Bronze Age firewood exploitation in south eastern Iberia: a study focusing on wood diameter estimation

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Summary: *This study evaluates the management of different sizes of firewood utilised in the Argaric settlement of Barranco de le Viuda (Lorca, Murcia). A dendrometric analysis was performed to estimate the radius of the curvature of growth rings in charcoal remains identified as* Pinus halepensis. *An analysis of two archaeological levels and two structures revealed that branches of a small calibre, mostly between two and five cm in diameter, were used. Fragments between five and fourteen cm were less abundant, and pieces larger than fourteen cm in diameter were found in only one of the structures. Treatment of the data by a mathematical model will allow the results to be corrected following certain parameters, such as the shrinkage caused by carbonisation or the error percentage associated with the measurement tool.*

Key words: *radius of curvature, dendrometry,* Pinus halepensis*, Prehistory, Iberian Peninsula*

INTRODUCTION

The interaction of Argaric Bronze Age groups with the wood resources available in their environment was probably conditioned by degraded forest areas (Pantaleón-Cano *et al*., 2003). The combination of their socio-economic patterns, based on the overexploitation of resources (Carrión *et al*., 2007) and the progressive climatic aridification of the Holocene (Jalut *et al*., 2009) is most likely the origin of that regional deforestation.

Studying firewood exploitation patterns is essential in characterising the economy of these societies. In addition to the taxonomic diversity of woodfuel, another key criterion in the analysis of the selection process is the caliber of the wood, which can be estimated using different dendrometric techniques (Ludemann and Nelle, 2002; Dufraisse, 2002; 2006; Marguerie and Hunot, 2007).

This study evaluates firewood management patterns in the Argaric village of Barranco de la Viuda (Lorca, Murcia). Its anthracological spectrum is dominated by *Pinus halepensis*, together with sclerophyllous *taxa* (*Olea europaea* var. *sylvestris*, *Pistacia lentiscus*), xerophytes (*Ephedra*, Chenopodiaceae), Ibero-African plants (*Periploca angustifolia*, *Tetraclinis articulata*) and dry riverbed vegetation (*Tamarix*) (García Martínez 2009). Specifically, this study presents the results of the dendrometric analysis carried out on *P. halepensis* charcoal fragments from Level I (1920-1680 cal BC 2σ) and Level II (1840-1640 cal BC 2σ), and from two structures (Vessel-Ashtray and Combustion Structure 6H15), associated with Level II.

METHODS

This study is based on an estimation of the radius curvature of *P. halepensis* growth rings by evaluating the distance between the pith and the rings of the measured charcoal fragment. A reference study was performed prior to application to the archaeological remains in order to assess the validity of two dendrometric methods on conifer anatomy. The methods were applied to two fresh and charred *P. halepensis* sections. Measurements were made with a binocular (magnification x10) and with the help of an image analysis program (NIS Elements 3.1).

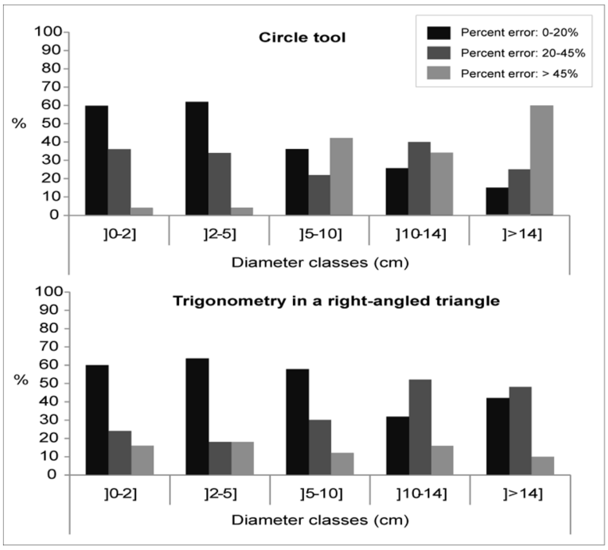

FIGURE 1. Error percentages associated with the use of the circle tool and the trigonometry on a carbonised P. halepensis section.

The first technique tested, known as a "circle tool," is based on the morphology of a growth ring. This tool extrapolates a perfect circle from certain reference points marked on the edge of the ring. The second method, based on the trigonometry of a right-angled triangle (hypotenuse = opposite side / sinus α) takes into account the angle formed by two wood radii and the distance between them.

The results of this reference frame (Fig. 1) clearly show that the circle tool is only acceptable for measuring diameters of less than 5 cm. The average error percentage is around 40-50%. However, the trigonometric tool is very reliable until at least 10 cm in diameter, and moderately reliable beyond 10 cm. The results with an error percentage greater than 45% are not significant. Its average error percentage, regardless of diameter class, is around 25%. As a result, the archaeological charcoals were all measured using the trigonometric tool.

DATA AND RESULTS

The first stage of the study was to estimate the diameter of the charcoal fragments from Barranco de la Viuda. The raw measurement data (Fig. 2) for Level I and II showed a similar trend of firewood composed mainly of small branches measuring up to 5 cm in diameter. A moderate number of fragments between 5 and 10 cm were documented. Branches longer than 10 cm were less common, and there were no branches that exceeded 14 cm. In the structures analysis, the Vessel-Ashtray also showed a preponderance of fragments up to 5 cm in diameter. The Combustion Structure 6H15 displayed slight differences, though: the majority of measurements were of the 2-5 cm diameter class. While there was little presence of small-caliber wood (0-2 cm), fragments exceeding 10 cm appeared more often. Diameters larger than 14 cm were documented only in this structure.

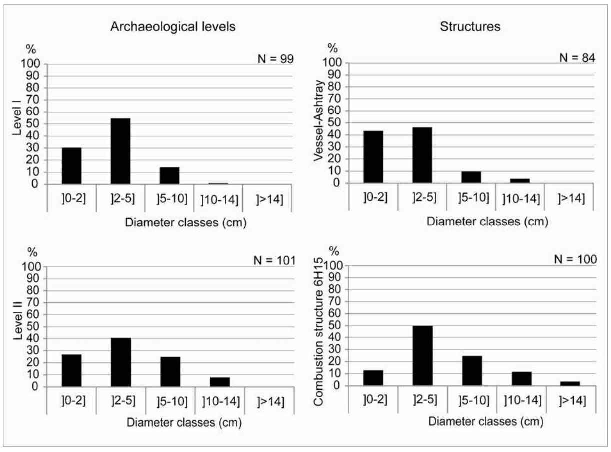

FIGURE 2. Raw results of the measurements of P. halepensis *charcoal fragments from Barranco de la Viuda.*

A second, exploratory phase will treat the raw results through mathematical modeling. This model (Dufraisse, 2002; 2006), whose goal is to restore the diameters of the originally burned wood, is currently under review within the ANR research project DENDRAC (dir. A. Dufraisse). Its use reveals a very useful tool for implementing certain corrective parameters (Dufraisse and García Martínez, submit.). In the present study, the correction factors will take into account the deformation of wood associated with combustion, and in particular to the shrinkage. An additional correction factor will be the error percentage associated with the trigonometric measurement tool. The average error percentage obtained (25%), as well as the overestimation (% of positive error) predominant in small diameters and underestimation (% negative error) which occurs more often in the largest calibers (> 10 cm) will all be taken into consideration.

ACKNOWLEDGEMENTS

M.S. Garcia's work is financed by the Fundación Séneca of the Region of Murcia. The authors would like to thank M. Lemoine for assistance in the treatment and carbonisation of the *P. halepensis* sections.

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