TERMITE GALLERY CHARACTERIZATION
in LIVING TREES USING DIGITAL RESISTOGRAPH
TECHNOLOGY

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Abstract Characterization of populations of subterranean termites on a research facility in New Orleans,
La., determined that a number of living trees were infested with the Formosan subterranean termite,
Coptotermes formosanus Shiraki. The amount of internal tree damage was evaluated using a resistograph.
The resistograph is functionally a cordless “smart” drill that transmits information to a computer regarding
the mechanical properties of wood along the length of the drill hole. A rapid fall in drilling energy at a
certain depth indicates the presence of a gallery. Plots of these data quantify the presence of termite galler-
ies through detection of changes in tree density. Probing of a tree on different sides was critical for detec-
tion of termite galleries, which were generally not centrally located. Termite galleries were detected in
58.3% of the 12 infested trees as follows: 3 of 5, 2 of 4, and 2 of 3, bald cypress, live oak, and pine trees,
respectively. Of the termite-infested trees, 33.0% were deemed likely to fail, specifically, 2 cypress and 2
pines. The resistograph is a viable tool for locating and quantifying internal structural loss of trees and
causes minimal damage to the tree. Acquired information can be incorporated into a decision-making
process regarding the structural integrity, safety, and the suitability of a tree for removal or drill and foam
treatment.

Key Words Coptotermes formosanus Reticulitermes sp.

INTRODUCTION

The Formosan subterranean termite, Coptotermes formosanus Shiraki, was introduced into
the United States in the thousands of tons of wooden military cargo shipped back from the Asian
theater following Word War II (La Fage, 1985). New Orleans, Louisiana, was one of the most
active ports of entry. Populations of Formosan termites flourished in the warm, humid climate of
New Orleans, virtually blanketing the city over the last half century. C. formosanus commonly
infests living urban trees in the greater New Orleans area (Osbrink et al., 1999). These infesta-
tions often remain undetected until the termite population becomes so great as to cause structural
failure of the tree or external signs such as mudding become visible. Quantification of termite
damage in living trees is an area that has been little studied. Understanding and detecting hidden
termite populations in trees is critical because of the danger of falling trees, the aesthetic and
historic importance of trees to the city, and to reduce the threat of termites moving into and
destroying urban structures (Osbrink et al., 1999). Recently, technology for the detection and
evaluation of incipient decay has been developed for use by arboriculturists (Bethge et al., 1996;
Costello and Quarles, 1999; Dolwin et al., 1999). One such device is the resistograph. The
resistograph is functionally a cordless “smart” drill that transmits information to a computer regarding
the mechanical properties of wood along the length of the drill hole (Costello and Quarles,
1999; Dolwin et al., 1999). A rapid fall in the drilling energy required at a certain depth indicates
the presence of a void. Plots of this data quantify the presence of voids through detection of
changes in tree density. The objective of this research was to quantify galleries in living trees
infested with subterranean termites at the Southern Regional Research Center in New Orleans,
Louisiana, U.S.A.
MATERIALS and METHODS

The Southern Regional Research Center (SRRC) occupies 141,645 m² and is located at the north east corner of City Park in New Orleans, Louisiana, U.S.A. Trees were identified to species and inspected for termites through visual inspection and by placing pine stakes (2 by 4 by 20 cm) on opposing sides of the base of a tree (Figure 1; Osbrink et al., 1999). Termite-infested trees were confirmed with a prototype acoustical listening device (Mankin et al., 2000). Each tree was evaluated for internal voids through drilling on one side at 4 heights (30.5, 61.0, 91.4, and 121.9 m).

Figure 1. Diagrammatic representation of the Southern Regional Research Center, New Orleans, Louisiana, U.S.A., showing location of drilled trees infested with termites.

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Susan C. Jones, Jing Zhai, and Wm H. Robinson editors. (2002)
cm) and then at a height of 30.5 cm on three other sides (labeled as north, west, south, and east). A Digital microProbe (DmP) was used for drilling (Sibert Technology Limited, Guildford, England). The DmP had a 500 mm by 1.5 mm diam. probe (bit) that would penetrate up to 350 mm into the trunk of a tree. Distance, probe rotations, and force are measured every 0.1 mm and transmitted in ASCII format to a computer via an RS-232 serial connector. Software supplied with the DmP creates graphs of the raw data, using Microsoft Excel, presenting graphs of the relative hardness of the wood drilled (Figure 3). R = radius from the center of the gallery to the surface of the tree and t = thickness of the healthy remaining wall were obtained from the graphs. When t/R < 0.35, a tree is considered a candidate for structural failure (Mattheck and Breloer, 1994). The percent of a tree that was hollowed was estimated by averaging the percent wood removed at each of the 4 samples taken at a height of 30.5 mm. Termites were identified to species using soldier keys (Scheffrahn and Su, 1994).

RESULTS and DISCUSSION

The resistograph detected voids in wood and was sensitive enough to relative hardness that annual rings were also resolved (Figure 3A). The following termite-infested living trees were sampled (common names, genus and species, family, and number sampled): Bald cypress, Taxodium distichum Rich., Taxodiaceae, 5; live oak, Quercus virginiana Mill, Fagaceae, 4; loblolly pine, Pinus taeda L., Pinaceae, 3. C. formosanus infested all of the trees sampled except for one of the pines (PNEQ5; Table 3.), which was infested with Reticulitermes sp. Damage (voids) were detected in 3 of 5 bald cypress (60.0%). Two of the 3 bald cypress with detected damage had t/R values < 0.35, indicating that they were candidates for failure (Table 1). Both of the bald cypress, which were candidates for failure, were estimated to have void damage exceeding 15% of a cross section of the structural wood. Two of the 4 infested oaks had internal damage. None of the infested oaks approached a t/R value of <0.35 (Table 2) and were therefore considered unlikely to fail. We had previously shown live oaks were infested 12.3 % of the time with C. formosanus (Osbrik et al., 1999). Two of the 3 infested pine trees, 66.6% had detectable amounts of wood removed. Both pines having detectable damage were considered candidates for failure using the
Figure 3. Resistograph charts, probe rotations (black line), and penetration force (gray line). A. Pine 2 X 4 drilled through rings with a 10 mm hole, photo (top) and graph. B. Oak tree drill graph indicating void beginning at ca. 240 mm into the trunk.
Table 1. Evaluation of internal damage in live trees attacked by *C. formosanus* at the Southern Regional Research Center, New Orleans, Louisiana, U.S.A.

<table>
<thead>
<tr>
<th>ID</th>
<th>Diam. (cm)</th>
<th>Height (cm)</th>
<th>Tree Sample</th>
<th>Sample Height (cm)</th>
<th>t/R^1</th>
<th>% Void</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>North</td>
<td>West</td>
<td>South</td>
<td>East</td>
<td></td>
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<tr>
<td>CYPRESS</td>
<td></td>
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<tr>
<td>CE1</td>
<td>62.3</td>
<td>30.5</td>
<td>0.31^2</td>
<td>0.48</td>
<td>0.16^2</td>
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<tr>
<td></td>
<td>61.0</td>
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<td>—</td>
<td>—</td>
<td>0.43</td>
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<tr>
<td></td>
<td>91.4</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>0.24^2</td>
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<td></td>
<td>121.9</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>0.53</td>
<td>—</td>
</tr>
<tr>
<td>CW1</td>
<td>63.9</td>
<td>30.5</td>
<td>NA^3</td>
<td>NA</td>
<td>NA</td>
<td>0</td>
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<tr>
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<td>61.0</td>
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<td>NA</td>
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<tr>
<td>CW2</td>
<td>46.9</td>
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<td>0.26^2</td>
<td>0.26^2</td>
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<tr>
<td></td>
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<td>NA</td>
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<tr>
<td>C2</td>
<td>44.5</td>
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<td>51.7</td>
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<td>—</td>
<td>0.59</td>
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</tbody>
</table>

^1 t = thickness of the healthy remaining wall, R = radius from the center of the void to the surface of the tree.

^2 t/R < 0.35 tree is in danger of failing.

^3 NA: there was no void detected to calculate t/R.

t/R criteria, even though % gallery damage was low (Table 3). Our previous study had shown pine had the highest incidence of termite infestation with 32.7 % infested with *C. formosanus* and 4.1% with *Reticulitermes sp.* (Osbrink et al., 1999). It should also be noted how critical it is to drill more than one side of the tree to detect galleries (Tables 2 and 3).

Though the occurrence of *C. formosanus* and *Reticulitermes sp.* in or on living trees has been observed before (Cooper and Grace, 1987; La Fage, 1985; Lai et al., 1983), there has been no documentation or quantification of potential hazard for tree failure nor the extent of gallery formation within an infested tree. In agreement with other researchers, we found the resistograph a viable tool for locating and quantifying internal structural loss of trees while causing minimal damage (Moore, 1999; Nicolotti and Miglietta, 1998; Mattheck et al., 1997; Mattheck et al., 1999). Information acquired with the resistograph can be incorporated into a decision-making process regarding the structural integrity (safety) and the suitability of a tree for drill and foam treatment or removal (Mattheck and Breloer, 1994; Rinn et al., 1996; Schwarze et al., 1997). Further, the precise locations of galleries within the trunk could be used to guide the placement of holes in a drill-and-foam tree treatment program. The absence of detected voids (41.7%) among infested trees included in this study indicate that the resistograph would not, by itself, be useful for determination of whether a tree is infested with termites. The resistograph should therefore be used to guide decisions concerning the soundness of the tree and to guide placement of treatments.
Table 2. Evaluation of internal damage in live trees attacked by *C. formosanus* at the Southern Regional Research Center, New Orleans, LA, U.S.A.

<table>
<thead>
<tr>
<th>ID</th>
<th>Tree Diam. (cm)</th>
<th>Sample Height (cm)</th>
<th>North</th>
<th>West</th>
<th>South</th>
<th>East</th>
<th>% Void</th>
</tr>
</thead>
<tbody>
<tr>
<td>OAK</td>
<td>91.4</td>
<td>30.5</td>
<td>NA</td>
<td>NA</td>
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<td>0</td>
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</tbody>
</table>

**Notes:**
1. *t* = thickness of the healthy remaining wall, *R* = radius from the center of the void to the surface of the tree.
2. *t/R* < 0.35 tree is in danger of failing.
3. NA: there was no void detected to calculate *t/R*.

Table 3. Evaluation of internal damage in live trees attacked by *C. formosanus* at the Southern Regional Research Center, New Orleans, LA, U.S.A.

<table>
<thead>
<tr>
<th>ID</th>
<th>Tree Diam. (cm)</th>
<th>Sample Height (cm)</th>
<th>t/R&lt;sup&gt;1&lt;/sup&gt;</th>
<th>North</th>
<th>West</th>
<th>South</th>
<th>East</th>
<th>% Void</th>
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<tbody>
<tr>
<td>PINE</td>
<td>91.4</td>
<td>30.5</td>
<td>NA&lt;sup&gt;3&lt;/sup&gt;</td>
<td>NA</td>
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<td>121.9</td>
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<td>NA</td>
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</table>

**Notes:**
1. *t* = thickness of the healthy remaining wall, *R* = radius from the center of the void to the surface of the tree.
2. *t/R* < 0.35 tree is in danger of failing.
3. NA: there was no void detected to calculate *t/R*.
4. *Reticulitermes* sp.
ACKNOWLEDGMENTS

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REFERENCES


