Elevational and tree height-related changes in xylem anatomical and hydraulic properties of European beech

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A terminal branch of a canopy tree at the treeline (15 m height at 1600 m a.s.l.) corresponded anatomically to that of a canopy tree in the valley (30 m height at 700 m a.s.l.).

Introduction

Due to rising drought frequency, European beech (*Fagus sylvatica* L.) is suffering from higher mortality in large parts of the Central European lowlands [1-3]. However, positive reactions to warmer temperatures have been found in the montane belt of Central European mountain ranges, including stimulated growth [2, 4] and upwards extension of the distribution range [5].

In order to gain a better understanding of the physiological variability of beech in mountain areas, we measured hydraulic and anatomical traits of beech stands along an elevational transect above Innsbruck. Our key research questions were:

a) **Do hydraulic and anatomical traits of beech change with elevation or tree height?**

b) **Can anatomy explain functional changes?**

Methods

elevational gradient
7 levels
(700 – 1600 m a.s.l.)

×

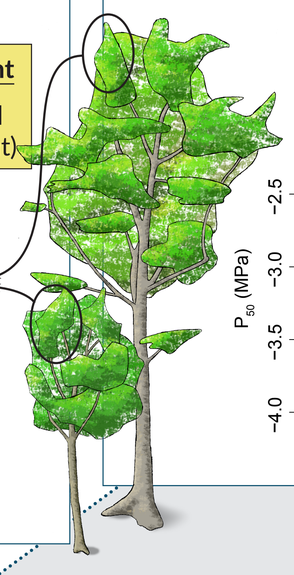
tree height gradient
~10 trees per level
(2 m – canopy height)

↓

samples
sun-exposed branches from crowns of 73 trees

↓

trait measurements
embolism resistance, conductivity, vessel anatomy, leaf traits



Results

- Tree height and elevation influenced wood **anatomical traits** of terminal branches of beech independently of each other.

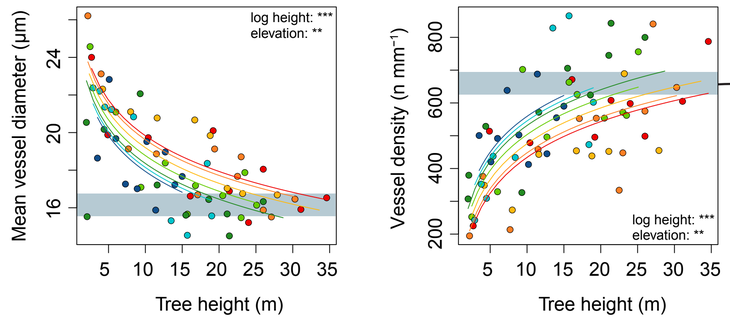
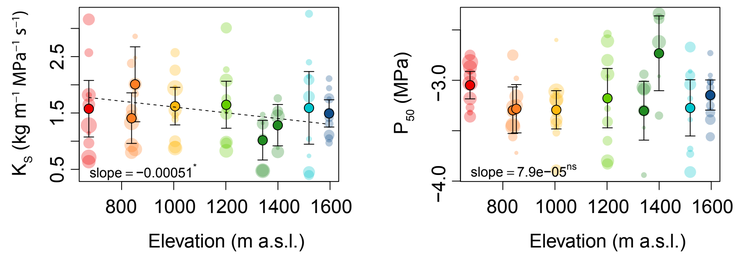
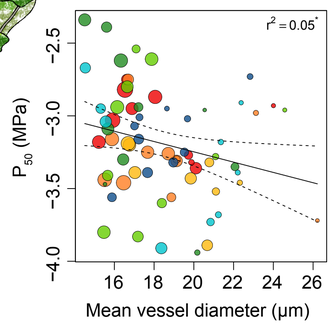


Fig. 1: Wood anatomical traits against tree height modelled for each elevational level. Blue bars indicate potential physiological limits. Colour code see X-axis Fig. 2.

- Important **functional traits** showed surprisingly little reaction: elevation as well as tree height only had a slight negative influence on xylem-specific hydraulic conductivity and did not affect embolism resistance at all.

Fig. 2: Elevation effects on functional traits: Xylem-specific hydraulic conductivity (K_S) and Embolism resistance (P_{50}).





- Measured anatomical traits such as mean vessel diameter explained only a small part of the variation found in embolism resistance while hydraulic conductivity was predicted relatively well.

Fig. 3: Embolism resistance (P_{50}) against mean vessel diameter. Point size represents tree height while colour indicates elevational level (see X-axis Fig. 2)

Conclusions

- The weak relation between embolism resistance and measured vessel characteristics suggests that other traits such as pit architecture might be more important for adjustements of hydraulic safety in beech.
- Anatomical traits of beech such as vessel diameter and density seem to be tightly coupled to the temperature gradient along elevation [c.f. 6, 7]. The similar reaction of vessel parameters to tree height is probably linked to a loss of productivity caused by a lower turgor [8] and higher path resistance [9] in tall trees.
- Embolism resistance of beech is linked neither to elevation nor to tree height but rather to small-scale water availability.

Future investigations might address...

- possible determinants of embolism resistance of individual beech trees such as small-scale soil water availability and stand climate.
- the hydraulic safety margin in trees of different height for a better understanding of the adaptive potential of their hydraulic system during ontogeny.

Sources

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