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Frost sensitivity of various deciduous plant species during leaf development in spring

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Frost damage in deciduous woody plants is a major climate component affecting fitness and distribution of species. It is a trade-off between early bud burst enlarging the potential growing season and frost risk for deciduous plants in many regions. In a warming world observed earlier budburst may lead to an increased risk of spring frost damage caused by higher variability in temperatures (IPCC 2007). Lenz et al. (2013) showed that leaves are in general more sensitive to frost in later leaf development stages. But still there is little knowledge on stages of leaf development and their susceptibility to frost damage in many deciduous species. Additionally there might be variation with plant traits or different strategies within specific groups of species. Frost risk minimization can also be achieved by variability in bud burst within a specimen.
Therefore, in this study we observed more than 174 individual plant specimen of 96 deciduous woody plant species growing in a comparable microclimate outside on the campus of the Technical University of Munich in Freising, southern Germany. Their phenology was intensively studied from 12th of March to 4th of May, including variation within a specimen. Several times twigs for the frost experiment were cut in different stages of leaf development and exposed to freezing temperatures of -4 and -6°C in two lab freezers.
Since the leaf development in spring 2015 started comparably late, too many species emerged simultaneously leading to some capacity problems in the freezers. Nevertheless, our results still reveal novel aspects concerning leaf development and frost sensitivity.
The phenological development proceeded in general from outside to inside of the crown (59%), in 33% of the cases all over the plant simultaneously. Sporadic, inside to outside or vertical development characteristics occurred in rare cases (8%). Mixed model analysis indicated impacts on phenology by plant family, natural origin, pollination mode, and development characteristic (in decreasing order of significance).
The frost experiment clearly showed that damage at -6°C was larger than at -4°C and that twigs frosted at later dates, thus in higher phenological development stages, were more prone to frost damage than twigs frosted at earlier dates / in lower development stages. Additionally, there was a phylogenetic effect since frost damage significantly varied with plant family whereas plant origin had no relevance.

References

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