Mangroves make a virtue of necessity

The vascular factor in the ecological success of *Avicennia* trees for survival in the precarious conditions of the mangrove forest

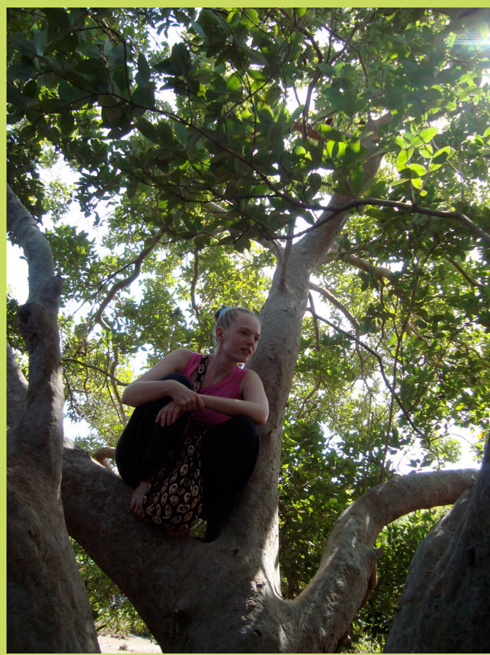
Invitation to the public PhD defence of Elisabeth Robert

Vrije Universiteit Brussel

Friday, 1st of June 2012
4:00 pm

Promoters: Prof. Dr. Nico Koedam
Dr. Nele Schmitz
Dr. Ir. Hans Beeckman

Location: Vrije Universiteit Brussel,
Pleinlaan 2, B-1050 Brussels, Belgium, D.2.01



mangrove sister taxa
sucessive cambia wood anatomy
mangrove micro-CT-scanning
Rhizophora salt stress dendrometers tree growth
water transport ecophysiology
physiological drought Kenya *Avicennia*
internal phloem tissue inundation stress
water-conducting vessels
magnetic resonance imaging

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Summary

Mangrove trees grow in an environment that is highly demanding for their water transport. Frequent tidal inundation may impede water uptake at the soil side, while in the prevailing tropical conditions, heat and wind are 'pulling' at the atmospheric side of the water column. On top, the mangrove environment is highly dynamic. Environmental conditions can quickly change in an unpredictable way. However, mangrove trees seem to make a virtue of necessity, thriving very well in these harsh environmental conditions. How can a water transport system of trees adapt to such environmental conditions? Is such adaptation part of the ecological success of the mangrove genus *Avicennia* in this environment as well as stretching its range into different climate zones? We address these two research questions through functional wood anatomy and ecophysiology, two research disciplines that search for anatomy-environment relationships both by physiological interpretation of observed internal structure and direct physiological experiments.

In **part one** of the study we investigate the requirements of the hydraulic system for survival in the mangrove environment and its adaptation to the gradient of environmental conditions within the intertidal zone. We compare the vessel characteristics of nine mangrove genera - representing all but one families with core mangrove species - with those of their respective non-mangrove sister taxa (Chapter 1). Furthermore, we assess the wood anatomy of *Avicennia marina* and *Rhizophora mucronata* - the two most widespread species of the only two pantropical mangrove genera - along the intertidal gradient in soil water salinity and inundation frequency of the mangrove forest in Gazi Bay (Kenya) (Chapter 2).

Our results show that survival in the mangrove forest requires a vascular system composed of numerous narrow water conducting vessels. This structure allows for bypassing air-filled vessel sections present to a greater extent in conditions of limiting water availability. With increasing soil water salinity and decreasing inundation frequency, the wood anatomy of mangrove trees has a more pronounced safety structure, *i.e.* numerous narrow vessels, and this at between-species and within-species level. *Avicennia* trees have the most pronounced hydraulic safety structure. This can partly explain the ecological success of the genus.

In **part two**, we focus on the study of the successive cambia in the genus *Avicennia*. Unlike in other mangrove trees, the radial growth of *Avicennia* trees occurs through several vascular cambia, characterizing the tree stem with internal phloem tissue. We investigate the possible ecological advantage this anatomical feature could offer *Avicennia* trees for survival in the mangrove environment, both by the presence of internal phloem (Chapter 3 and 5) and the special patchy nature of radial growth (Chapter 4). We make a three-dimensional reconstruction of the internal hydraulic structure of *Avicennia* trees along the intertidal gradient through (micro-) CT-scanning (Chapter 3), investigate the link between species with internal phloem and drought-characterized habitats through a database analysis (Chapter 3), study the growth patterns of two *Avicennia* trees through a dendrometer analysis (Chapter 4) and assess the internal water content of two species with internal phloem, *Bougainvillea spectabilis* and *Avicennia marina*, a non-mangrove and a mangrove species respectively, through Magnetic Resonance Imaging (MRI) (Chapter 5).

The internal hydraulic structure of *Avicennia* is a complex network of xylem and phloem patches that can change extensively with small vertical distance. A large amount of internal phloem tissue is present in conditions that are highly demanding for the water transport, *i.e.* higher soil water salinity and less frequent inundation. Also, trees and shrubs with internal phloem mainly occur in habitats that are characterized by periodical or continuous physiological drought. This indicates the ecological significance of internal phloem tissue. Since internal phloem tissue shows high water content on MRI-scans, a high water storage capacity could allow trees with internal phloem to better overcome air-filling of vessel sections.

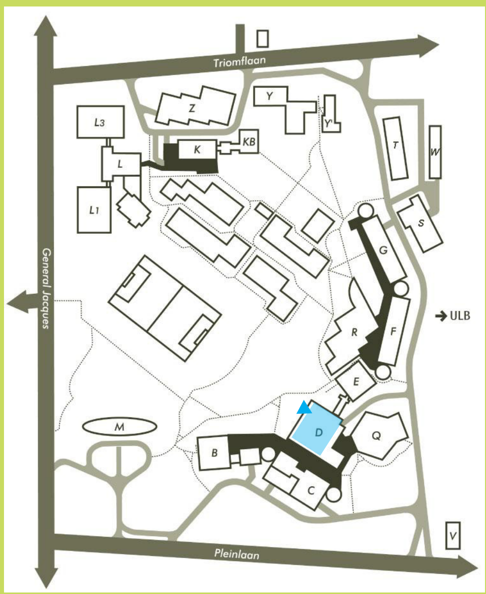
Avicennia trees show a high degree of patchiness in their anatomical structure and in the shrinking and swelling patterns of their stems. Different locations around the stem circumference can, but do not necessarily, react in a similar way to the prevailing environmental conditions. Correspondingly, radial stem increment can be patchy, but is not a systematic feature. In this way, *Avicennia* has a large adaptive toolbox of possibilities to interact with the environment and to optimally distribute available resources over the tree stem, dynamic both in space and in time, adding to the explanation for its ecological success within the mangrove forest.

We can conclude that the vascular factor plays an important role in the survival of mangrove trees in their environment. It is the combination of a safe water conducting vessel system, internal phloem tissue with high water content and a spatially and temporally dynamic growth system that makes *Avicennia* successful in the mangrove environment, being able to stand a gradient in soil water salinities and inundation frequencies.

This research adds to the general understanding of tree functioning since it has brought insight in important vascular factors for tree survival in harsh environmental conditions. Future research focusing on ecological wood anatomy in a phylogenetic context and on the link between anatomy and physiology could deepen these insights.

Practicalities

Location: Vrije Universiteit Brussel, Pleinlaan 2, B-1050 Brussels, Belgium



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Car:
- The Pleinlaan offers parking possibilities.
- Parking on the campus is also possible after registration of your number plate (please mail to: erobert@vub.ac.be).

Train:
- Etterbeek Station

Metro:
- Pétillon (line 5)

Tram:
- tram 7 and 25, stop: VUB

You are cordially invited for dinner after the public defence.

Dinner will take place in restaurant "Shanti", Adolphe Buyllaan 68, B-1050 Brussels and costs around 20 euro per person. Please confirm your attendence (mail to: erobert@vub.ac.be).

If you wish to receive a free digital copy of the PhD document, please send us your email address (mail to: erobert@vub.ac.be). Copies will be sent after the public defence.

A printed copy can also be ordered (20 euro).

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