

Do reproductive crown architecture of subalpine rowan (*Sorbus aucuparia* L.) differ with canopy openness?

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Trees realize multi-objective optimization to fulfill growth and reproduction (Farnsworth & Niklas, 1995). These are governed by several trade-offs among light and hydraulic efficiencies, storage capacity, and mechanical support functions (Pratt & Jacobsen, 2016). In resource-limited environments, or otherwise in stressful conditions, these trade-offs become acute and crucial for the overall tree performance (Rasmussen & Kollmann, 2004; Dobbertin, 2005; Hackett-Pain et al., 2018). Whole tree architecture, at any time of its development, is the effect of the past interactions between the internal growth processes and exogenous constraints exerted by the environment (Barthélémy & Caraglio, 2007). Thanks to the rapid progress in close-range remote sensing methods to quantify tree architecture (Barbeito et al., 2017), many recent studies addressed the problem of encoding and extracting the information about tree functional fitness from the structural information (Verbeeck et al., 2019; Nunes et al., 2023; McNeil et al., 2023). Much focus was on the economically relevant, abundant large-statured trees, either mature or saplings, growing in good conditions (McNeil et al., 2023). The small-statured trees or shrubs attained much less attention (Charles-Dominique et al., 2012), although these may provide large fruit crops (Greene & Johnson, 1994), and while often being stress-tolerant (Brzeziecki & Kienast, 1994), form stable elements of disturbance-prone ecosystems (Żywiec & Ledwoń, 2007). In this paper we analyze a unique data from detailed tree measurements of a fleshy-fruited phenotypically plastic tree species, growing near the upper distribution limit, to test the idea that similar tree architectures may result in contrasting performances, represented by long-term fruit yield, depending on the ecological context and canopy openness gradient.

Trait multi-functionality sets individual traits sub-optimal for specific functions (Sack & Buckley, 2019). Whole-tree size structural traits are typically multi-functional (Poorter et al., 2003) and may be both polygenic and pleiotropic (Farnsworth & Niklas, 1995), resulting from hierarchical, emergent consolidation of lower-level traits (Charles-Dominique et al., 2012). As a result, high co-linearity is usually found among the tree size traits (Martin-Ducup et al., 2020; Verbeeck et al., 2019), making the contributions to individual functions hard to disentangle (Messier et al., 2017; Sack & Buckley, 2019). Nonetheless, a division of the size traits into vertical and horizontal extents was proposed (Seidel et al., 2019), reflecting the predominant linkages to functions of space exploration and light harvest, respectively (Hallé, 2001). A better insight into the structure-function network in trees may be provided by including the so-called relative traits, or architectural proportions (Iida et al., 2011; MacFarlane & Kane, 2017), with both a higher level of trait orthogonality and specific trade-offs (negatively correlated traits) within the major trait dimensions (Martin-Ducup et al., 2020; Kędra & Barbeito, 2022). Using this approach, it was revealed that trees may amplify specific functions along ontogeny and increasing size, such as for light harvest and reproduction, resulting in architecture convergence with increasing canopy position in large-statured trees (Martin-Ducup et al., 2020). However, architecture divergence (Loubota Panzou et al., 2018) was also reported when both large- and small-statured trees were included, suggesting two or more viable architectural trait combinations. The architecture convergence-divergence hypotheses require further testing (Martin-Ducup et al., 2020; Loubota

Panzou et al., 2018). Particularly, of interest are the intraspecific architecture-function trajectories in the small-statured species of mixed life-history strategy, while it appears that such species have a predominant effect on the community-level structural diversity (Iida et al., 2011; Loubota Panzou et al., 2018), exhibiting more than a single architectural optimum depending on local environment and type of stress (Sack & Buckley, 2019).

The intraspecific variability of rowan architecture has. . . (Laurans et al., 2024)

References

- Theories of Optimization, Form and Function in Branching Architecture in Plants. (1995). *Functional Ecology*, 9(3). <https://doi.org/10.2307/2389997>
- Conflicting demands on angiosperm xylem: Tradeoffs among storage, transport and biomechanics. (2016). *Plant, Cell Environment*, 40(6). <https://doi.org/10.1111/pce.12862>
- Poor sexual reproduction on the distribution limit of the rare tree *Sorbus torminalis*. (2004). *Acta Oecologica*, 25(3). <https://doi.org/10.1016/j.actao.2004.02.001>
- Tree growth as indicator of tree vitality and of tree reaction to environmental stress: a review. (2005). *European Journal of Forest Research*, 124(4). <https://doi.org/10.1007/s10342-005-0085-3>
- Climatically controlled reproduction drives interannual growth variability in a temperate tree species. (2018). *Ecology Letters*, 21(12). <https://doi.org/10.1111/ele.13158>
- Plant Architecture: A Dynamic, Multilevel and Comprehensive Approach to Plant Form, Structure and Ontogeny. (2007). *Annals of Botany*, 99(3). <https://doi.org/10.1093/aob/mcl260>
- Terrestrial laser scanning reveals differences in crown structure of *Fagus sylvatica* in mixed vs. pure European forests. (2017). *Forest Ecology and Management*, 405. <https://doi.org/10.1016/j.foreco.2017.09.043>
- Time for a Plant Structural Economics Spectrum. (2019). *Frontiers in Forests and Global Change*, 2. <https://doi.org/10.3389/ffgc.2019.00043>
- Edge effects on tree architecture exacerbate biomass loss of fragmented Amazonian forests. (2023). *Nature Communications*, 14(1). <https://doi.org/10.1038/s41467-023-44004-5>
- Tree crown economics. (2023). *Frontiers in Ecology and the Environment*, 21(1). <https://doi.org/10.1002/fee.2588>
- Architectural strategies of *Rhamnus cathartica* (Rhamnaceae) in relation to canopy openness. (2012). *Botany*, 90(10). <https://doi.org/10.1139/b2012-069>
- Estimating the Mean Annual Seed Production of Trees. (1994). *Ecology*, 75(3). <https://doi.org/10.2307/1941722>
- Classifying the life-history strategies of trees on the basis of the Grimian model. (1994). *Forest Ecology and Management*, 69(1-3). [https://doi.org/10.1016/0378-1127\(94\)90227-5](https://doi.org/10.1016/0378-1127(94)90227-5)
- Spatial and temporal patterns of rowan (*Sorbus aucuparia* L.) regeneration in West Carpathian subalpine spruce forest. (2007). *Plant Ecology*, 194(2). <https://doi.org/10.1007/s11258-007-9291-z>
- Trait Multi-Functionality in Plant Stress Response. (2019). *Integrative and Comparative Biology*, 60(1). <https://doi.org/10.1093/icb/icz152>

- Architecture of 53 rain forest tree species differing in adult stature and shade tolerance. (2003). *Ecology*, 84(3). [https://doi.org/10.1890/0012-9658\(2003\)084\[0602:aorfts\]2.0.co;2](https://doi.org/10.1890/0012-9658(2003)084[0602:aorfts]2.0.co;2)
- Tjoelker, M. (Ed.). (2020). Terrestrial laser scanning reveals convergence of tree architecture with increasingly dominant crown canopy position. *Functional Ecology*, 34(12). <https://doi.org/10.1111/1365-2435.13678>
- Cornelissen, H. (Ed.). (2017). Interspecific integration of trait dimensions at local scales: the plant phenotype as an integrated network. *Journal of Ecology*, 105(6). <https://doi.org/10.1111/1365-2745.12755>
- Identifying architectural characteristics that determine tree structural complexity. (2019). *Trees*, 33(3). <https://doi.org/10.1007/s00468-019-01827-4>
- Branching in Plants. (2001). In *Branching in Nature* (pp. 23–40). Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-662-06162-6_2
- Tree architecture and life-history strategies across 200 co-occurring tropical tree species. (2011). *Functional Ecology*, 25(6). <https://doi.org/10.1111/j.1365-2435.2011.01884.x>
- Larjavaara, M. (Ed.). (2017). Neighbour effects on tree architecture: functional trade-offs balancing crown competitiveness with wind resistance. *Functional Ecology*, 31(8). <https://doi.org/10.1111/1365-2435.12865>
- Estimation of Individual Norway Spruce Crown Metrics Using a Smartphone Device. (2022). *PFG – Journal of Photogrammetry, Remote Sensing and Geoinformation Science*, 90(2). <https://doi.org/10.1007/s41064-022-00201-3>
- Larjavaara, M. (Ed.). (2018). Architectural differences associated with functional traits among 45 coexisting tree species in Central Africa. *Functional Ecology*, 32(11). <https://doi.org/10.1111/1365-2435.13198>
- Why incorporate plant architecture into trait-based ecology?. (2024). *Trends in Ecology Evolution*. <https://doi.org/10.1016/j.tree.2023.11.011>