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Hidden phenology in wood: growth dynamics in Mediterranean trees and shrubs in response to climate

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Tree-rings represent the best-dated archive of climate and environmental information: anatomical and isotopic signals are a synthesis of the various environmental factors and interconnected processes which occurred during tree growth. In Mediterranean-type ecosystems, the timing of wood formation and the features of formed xylem cells are influenced by the action of environmental factors, including temperature and water availability. Seasonal fluctuations in environmental factors result in the so-called “false rings” or “double rings” or “intra-annual density fluctuations” (IADFs) in tree rings that can be useful to follow the periodicity of wood growth, thus gaining phenological information with intra-annual resolution.
In this study, a new approach, based on the combination of dendro-ecological information with the analysis of stable isotope composition and quantitative wood anatomy (QWA) along tree-rings, is proposed to reconstruct a more continuous view of the process of wood formation.
The research was conducted using woody species characterised by different ecological strategies (i.e. Erica arborea L. Arbutus unedo L., Quercus ilex L. Pinus pinaster Ait.). Shrubs were included since they are very plastic and can be considered sensitive models for studying intra-annual variations in properties of Mediterranean woods. Two study sites, characterized by different water availability and temperature, were selected on Isola d’Elba, an island in the Tyrrhenian sea (Italy). Cores and thick cross sections were sampled from the main stem and subjected to dendro-chronological analyses including the measurement of ring-width, identification of IADFs and their classification according to the position along ring width. Rings were dissected under a light microscope to obtain two series of sub-samples for anatomical and stable isotope measurements. For anatomical analyses, microphotographs of semi-thin cross sections (10-20 microns) were subjected to digital image analysis to measure parameters including size and shape of conduit lumen and cell wall thickness. The same selected rings were analyzed for d13C using an elemental analyser linked to an isotopic ratio mass spectrometer via a variable open split interface. Both anatomical and isotopic analyses were performed not only following the standard methodology, based on the selection of sub-samples in various regions of the ring, but also evaluating their variability along ring width (in continuum). Correlations between anatomical, eco-physiological, isotopic and environmental variables (e.g. precipitation, temperature, water availability) were calculated.
Results showed that IADFs characterised by various anatomical and chemical features are triggered by different environmental conditions. Moreover, this phenomenon is species-specific and related to the different strategies of efficiency/safety in water transport of each species.
In conclusion, this combined approach was valuable to gain information about the relationship between environmental factors and tree growth at the seasonal level and is a promising way for dating problematic samples in Mediterranean woods.