Diatomaceous Earth is Not a Barrier to Formosan Subterranean Termites (Isoptera: Rhinotermitidae)

By

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ABSTRACT

Diatomaceous earth is an abrasive desiccant of value in pest control. We tested the efficacy of diatomaceous earth as a barrier to foraging Formosan subterranean termites, *Coptotermes formosanus* Shiraki. In a 4-day laboratory tunneling assay, diatomaceous earth did not prevent termite penetration, nor cause significant mortality. Termites also penetrated a layer of diatomaceous earth in a 4-week tunneling assay, although mortality exceeded that observed in the controls. This elevated mortality suggests that diatomaceous earth may be effective as a desiccant against termites in attics or other dry above-ground structural cavities. However, it should not be relied upon to prevent penetration of the soil surface by foraging subterranean termites.

KEYWORDS: *Coptotermes formosanus*, physical barrier, termite control

INTRODUCTION

The Formosan subterranean termite, *Coptotermes formosanus* (Isoptera: Rhinotermitidae) is the most destructive insect pest in the Hawaiian Islands. The costs of termite control and repairs in Hawaii have been estimated to exceed $100 million annually (Tamashiro *et al.* 1990b). Soil insecticides remain the principal method of subterranean termite control (Grace *et al.* 1993a, 1993b), although use of the commercially available gravel (uniform particle size) Basaltic Termite Barrier (BTB) as a preventative measure is increasing. The characteristics of this particle barrier have been described by Tamashiro *et al.* (1987, 1990b, 1991). Recently, Su *et al.* (1991) and Su & Scheffrahn (1992) evaluated quartz and coral sand barriers against Formosan and eastern subterranean termites in the laboratory and field, and Smith & Rust (1990) tested granite particles against *Reticulitermes hesperus* Banks.

Ebeling & Pence (1957) first demonstrated in laboratory assays that sand and volcanic cinder barriers prevented penetration by *R. hesperus*.

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In another low-toxicity approach, Ebeling & Wagner (1959, 1961) and Wagner & Ebeling (1959) also demonstrated the efficacy of various inert sorptive powders, such as silica aerogel, against the drywood termite *Incisitermes minor* (Hagen). Diatomaceous earth (diatomite) is an inert dust that is both sorptive and abrasive in its action against insects. Recent articles in pest control trade journals (St. Aubin 1991; Quarles 1992; Katz 1993) have reported renewed interest in the use of diatomaceous earth as a desiccant against household pests.

Our study was stimulated by reports (C. Uyehara, pers. commun.) that an Arizona pest control operator had observed that diatomaceous earth placed on the surface of soil in crawl spaces beneath homes prevented subterranean termite penetration. Use of diatomaceous earth in this fashion is analogous to the post-construction use of sand barriers in crawl spaces for subterranean termite control (Ebeling & Forbes 1988). Although it seemed likely that diatomaceous earth would absorb moisture from the soil, limiting its desiccant action, it was possible that its abrasive action might result in physical damage and desiccation of termite foragers that would be sufficient to prevent penetration of the diatomite barrier. Thus, we performed 2 sets of laboratory assays to test the efficacy of diatomaceous earth as a barrier to *C. formosanus*.

MATERIALS AND METHODS

Diatomaceous earth sold for commercial pest control (White Mountain Diatomaceous Earth P-1858A, White Mountain of America, Sandy, UT) was provided by Diacide Distributors of Hawaii (Hilo, HI). Formosan subterranean termites were collected as needed from the Manoa campus of the University of Hawaii using a trapping method described by Tamashiro et al. (1973).

The first tunneling assay performed was the standard test used in our laboratory to evaluate particle barriers and insecticide-treated soils (Tamashiro *et al.* 1990a; Grace *et al.* 1993b). In this assay, 4cm of dry diatomaceous earth, clay soil (Poamoho Agricultural Experiment Station, Waialua, HI), or loamy sand (Dune Sand, Ameron HC&D, Honolulu, HI) was sandwiched between two plugs of 8% agar in a 13mm diameter glass tube. Paper toweling was provided at each end of the tube for food, 150 termites (131 workers and 19 soldiers) were placed in the bottom of the tube, and the ends were sealed with metal caps. The distance tunneled upward through the test substrate was measured daily, and termite mortality was recorded after 4 days of incubation in an unlighted temperature cabinet at 29 ± 0.5°C. Percentage mortality was transformed by the arcsine of the square root and subjected to analysis of variance (ANOVA), with means significantly different at the 0.05 level separated by the Ryan-Einot-Gabriel-Welsch multiple F test (SAS Institute 1987).

A second tunneling assay was also performed to simulate field use of diatomaceous earth as barrier on top of the soil surface. In this assay, a 0.5 cm layer of silica sand (Silica S151 [Fine Granular Silicon Dioxide], Fisher Scientific, Fair Lawn, NJ) was placed in the bottom of a wide-mouth 8cm diameter by 10cm high plastic screw-top jar. Termites (360 workers and 40 soldiers) were placed in an open 3.5cm plastic Petri dish, which was then covered with Parafilm (American Can Co., Greenwich, CT) containing pin holes for gas exchange. The Petri dish was turned upside down, placed upside down on the sand surface, and covered with ca. 1.5cm of sand (total of 150g). Distilled water (28ml) was added to moisten the sand, and a 2cm layer of diatomaceous earth (50g) was poured over the sand. Silica sand alone was used in place of diatomaceous earth in the controls. A 2x2x2cm cube of western hemlock (*Tsuga heterophylla* [Rafn.] Sarg.) was placed on the surface of the diatomaceous earth (or sand in the controls) as the target food for the termites. The termites readily tunneled down through the Parafilm containing them within the Petri dish, then up through the sand to reach the test barrier, and ultimately the hemlock cube. Treatments and controls were replicated 5 times, and placed in an unlighted temperature cabinet (29 ± 0.5°C) for 4 weeks (28 days). Wood consumption was estimated by visual examination, and termite mortality and the distance penetrated through the test substrate were recorded. Percentage wood consumption and termite mortality were transformed by the arcsine of the square root and compared by *t*-test at the 0.05 level (SAS Institute 1987).

RESULTS AND DISCUSSION

In the 4-day tunneling assay, termites completely penetrated all of the clay soil and loamy sand replicates, and 3 of the 5 diatomaceous earth replicates within 24 hours. The remaining 3 diatomaceous earth replicates were penetrated by 48 hours (Table 1). Termite mortality from exposure to diatomaceous earth did not exceed that observed in the clay controls.

In the 4-week assay, termites also rapidly penetrated the layer of diatomaceous earth to feed on the hemlock cube. In this longer-term test, mortality from exposure to the diatomaceous earth (38.75 ± 6.60%) was approximately twice that observed in the sand controls (16.20 ± 7.03) (Table 2). This elevated mortality, although not extremely high for a test of this duration, resulted in slightly decreased feeding on the wood

Table 1. Penetration and mortality of Formosan subterranean termites (150 per replicate) exposed to 4 cm of clay soil, loamy sand, or diatomaceous earth in a four-day tunneling assay.

Substrate	% Penetration	% Mortality	Mean (± SD) %Mortality*
Clay soil	100	7.33	11.20 ±2.89a
	100	12.00	
	100	9.33	
	100	14.67	
	100	12.67	
Loamy sand	100	5.33	5.73 ± 2.52b
	100	10.00	
	100	4.67	
	100	3.33	
	100	5.33	
Diatomaceous earth	100	7.33	9.73 ± 2.14a
	100	10.67	
	100	8.00	
	100	12.67	
	100	10.00	

*Means followed by the same letter are not significantly different (ANOVA of transformed percentages, Ryan-Einot-Gabriel-Welsch multiple F test, $\alpha=0.05$).

cube, and indicates that diatomaceous earth is termiticidal to some extent. However, it did not act as a barrier to foraging termites, nor prevent damage to the hemlock cube. This is similar to the situation

Table 2. Penetration, wood consumption, and mortality of Formosan subterranean termites (400 per replicate) forced to tunnel through 2 cm of sand or diatomaceous earth to reach a food source in a four-week laboratory assay.

Substrate	% Penetration	Estimated % Wood Consumption*	Mean (±SD) % Consumption**	% Mortality	Mean (± SD) %Mortality**
Silica sand	100	50	50 ± 0	28.50	16.20 ± 7.03
	100	50		15.50	
	100	50		11.75	
	100	50		13.25	
	100	50		12.00	
Diatomaceous earth	100	25	28 ± 4	41.25	38.75 ± 6.60
	100	25		45.75	
	100	33		28.00	
	100	33		40.50	
	100	25		38.25	

*Visual estimate of wood consumption.
**Means are significantly different (t-test of transformed percentages, $\alpha=0.05$).

with borate insecticides, which also kill termites (more rapidly than diatomaceous earth) but are not effective as soil barriers (Grace 1991). As was suggested by Grace (1991), subterranean termites move a great deal of soil as they tunnel and, after initially penetrating a "barrier," may be able to line their channels with imported soil to avoid contact with it.

No water was added directly to the diatomaceous earth in our assays. However, contact with the agar, damp sand, and the termites themselves undoubtedly increased the moisture content of the diatomite, interfering with its desiccant action. Even in dry habitats, movement of soil by subterranean termites as they tunnel upward would be likely to have this effect.

Desiccants, especially silica aerogel, have been used quite successfully to prevent penetration by termite (usually drywood) alates of wood in attics and other enclosed cavities in structures (Wagner & Ebeling 1959). The termite mortality observed in our second assay indicates that diatomaceous earth has potential for use in this fashion. However, its abrasive, desiccant, or other insecticidal properties are not sufficient for use as a barrier to prevent penetration of the soil surface by foraging subterranean termites.

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