Detecting Fungal Decay in Palm Stems by Resistance Drilling

Frank Rinn, Heidelberg, Germany

Like trees, palms can deteriorate internally at the stem base by fungal decay, coming from the roots or bud. But, visual detection is much more limited because palms do not show secondary growth and hence there is no outer response wood indicating compensation of strength loss due to internal decay. Tapping with a mallet thus is the first option to enhance the defect detection. But, because of the bark structure and the internal mechanical design of palms, only extremely hollow stages (more than 90%) may be detected through resonant sound reaction of the stem by tapping.

Picture by Steve Nimz showing his colleague Waylen drilling a coconut palm on Hawaii

Because of the limitation of visual inspection and tapping with a hammer, technical devices can be of great help in order to detect internal decay in palms in earlier stages. In principle, sonic tomography is able to detect internal decay in palms too, but due to the mechanical architecture of palm stems, only big cavities or decay pockets can be detected reliably – because the high-density outermost areas of palm stems lead the sonic waves around the naturally soft center. And, the difference in stress-wave speed between the naturally soft center of palms and decayed wood is quite small. Because sonic-tomographs usually detect and measure the apparent speed of the first incoming wave only, they generally do not detect any signals from the very soft center of palms (and some conifers, too). Therefore, conventional sonic tomography is not the most appropriate method for decay detection in palms and usually fails to detect incipient central decay.

Although resistance drilling is not completely non-destructive, it can help inspecting palms. Resistance drilling was originally developed for measuring latewood density of oak tree rings in order to reconstruct past climate (Rinn 1988). As a welcomed side-effect, the ability to detect defects in trees and timber was observed (Rinn 1989). The first series of devices was sold to scientists and tree- and timber experts for testing its suitability in 1987. Results clearly showed that the key condition for the capability of the method for inspecting trees, timber structures and poles is to reliably measure and reveal wood density (Görlacher & Hättich 1990). Because of that, early versions of the resistance drills of 1984 with a spring-driven recording mechanism were abandoned because they did not allow to reliably measure wood density: the profiles did either over-tune in resonance or were flat-damped and did not show both the real levels and the real variation of the wood density. In the naturally soft center of conifers or palms, such profiles often dropped down to zero although the wood was intact. In the soft sapwood of broad leave trees they often showed an expressionless plateau that is often misinterpreted as sapwood-decay. In narrow tree rings, the profiles often varied from zero to maximum scale, over- and under-estimating the real values making it impossible to interpret the result. Thus, both sensitivity and resolution did not fulfill basic requirements a reliable measurement tool has to meet. Consequently, electronic regulation and recording was developed and shown to be critical and mandatory for obtaining profiles that can reliably be interpreted in terms of wood condition (Rinn 1990). Because of that, only resistance drills with electronic regulation and recording were officially allowed to be labeled with the trademark "RESISTOGRAPH", providing a linearly scaled profile, revealing wood density and its changes correctly (for details see: Basics of typical resistance-drilling profiles. Western Arborist, Winter 2012).

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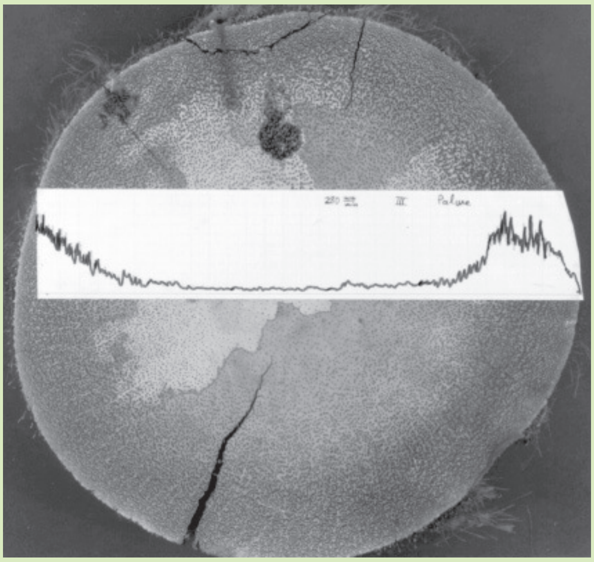
Fungal decay in palms often arises from the base, originally coming from roots. To detect such decay, drillings are usually carried out at stem base, mostly horizontally as shown here with a cordless resistance drill. The profile is printed simultaneously in 1:1-scale on a mobile printer, automatically connected to the machine via Bluetooth. Because of several reasons, it is very important to immediately interpret the profile on the spot and determine its meaning for the evaluation of the stability of the palm: later in the office, all the surrounding parameters that may influence the profile are not present. And: if the interpretation is not clear, an additional drilling may be required. All this can only be done efficiently on the spot.



Resistance drilling profile of a coconut palm stem disk showing incipient decay in the center.

Resistance drilling profiles are mostly showing relative ordinate units but may, if calibrated, show real density values (kg/m³). The abscissa represents the drilling path, mostly printed in 1:1-scale.

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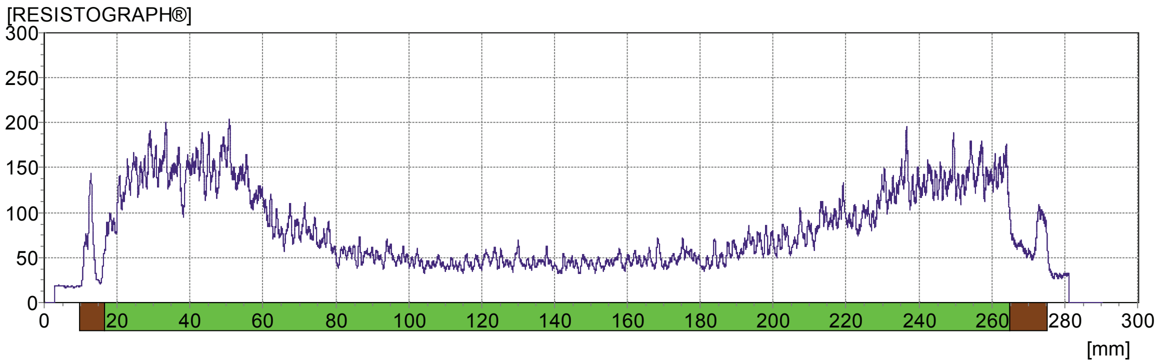
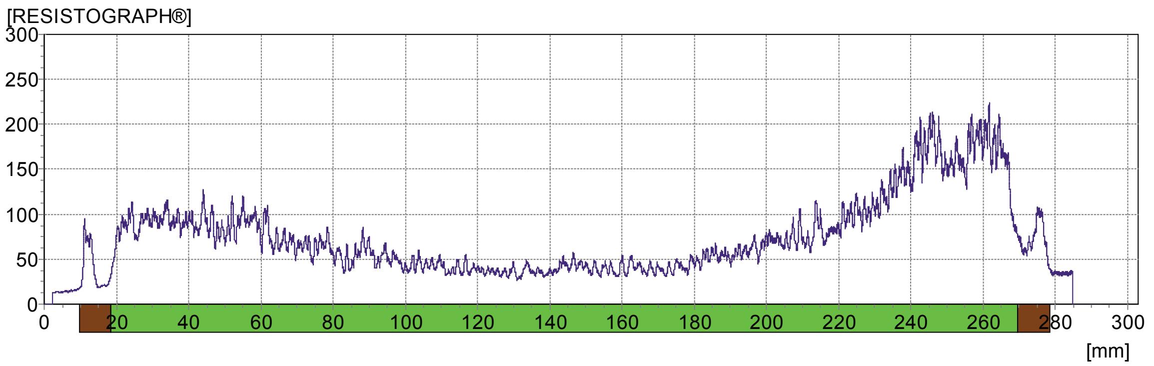
Typical resistance drilling profile of an intact coconut palm (Cocos nucifera). Intact parts are marked green, the bark area is marked brown.





Detecting Fungal Decay in Palm Stems by Resistance Drilling Part 2

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This article is a continuation of Part 1, printed in the Spring 2013 issue of the Florida Arborist, page 10. *Click here to refer to Part 1.*

Introduction

As trees, palms can deteriorate internally at the stem base by fungal decay, coming from the roots. But, visual detection is much more limited because palms do not show secondary growth and hence there is no outer response wood indicating compensation of strength loss due to internal decay. Tapping with a mallet thus is the first option to enhance the defect detection. But, because of the bark structure and the internal mechanical design of palms, only extremely hollow stages (more than 90%) may be detected through resonant sound reaction of the stem by tapping.

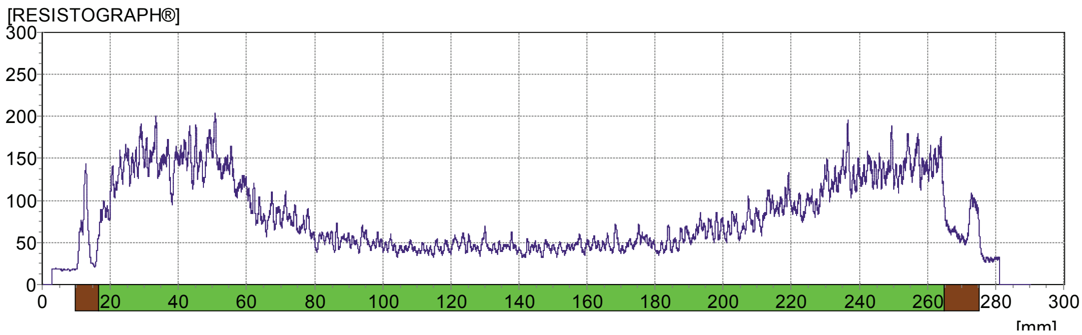
Summary: If a resistance drill provides a high resolution and a linearly scaled ordinate axis by electronic regulation and measuring, thus clearly revealing real wood density, radial profiles from palms enable the trained user to reliably identify even early stages of fungal decay with a measurement that only takes some seconds. This does not apply to mechanical resistance drills with spring-recording mechanisms.

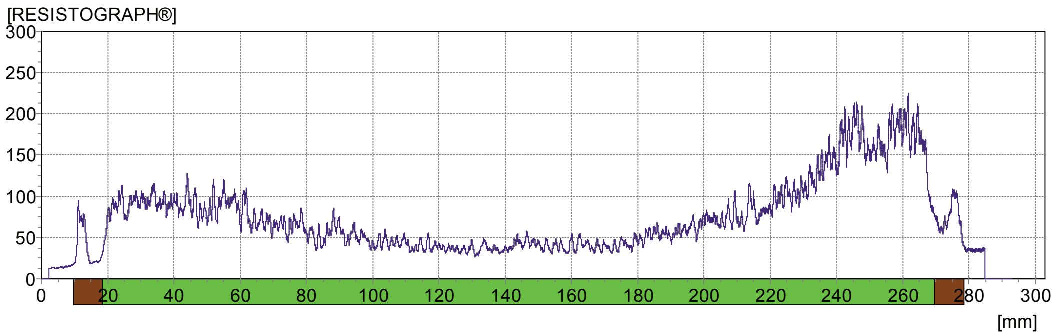
Typical resistance drilling profiles of palms

Interestingly, in coconut palms (Cocos nucifera), often approximately 1/3 of the radius shows a significantly higher density. This seems to be a mechanical design rule for plants of this architecture, weight distribution and wind load pattern. Real date palms (Phoenix dactylifera) often only show 1/10 of the radius with a significantly higher density. Other Phoenix palms may show a nearly constant density level across the whole diameter of the stem.

Sometimes, the profiles are symmetrically shaped, sometimes one side of the stem is higher in density than the other. The reasons for that are not yet fully understood but may be correlated to lean of the stem and prevailing wind directions. In all profiles from intact palms, the curves were found to oscillate along the whole drilling path, however the magnitude of the density variations can be slightly smaller in the center.

Typical resistance drilling profile of an intact coconut palm (Cocos nucifera). Intact parts are marked green, the bark area is marked brown:





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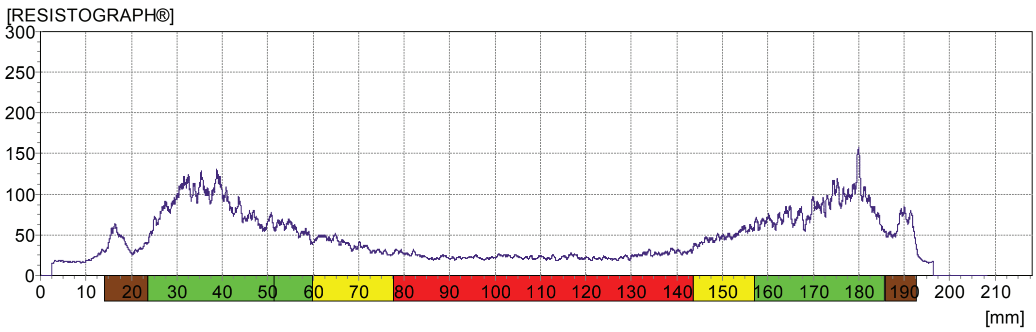
Identification of decay

Decay is detected mainly by identifying profile changes in comparison to the typical pattern. If the density variations are significantly smaller, this indicates incipient decay, if they are absent and the profile level is lower, the decay is advanced. A flat and significantly lower line mostly indicates a void or completely decomposed wood.

If an inspector is unsure whether a profile at the base of a palm shows decay, a reference drilling further up the stem (in the same direction and angle) helps finding the natural density variation pattern to compare with.

Central fungal decay in palm stems mostly leads to profiles with significantly smaller oscillations and a lower mean profile level. Total decomposition would lead to a severe drop of the profile and a nearly flat line.

Due to the grade of the missing density variations, different levels of deterioration can be distinguished, such as incipient (yellow) and advanced (red):



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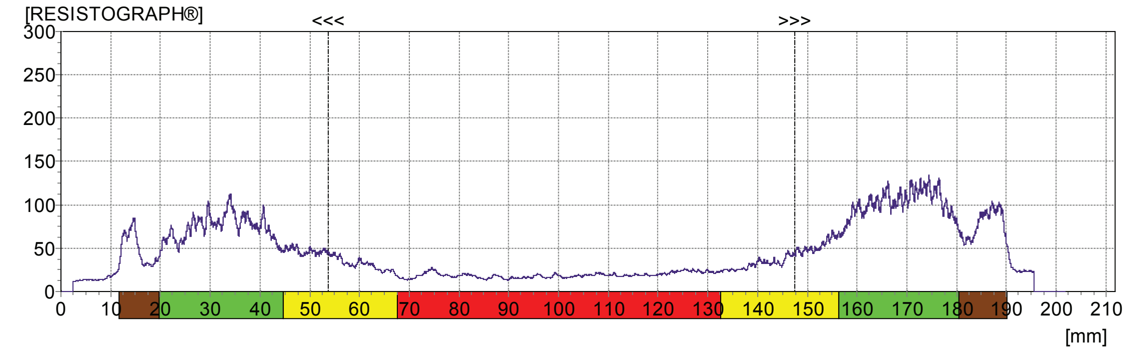
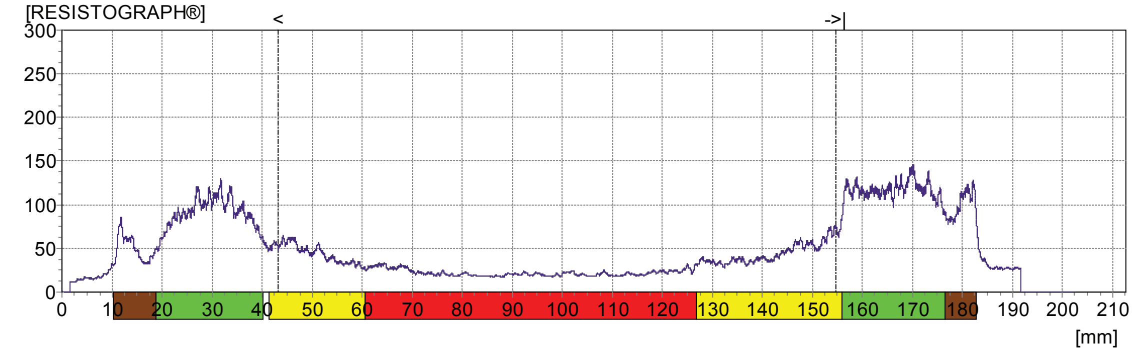
Future extension of decay

Palms do not show the same reaction pattern to decay as trees, described by Shigo in the CODIT model (Shigo 1979). But, experiences from repeated measurements indicate that the slope of the drilling resistance profile from decay to intact sections seems to represent the radial extension rate of the internal deterioration: the steeper the slope from decay to intact, the slower the radial extension rate.

If the profile arises slowly from the decayed area to the intact part, this mostly is related to a relatively rapid radial extension of the decay (“>>>”):



If the profile drops down from intact into the decay, this mostly indicates that the decay stopped extending radially in this area (“->|”):



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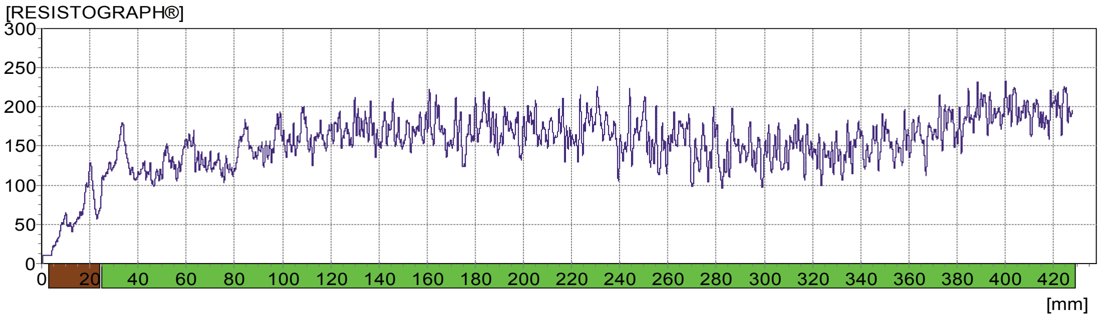
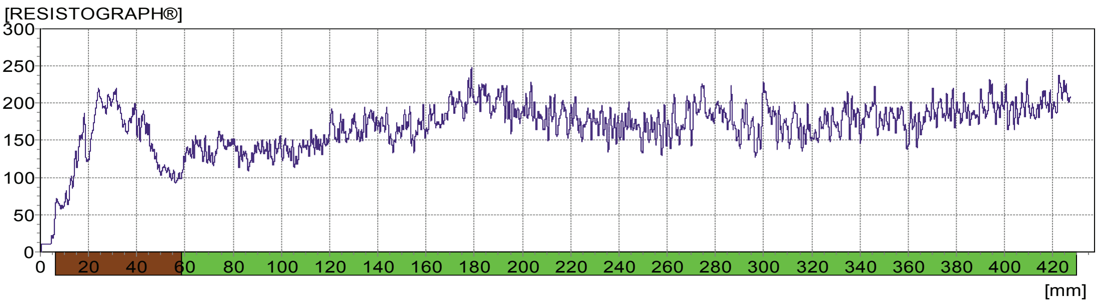
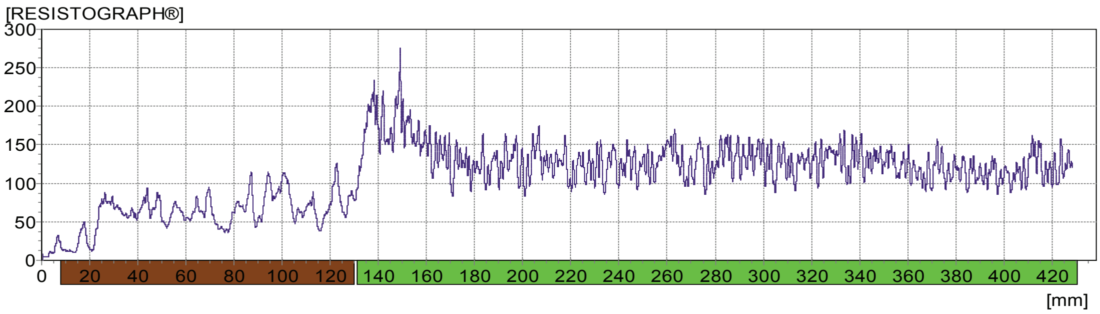
Thick bark is not decay!

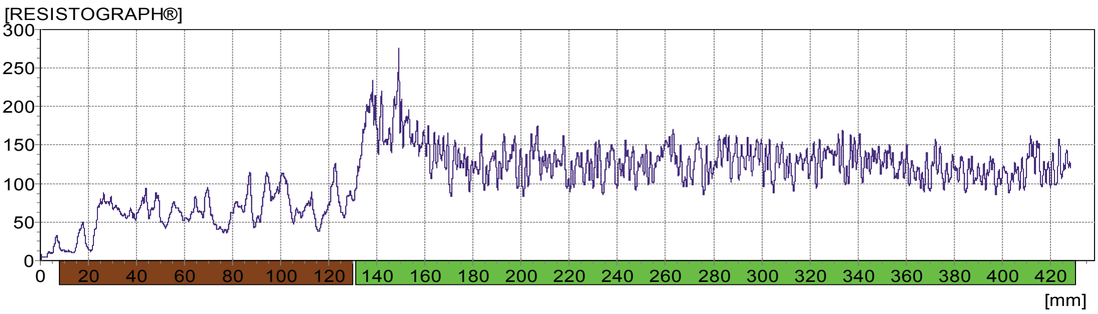
The thickness of the bark can vary strongly, even on the same palm. So it has to be carefully distinguished between bark and potential (external) decay. The profiles shown here were measured on one single Phoenix palm that was not pruned for many years, thus in some areas there were many old fronds to drill through. It is important that such profiles are not misinterpreted as if showing decay. This fact emphasizes the need for direct interpretation of the obtained profiles on the spot. Later, back in office, the knowledge about the thickness of the bark or fronds is difficult or impossible to reconstruct. But, without this knowledge, it is impossible to reliably interpret such profiles.

Some profiles with bark (marked brown) in different thicknesses:









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