. 1992). In all cases, termites had been actively foraging on an untreated wooden box placed within each can immediately prior to its replacement with a new box and the test sample.

After three sequential 10-week exposures, each to a different termite colony, the samples were exposed again for 10 weeks to the first colony tested, since this colony was noted to have fed considerably more on the control (untreated) samples than either of the other two termite colonies. Differences in feeding activity among termite colonies have been documented in other studies (Su and LaFage 1984), although the basis of these differences is not understood. The foraging populations of the three colonies were estimated, using a mark-release-recapture method (Grace 1992), to be approximately 1.0, 1.6, and 2.4 million.

Weight losses of the test samples after each 10-week termite exposure, and cumulative weight losses after 40 weeks, were subjected to analysis of variance (ANOVA) and means significantly different at the 0.05 level were separated by Duncan's multiple range test (SAS 1987).

3 RESULTS AND DISCUSSION

At least minor evidence of termite feeding was noted on all test samples, and the degree of cosmetic damage was negatively correlated with DOT retention. With wood treated to the highest retention of 2.10% DOT (2.52% BAE), extremely shallow feeding depressions were visible on the wood surface at the end of the 40 weeks of termite exposure. However, weight losses from termite "tasting" at 2.10% DOT averaged less than 1% of the initial wood weight during each 10-week exposure, for a cumulative weight loss of only 2.4% after 40 weeks (Table 1 and 2).

With wood treated to the lowest preservative retention of 0.88% DOT (1.06% BAE), the mean cumulative wood weight loss after 40 weeks of 10.2% (Table 2) exceeded the 2.5% weight loss recorded in our previous field test with wood treated to a comparable retention (0.85% DOT) after 23 weeks of exposure to a single *C. formosanus* colony (Grace et al. 1992). These results indicate that increasing damage to DOT-treated wood can occur from repeated exploratory attacks by different termite colonies, although each attack may be of brief duration. However, it must be emphasized that this was an extremely rigorous field test in which wood samples were physically moved from colony to colony. In practice, the likelihood of attack on wood in service in structures by multiple Formosan subterranean termite colonies should be much less than was the case in this field test, and such attacks would only occur over a period of many years.

In our view, it is prudent to consider any preservative-treated wood as "termite-resistant" rather than "termite-proof," and as one component of a termite management program. Termite-resistant architectural design, frequent building inspections, and the presence of chemical or physical barriers in the soil beneath and around the structure are important in reducing termite pressure on both the treated wood and other cellulosic materials within the structure. Under conditions of high Formosan subterranean termite hazard, wood treatment to retentions greater than 1% DOT can be expected to provide protection from serious structural damage, while progressively higher DOT retentions can be expected to progressively minimize, although not completely eliminate, the possibility of minor cosmetic damage to the wood surface.

4 ACKNOWLEDGMENTS

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TABLE 1. Mean weight losses from termite feeding on borate-treated Douglas-fir boards (ca. 74.5 g) during each sequential 10-week exposure to four Formosan subterranean termite field colonies.

DOT	BAE	Mean (+SD) Wood Weight Losses During Sequential 10-Week Termite Exposures[1]							
		1st		2nd		3rd		4th	
%	%	g	%	g	%	g	%	g	%
2.10	2.52	0.7±0.2a	0.9±0.2	0.4±0.3a	0.6±0.4	0.3±0.2a	0.4±0.3	0.5±0.2a	0.7±0.3
1.60	1.92	0.6±0.1a	0.7±0.1	0.7±0.5ab	0.8±0.5	0.8±0.4ab	0.9±0.5	1.0±0.4a	1.3±0.5
1.23	1.48	1.3±0.7a	2.0±1.0	0.7±0.2ab	1.2±0.4	2.7±2.1b	4.4±3.4	0.9±0.8a	1.5±1.3
0.88	1.06	1.6±1.2a	2.0±1.4	1.0±0.5ab	1.2±0.5	2.5±2.2ab	3.1±2.7	3.4±1.2ab	4.6±1.7
0	0	10.9±4.3b	15.1±5.9	1.1±0.4b	1.6±0.5	1.0±1.0ab	1.3±1.4	10.1±10.4b	14.1±14.7

[1]Each mean represents four boards pressure-treated with disodium octaborate tetrahydrate (DOT), expressed as cross-sectional weight/weight percentage. New control boards were used during each exposure. Means within a column followed by the same letter are not significantly different (ANOVA, Duncan's Multiple Range Test, $p = 0.05$).

TABLE 2. Cumulative mean weight losses of borate-treated Douglas-fir boards (ca. 74.5 g) during four 10-week exposures to four Formosan subterranean termite field colonies.

		Cumulative Mean (+SD) Wood Weight Losses Over Four 10-Week Termite Exposures[1]							
		10 Weeks		20 Weeks		30 Weeks		40 Weeks	
DOT %	BAE %	g	%	g	%	g	%	g	%
2.10	2.52	0.7±0.2	0.9±0.2	1.1±0.2	1.4±0.2	1.4±0.4	1.8±0.5	1.9±0.5a	2.4±0.8
1.60	1.92	0.6±0.1	0.7±0.1	1.3±0.5	1.5±0.5	2.0±0.9	2.4±1.0	3.1±0.7ab	3.6±0.8
1.23	1.48	1.3±0.7a	2.0±1.0	2.0±0.5	3.1±0.6	4.7±1.9	7.4±3.0	5.6±1.5b	8.7±2.3
0.88	1.06	1.6±1.2a	2.0±1.4	2.6±0.8	3.1±0.8	5.1±2.9	6.1±3.4	8.5±3.1c	10.2±3.6

[1]Each mean represents four boards pressure-treated with disodium octaborate tetrahydrate (DOT), expressed as cross-sectional weight/weight percentage. Means in the 40-weeks column followed by the same letter are not significantly different (ANOVA, Duncan's Multiple Range Test, $p = 0.05$).

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