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# TUNNELING BEHAVIOR OF THE FORMOSAN SUBTERRANEAN TERMITE (ISOPTERA: RHINOTERMITIDAE) IN DRY SOIL

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**Abstract** This study examines the effect of dry soil on tunnel construction by the Formosan subterranean termite, *Cptotermes formosanus*. Termites did not construct tunnels in dry soil in any of the treatments. Termites only constructed tunnels in moist areas in treatments where the soil was partially moistened. This research demonstrates the importance of limiting moisture in buildings at risk for attack by subterranean termites.
**Key Words** Moisture, barrier, foraging, water

## INTRODUCTION

Many studies have examined the influence of moisture on the tunneling and feeding behavior of subterranean termites (Evans, 2003; Su and Puche, 2003; Arab and Costa-Leonardo, 2005; Green et al., 2005; McManamy et al., 2008; Cornelius and Osbrink, 2010). Subterranean termites are highly susceptible to desiccation. In order to tunnel into dry soils, termites need to relocate water molecules from moist soil into the dry soil by using their salivary reservoirs as water sacs (Grube and Rudolph, 1999a, 1999b; Gallagher and Jones, 2010). Both soil type and moisture availability affected the foraging behavior of the Formosan subterranean termite, *Coptotermes formosanus* Shiraki (Cornelius and Osbrink, 2010). The current study examines the effect of dry soil on tunnel construction.

## MATERIALS AND METHODS

### Termite Collection and Maintenance

Termites were collected from field colonies in City Park, New Orleans, LA, using cylindrical irrigation valve boxes (22.5 cm by 14.8 cm) (NDS, Lindsay, CA) buried in the ground so that the lid was level with the surface of the soil and filled with blocks of wood (spruce, *Picea* sp.). The collected termites were maintained in the laboratory in 5.6- L covered plastic boxes containing moist sand and slats of spruce (8 cm by 4 cm by 0.5 cm) until they were used in experiments.

### Soil Types

For the foraging arena assays, three soil types were used: a uniformly coarse sand (20-30 mesh = .84-.59 mm) (Ottawa sand, VWR Scientific, West Chester, PA), a uniformly fine sand (100-120 mesh = .149-.125 mm) (Ottawa sand, Frey Scientific, Mansfield, OH.), and topsoil (GardenPlus, Hope Agri Products, Powerly, TX).

**Effect of soil type and moisture levels on tunneling in foraging arenas.** The experiment was conducted in the laboratory at ambient conditions, using plastic ant farms (21.0 cm length by 1.0 cm width by 13.5 cm height) (Uncle Milton Industries, Corsica, CA) as test chambers. A thin piece of red oak (7.6 cm x 1.0 cm x 0.3 cm) was placed in the bottom of each test chamber. Each test chamber had a portal on each side, covered with a plastic cap. The release chamber in each replicate was filled with sand until the sand reached the same height as the portal and moistened with 25 ml water. Termites were allowed to acclimate and construct a network of tunnels in the release chamber for 24 h before the release chamber was connected to a second chamber. The two test chambers were connected by removing the caps and attaching the ends of a 3-cm length piece of tygon tubing (0.8 cm diam.) to the portals of the two chambers. The second chamber in each replicate was filled with one of the following substrates: fine sand, coarse sand, or topsoil. There were five treatments with different moisture levels for each substrate. Treatments included: 1) dry: no moisture added; 2) moist: distilled water was added from the top until it thoroughly moistened soil; 3) proximate 10 ml: 10 ml of distilled water was added through the portal on the same side of the chamber that was connected to the release chamber; 4) 5 ml proximate: 5 ml of distilled water was added through the portal on the same side of the chamber that was connected to the release chamber; 5) 5 ml distal: 5 ml of distilled water was added through the portal on the opposite side of the chamber than the side that was connected to the release chamber. The area tunneled by termites in each foraging arena was measured after 3 d. Tunnels were traced on transparent film using a blue sharpie, and photographed. The tunneling area was measured using SigmaScan (SigmaScan Pro 5.0, SigmaScan 1999).

**Statistical Analysis**

The effect of soil type and treatment with different moisture levels on the area tunneled ($cm^2$) in foraging arenas was compared using a Kruskal-Wallis one-way ANOVA for both soil type and treatment. Means were separated using a Tukey's HSD test for all tests (Systat Software, 2008).

## RESULTS AND DISCUSSION

There were no significant differences in survival based on either soil type ($H = 0.95$; $df = 2$; $P = 0.62$) or treatment ($H = 0.80$; $df = 4$; $P = 0.94$). Although there were no significant differences in survival, the average survival of termites in the moist topsoil was only 53% (Table 1). It is possible that thoroughly moistened topsoil provided too much moisture for optimal conditions.

There were no significant differences in area tunneled based on soil type ($H = 1.2$; $df = 2$; $P = 0.55$). However, there were significant differences in area tunneled based on treatment ($H = 0.80$; $df = 4$; $P = 0.94$). Termites did not construct tunnels in dry soil in any of the treatments. In treatments where soil was only partially moistened, termites restricted tunnel construction to the moist areas of the arena. When soil was only moistened at the distal end of the arena, termites walked across the top of the soil until they reached the moistened area, and then they constructed tunnels downward into the moist soil. There were no tunnels in the chambers where no moisture was added. The only significant difference in area tunneled between treatments occurred in the treatment with completely dry sand (Tukey's HSD test: $P > 0.05$) (Table 1).

**Table 1.** Percent survival and area tunneled in test chambers with different moisture levels .

| Soil Type | Treatment | Mean (±SE) % Survival | Mean Area (±SE) ($cm^2$) Tunneled Per Soil Type | Per Treatment |
|---|---|---|---|---|
| Fine Sand | Moist | 87.9 ± 2.3 | 9.3 ± 0.8 | |
| Coarse Sand | Moist | 80.8 ± 6.6 | 8.5 ± 1.8 | 8.3 ± 0.9a |
| Topsoil | Moist | 52.6 ± 13.1 | 7.1 ± 1.9 | |
| Fine Sand | 10 ml | 77.7 ± 10.2 | 11.4 ± 1.4 | |
| Coarse Sand | 10 ml | 81.4 ± 2.9 | 10.3 ± 2.2 | 12.0 ± 1.5a |
| Topsoil | 10 ml | 82.8 ± 8.0 | 14.4 ± 3.9 | |
| Fine Sand | 5 ml Proximate | 69.3 ± 15.4 | 7.5 ± 1.9 | |
| Coarse Sand | 5 ml Proximate | 85.9 ± 7.9 | 3.0 ± 0.8 | 6.2 ± 1.0a |
| Topsoil | 5 ml Proximate | 71.6 ± 7.8 | 8.1 ± 1.4 | |
| Fine Sand | 5 ml Distal | 69.8 ± 19.8 | 7.9 ± 3.2 | |
| Coarse Sand | 5 ml Distal | 78.2 ± 3.8 | 5.9 ± 2.5 | 7.2 ± 1.4a |
| Topsoil | 5 ml Distal | 79.2 ± 6.0 | 7.9 ± 1.8 | |
| Fine Sand | Dry | 76.6 ± 4.3 | 0.0 ± 0.0 | |
| Coarse Sand | Dry | 69.3 ± 4.3 | 0.0 ± 0.0 | 0.0 ± 0.0b |
| Topsoil | Dry | 76.4 ± 11.7 | 0.0 ± 0.0 | |

Means followed by different letters within a column were significantly different (Kruskal-Wallis ANOVA, Tukey's HSD test: $P \leq 0.05$).

Termites are able to tunnel through dry soil by relocating water (Gallagher and Jones, 2010). However, termites did not construct tunnels in dry soil in this assay. When the second chamber was filled with dry soil, termites did not construct any tunnels and when the second chamber was filled with partially moist soil, termites restricted their tunnel construction to the moist soil. Cornelius and Osbrink (2010) found that termites suffered significantly greater mortality when they had to access a food source located on dry soil compared to moist soil. Although termites are capable of transporting water to construct tunnels in dry soil, there is a risk of increased mortality. In addition, transporting enough water to construct tunnels in dry soil requires metabolic energy. In this assay, termites probably did not construct exploratory tunnels in the dry soil because they had a food source and a network of tunnels in the release chamber. This research demonstrates the importance of limiting moisture in buildings at risk for attack by subterranean termites. The lack of moisture presents a significant obstacle to the construction of exploratory tunnels by subterranean termites.

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