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Comparative Response of *Reticulitermes flavipes* and *Coptotermes formosanus* to Borate Soil Treatments

by

J. Kenneth Grace

Department of Entomology
3050 Maile Way
University of Hawaii
Honolulu, Hawaii 96822
USA

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Comparative Response of *Reticulitermes flavipes* and *Coptotermes formosanus* to Borate Soil Treatments[1,2]

J. Kenneth Grace

Department of Entomology, 3050 Maile Way, University of Hawaii
Honolulu, Hawaii 96822, USA

ABSTRACT
Eastern (*Reticulitermes flavipes* [Kollar]) and Formosan (*Coptotermes formosanus* Shiraki) subterranean termite workers (Isoptera: Rhinotermitidae) were exposed to borate-treated sand in an indirect exposure tunneling assay in the laboratory. In the ten day assay period, both termite species readily penetrated sand containing 5000, 10000, or 15000 ppm (wt. of compound / wt. of sand) disodium octaborate tetrahydrate (Tim-Bor®) or zinc borate (Firebrake ZB-Fine®). With *R. flavipes*, significant mortality (85-93%) resulted from workers tunneling through sand treated with 5000 ppm disodium octaborate tetrahydrate (higher concentrations were also effective), or 15000 ppm zinc borate. Responses of *C. formosanus* workers were lesser and more variable, with only concentrations of 10000 and 15000 ppm zinc borate resulting in mortality (70-89%) significantly different from that in the control groups. These results suggest that differences between these two species in tunneling behavior may reduce exposure of *C. formosanus* to the borate-treated sand.

KEYWORDS: termite control, disodium octaborate tetrahydrate, zinc borate, Rhinotermitidae, Isoptera

1 INTRODUCTION

Boric acid and boron salts are effective termiticides (Randall *et al.* 1934; Reierson 1966; Williams & Amburgey 1987; Grace 1990b; Grace & Abdallay 1990), although the basis of their toxicity is not well understood (Williams *et al.* 1990). Sodium and zinc borates are used in wood preservation (Williams & Amburgey 1987; Barnes *et al.* 1989) and are currently of interest as soil insecticides (Grace 1990a), bait toxicants (D'Orazio 1982; Mori 1987; Grace 1990b; Grace *et al.* 1990), and termiticidal dusts (Grace & Abdallay 1990).

This conference report to the International Research Group on Wood Preservation summarizes the results of recent studies of borates as soil treatments to control Formosan subterranean termites, *Coptotermes formosanus* Shiraki (Isoptera: Rhinotermitidae), and compares the response of *C. formosanus* to that of the eastern subterranean termite, *Reticulitermes flavipes* (Kollar). Commercially available disodium octaborate tetrahydrate and a fine-grain zinc borate were evaluated.

[1]This conference report for circulation to the members of the International Research Group on Wood Preservation summarizes research results submitted for publication elsewhere in a refereed journal.

[2]Journal Series No. 3539 of the Hawaii Institute of Tropical Agriculture and Human Resources.

2 MATERIALS AND METHODS

2.1 Termite collection

Termites were collected from active field colonies, using previously published trapping techniques, just prior to their use in the laboratory studies. Eastern subterranean termites, *R. flavipes*, were collected from traps consisting of corrugated cardboard rolled within short lengths of plastic pipe buried just below the soil surface at an urban site in Toronto, Ontario (Grace 1989). Formosan subterranean termites, *C. formosanus*, were collected from boards placed in traps on the soil surface at the Manoa campus of the University of Hawaii (Tamashiro *et al.* 1973). Assays were performed with workers (pseudergates older than the third instar as determined by size) in unlighted incubators at 27±0.5°C for *R. flavipes* and 29±0.5°C for *C. formosanus*, and ca. 90% RH.

2.2 Assay materials

Two commercial borate powders were evaluated: disodium octaborate tetrahydrate (TIM-BOR®, 20.96% B, 1.20 Boric Acid Equivalents [BAE]), and a fine-grain (mean particle size = 3 microns) zinc borate (FIREBRAKE® ZB-Fine, 14.92% B, 0.86 BAE) (United States Borax & Chemical Corporation, Anaheim, CA). Other materials used in the assays differed slightly for the two termite species. *Reticulitermes flavipes* workers were kept in white silica sand (passing a U.S. 16-mesh screen) and fed strips of Whatman No. 1 filter paper (2 by 6 cm), while *C. formosanus* workers were maintained in crushed coral sand (passing a U.S. 20-mesh screen) and fed short lengths of wooden tongue depressors (1.5 by 2.5 cm) (Puritan No. 25-705, Hardwood Products Co., Guilford, Maine).

2.3 Tunneling assay

Termite workers were exposed to borate-treated sand in an assay described by Grace (1990a), and similar to that of Jones (1989, 1990) except that horizontal rather than vertical tunneling is recorded. This assay mimics indirect exposure to pesticide-treated soil in a field situation, in that termites are presented with the option of tunneling through treated sand to reach a second food source. The assay apparatus (Fig. 1) has three compartments: (1) a plastic vial containing untreated sand, termites and cellulosic food, (2) a glass "sandwich", or tunneling arena, containing the treated sand, and (3) a second vial containing untreated sand and an additional food source. These are connected serially by 1 cm lengths of Tygon tubing. The sandwich-like tunneling arena consists of two glass microscope slides (2.5 by 7.5 cm) spaced 3-4 mm apart and secured in a horizontal upright position on one long edge by silicone rubber sealant (General Purpose Clear Sealant, Dow Corning Corp., Midland, MI) to a third flat glass slide as a base. The ends of the tunneling arena are sealed with plastic spacers and silicone caulking, with a 1 cm long Tygon tube at the base of each end of the sandwich leading into the base of one of the two 55 ml (15 dram) polystyrene vials (60 by 35 mm diameter). Each of these vials contains 10-15 g untreated sand, 2-3 ml water, and either a strip of filter paper or piece of wooden tongue depressor as food.

Each of the borate powders was thoroughly mixed in oven-dried sand to achieve compound concentrations of 5,000, 10,000 or 15,000 ppm (wt. of compound / wt. of sand). Previous assays (Grace 1990a) have evaluated disodium octaborate tetrahydrate at 2,500 ppm, the rate recommended in experimental soil applications of this material in the United States (E. Docks, US Borax & Chemical Corp., personal communication). In the language of termiticide labels, this latter concentration is equivalent to 1 lb. disodium octaborate tetrahydrate (1 gal. TIM-BOR®) per 10 square feet of soil (assuming penetration of ca. 2 inches of soil).

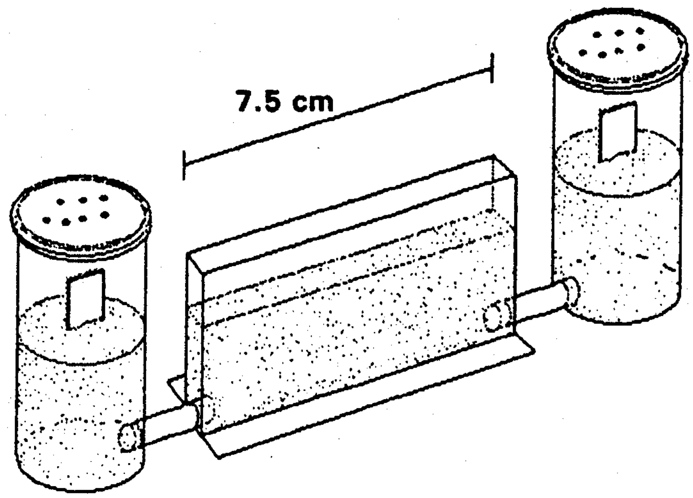

Figure 1 Assay apparatus for measuring tunneling by *R. flavipes* and *C. formosanus* workers. Termites placed in one of the vials containing sand and cellulosic food must tunnel through the chemically-treated sand in the center tunneling arena (constructed of microscope slides) to reach the second vial. Short lengths of plastic tubing create an airspace between the untreated sand in the vials and the treated sand in the tunneling arena.

The treated sand (ca. 9 g) was poured into the tunneling arena, and 1.5 ml water added by pipette along the open top edge. The addition of water visibly moistened the sand to the base of the tunneling arena. The top edge of each tunneling arena was sealed with plaster of paris (to retain moisture), and 50 termite workers placed in one of the adjacent vials. The vials were capped (a heated insect pin was used to pierce air holes in the caps), and the three-chamber apparatus placed in the incubator. Each treatment was replicated 6 times. At 10 days, total tunneling distance in the arena and termite mortality were recorded and subjected to analysis of variance (ANOVA), and significant means separated by the Ryan-Einot-Gabriel-Welch Multiple F Test (REGWF), $\alpha \leq 0.05$ (SAS Institute 1987). Tunneling distances could exceed the 7.5 cm length of the arena due to sinuous tunnels or multiple tunnels occurring within a single sandwich. Percentage mortality data was transformed by the arcsine of the square root prior to analysis.

3 RESULTS AND DISCUSSION

Neither disodium octaborate tetrahydrate nor zinc borate inhibited tunneling by *R. flavipes* and *C. formosanus* in treated sand, even at concentrations as high as 15,000 ppm (Table 1). However, ten days exposure to borate-treated sand elicited significant mortality in *R. flavipes*. At 5,000 ppm disodium octaborate tetrahydrate, *R. flavipes* mortality ($85.33 \pm 8.76\%$) was similar to that ($80.56 \pm 3.38\%$) reported in a similar assay with an aqueous solution of this compound (Grace 1990a). Less, and more variable, mortality was noted with *C. formosanus*, with only zinc borate at 10,000 and 15,000 ppm eliciting mortality significantly different from the controls. Penetration of the tunneling arena generally occurred within 24 hours and *C. formosanus* tended to excavate fewer and larger galleries than *R. flavipes*, which could have served to reduce exposure of the former species to the treated sand once the initial gallery was constructed. *Coptotermes formosanus* has also been observed "covering" insecticide-treated soil with bits of masticated wood and filter paper (unpublished observations), suggesting that this species may have an ability to reduce exposure to the treated sand by lining its galleries. Subterranean termite colonies are characteristically lined with excreta (Klee and Wood 1971).

Table 1 Tunneling and mortality of *R. flavipes* and *C. formosanus* workers in sand treated with Tim-Bor® (disodium octaborate tetrahydrate) or Firebrake ZB-Fine® (zinc borate).

		Reticulitermes flavipes		*Coptotermes formosanus*	
Compound	ppm[1]	Tunneling Distance (cm)[2]	Percent Mortality[2]	Tunneling Distance (cm)[2]	Percent Mortality[2]
Tim-Bor®	5,000	8.27 ± 0.85a	85.33 ± 8.76ab	5.28 ± 1.61a	19.67 ± 2.39bc
	10,000	9.10 ± 1.38a	92.00 ± 6.53a	7.78 ± 0.52a	50.00 ± 17.46abc
	15,000	8.10 ± 0.60a	94.33 ± 2.03a	6.28 ± 1.10a	57.33 ± 14.37abc
Firebrake ZB-Fine®	5,000	9.05 ± 1.71a	52.33 ± 6.44c	4.68 ± 2.55a	32.33 ± 13.96abc
	10,000	8.88 ± 1.25a	69.00 ± 3.99bc	7.87 ± 1.57a	89.00 ± 6.17a
	15,000	8.50 ± 0.95a	93.33 ± 2.29a	7.05 ± 1.88a	69.67 ± 14.38ab
Control (Water)		9.85 ± 0.97a	9.67 ± 2.60d	6.05 ± 0.87a	7.33 ± 1.84c

[1]Weight of compound to weight of sand. Powdered compounds were mixed dry in dry sand.

[2]Mean ± SEM of 6 groups of 50 termite workers. Means within each column followed by the same letter are not significantly different (ANOVA, REGWF, $\alpha \leq 0.05$).

The results of these and other (Grace 1990a) tunneling assays demonstrate that treatment of the soil with disodium octaborate tetrahydrate or zinc borate does not create a barrier to termite penetration, as is expected of conventional termiticides (Jones 1989; Smith & Rust 1990). Although treatment of cellulosic materials with high concentrations of disodium octaborate tetrahydrate can deter termite feeding (Williams & Amburgey 1987; Grace *et al.* 1990), borates generally fit the profile of slow-acting non-repellent, or type III (Su *et al.* 1982), toxicants. Current soil treatments around buildings with fast-acting or repellent termiticides have little effect on termite populations outside of the narrow band of treated soil (Su & Scheffrahn 1988; Grace *et al.* 1989). However, passage of termite foragers through borate-treated soil could be expected to gradually reduce the termite population. This study indicates that borate treatment of a band of soil outside of the primary perimeter treatment or around food sources such as stumps (Grace 1990a) may prove more effective with *R. flavipes* than with *C. formosanus*.

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