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# Shell oxygen isotope values and sclerochronology of the limpet *Patella vulgata* Linnaeus 1758 from northern Iberia: Implications for the reconstruction of past seawater temperatures

Igor Gutiérrez-Zugasti [a,*], Roberto Suárez-Revilla [a], Leon J. Clarke [b], Bernd R. Schöne [c], Geoffrey N. Bailey [d], M.R. González-Morales [a]

[a] Instituto Internacional de Investigaciones Prehistóricas de Cantabria, Universidad de Cantabria, Edificio Interfacultativo, Avda. Los Castros s/n., 39005 Santander, Spain
[b] School of Science and the Environment, Faculty of Science and Engineering, Manchester Metropolitan University, Manchester M1 5GD, UK
[c] Institute of Geosciences, University of Mainz, Johann-Joachim-Becherweg 21, 55128 Mainz, Germany
[d] Department of Archaeology, University of York, King's Manor, YO1 7EP York, UK

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ABSTRACT

Understanding environmental conditions faced by hunter-fisher-gatherers during the Pleistocene and Holocene, and interpretation of subsistence strategies, social organisation and settlement patterns, are key topics for the study of past human societies. In this respect, oxygen isotope values ($\delta^{18}O$) of mollusc shell calcium carbonate can provide important information on palaeoclimate and the seasonality of shell collection at archaeological sites. In this paper, we tested *P. vulgata* shells from northern Iberia as a paleoclimate archive through the study of shell oxygen isotope values and sclerochronology of modern samples. Results showed that limpets formed their shells close to isotopic equilibrium, with an average offset between measured and predicted values of 0.36‰. This offset is significantly reduced with respect to those reported in previous studies, probably due to the use of highly resolved data on the isotopic composition of the water when calculating predicted values. Despite large intra-specific variability, shell growth patterns of *P. vulgata* revealed a common pattern of higher growth in spring and a growth cessation/slowdown in summer and winter. The seasonal growth cessation/slowdown did not exceed three months. Therefore, a correct interpretation of the season of shell collection is still possible. Reconstructed seawater temperature exhibited a high correlation with instrumental temperature ($R^2 =$ 0.68 to 0.93; $p < 0.0001$). Despite periods of growth cessation/slowdown, mean seawater temperatures and annual ranges were reconstructed accurately. As demonstrated here, seawater temperature can be reconstructed with a maximum uncertainty of $\pm 2.7$ °C. Therefore, our study shows that oxygen isotope values from *P. vulgata* can be used for the reconstruction of paleoclimate and the season of shell collection.



## 1. Introduction

Marine molluscs are usually found in archaeological sites worldwide (Colonese et al., 2011; Erlandson, 2001; Gutiérrez-Zugasti et al., 2011). Ancient shells can provide a wide range of information on past subsistence strategies (e.g. Ainis et al., 2014; Cuenca-Solana, 2015; Manne and Bicho, 2011; Vanhaeren and d'Errico, 2006), but they also serve as palaeoclimate archives (Andrus, 2011; Schöne et al., 2004; Surge et al., 2003). Many molluscs grow their shells in isotopic equilibrium with the surrounding environment. This means that during shell formation chemical signatures from the environment in which the shells were living are incorporated into the carbonate (Dettman et al., 1999). The oxygen isotope value ($\delta^{18}O_{shell}$) in shell carbonate is mainly a function of both the temperature and the oxygen isotope composition of the ambient water experienced by the mollusc during shell formation (Wanamaker et al., 2006). Therefore, oxygen isotope signatures recorded in ancient shells can be potentially used for reconstruction of past seawater temperatures, but also for determination of subsistence strategies and settlement patterns of past populations through the study of season of shell collection (Burchell et al., 2013; Colonese et al., 2009; Culleton et al., 2009; Mannino et al., 2003).

However, before oxygen isotope based techniques are applied to archaeological material, it is necessary to understand how reliably modern representatives of the respective species record their environment by means of $\delta^{18}O_{shell}$ (see for example Hallmann et al., 2009; Prendergast et al., 2013). A range of kinetic factors (usually known as "vital effects") can disrupt isotopic equilibrium. For example, a

* Corresponding author.
*E-mail address:* gutierfi@unican.es (I. Gutiérrez-Zugasti).

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