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Method Article

Dating old hollow trees by applying a multistep tree-ring and radiocarbon procedure to trunk and exposed roots



Gianluca Piovesan^{a,*}, Franco Biondi^b, Michele Baliva^a,
Lucio Calcagnile^c, Gianluca Quarta^c, Alfredo Di Filippo^a

^a *DendrologyLab, Department of Agriculture and Forest Sciences (DAFNE), University of Tuscia, Viterbo, Italy*

^b *DendroLab, Department of Natural Resources and Environmental Science, University of Nevada, Reno, USA*

^c *CEDAD (Centre of Applied Physics, Dating and Diagnostics), Department of Mathematics and Physics "Ennio De Giorgi", University of Salento, Lecce, Italy*

A B S T R A C T

In the process of dating the oldest trees, which are often hollow, we developed a new method that combines tree-ring cross dating and wiggle matching radiocarbon techniques on wood samples extracted from the stem and from exposed roots. The method can be illustrated by the following steps:

- crossdated tree-ring series from trunk cores reveal a multi-century tree age, and the hollow section is large enough to contain several more years (decades to centuries)
- exposed roots can be cored for acquiring wood samples older than the stem cores and for construction of a floating root average tree-ring series
- if synchronization between stem and exposed roots is unclear, proceed to date the root wood samples by radiocarbon wiggle matching; match root and stem tree-ring series within the radiocarbon-dated period to more accurately date the tree.

This new multistep dating method allowed for refining the age estimation of the oldest *Pinus heldreichii* tree in Pollino National Park by 166 years, to 789 CE. This tree, which we named *Italus*, was 1229 years old in 2017, making it the oldest, scientifically dated, living tree in Europe. Any study that relies on tree age determination for paleo-reconstructions, for biological and genetic research on what controls longevity, or for understanding structural dynamics and succession in old-growth forests, would potentially benefit from the multistep dating method we tested.

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A R T I C L E I N F O

Method name: Tree-ring and radiocarbon multistep dating of old hollow trees

Keywords: Hollow tree, Tree dating, AMS, Wiggle matching, Old tree, Radiocarbon, Longevity, Dendrochronology

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* Corresponding author.

E-mail address: piovesan@unitus.it (G. Piovesan).

Specifications Table [please fill in right-hand column of the table below]

Subject area	Select one of the following subject areas: <ul style="list-style-type: none"> • Agricultural and Biological Sciences
More specific subject area	<i>Dendrology, Forest biology and ecology, Dendrochronology</i>
Method name	Tree-ring and radiocarbon multistep dating of old hollow trees
Name and reference of original method	<i>If applicable, include full bibliographic details of the main reference(s) describing the original method from which the new method was derived.</i>
Resource availability	<i>If applicable, include links to resources necessary to reproduce the method (e.g. data, software, hardware, reagent)</i>

Method details

Overview

Measuring the maximum lifespan of old trees and their associated growth patterns is necessary to scientifically assess forest health and dynamics, which is required for long-term conservation of threatened species that survive in rare habitats [1]. However, heart rot is frequent in old trees, especially if deciduous [2], and for this reason wood increment cores underestimate tree age. In particular, the calculation of missing years in the hollow section of the trunk can be biased by the non-linearity of growth processes, so that using the average increment in the innermost visible part of wood cores does not provide reliable estimates. For this reason, in the study of maximum tree longevity, estimated ages of samples without pith are generally excluded from the analyses [3]. However, when tree-ring analyses of trunk cores reveal a multi-century tree age, and the hollow section is large enough to contain several



Fig. 1. The millennium-old pine tree named *Italus*. Wood cores were extracted at breast height (~1.3 m; red dot; stem) and from the exposed vertical root system using a modified increment borer (also shown, red square and lower inset box).

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