Chemical Geology 526 (2019) 49–61

Contents lists available at ScienceDirect

Chemical Geology

journal homepage: www.elsevier.com/locate/chemgeo

Growth patterns of the topshell *Phorcus lineatus* (da Costa, 1778) in northern Iberia deduced from shell sclerochronology

Asier García-Escárzaga[a,b,*], Igor Gutiérrez-Zugasti[a], Bernd R. Schöne[c], Adolfo Cobo[b,e,f], Javier Martín-Chivelet[d], Manuel R. González-Morales[a]

[a] Instituto Internacional de Investigaciones Prehistóricas de Cantabria, Universidad de Cantabria, Gobierno de Cantabria, Santander. Edificio Interfacultativo, Avda. de los Castros s/n, 39005 Santander, Spain
[b] Photonic Engineering Group, Department of TEISA, University of Cantabria, Edificio I+D+i de Telecomunicaciones, Avda. Los Castros s/n, 39005 Santander, Spain
[c] Institute of Geosciences, University of Mainz, Joh.-J.-Becher-Weg 21, 55128 Mainz, Germany
[d] Departamento de Estratigrafía, Facultad de Ciencias Geológicas, Universidad Complutense, Instituto de Geociencias (CSIC-UCM), Ciudad Universitaria, 28040 Madrid, Spain
[e] Centro de Investigación Biomédica en Red de Bioingeniería, Biomateriales y Nanomedicia (CIBER-BBN), Cantabria, Spain
[f] Instituto de Investigación Sanitaria Valdecilla (IDIVAL), Cantabria, Spain

ARTICLE INFO

Keywords:
Sclerochronology
Stable oxygen isotopes
Shells
Phorcus lineatus
Growth patterns
Palaeoenvironmental reconstruction
Archaeology

ABSTRACT

Combined shell growth pattern and oxygen isotope analysis has become a powerful approach in palaeoclimate and archaeological studies for reconstructing palaeoclimate conditions and littoral exploitation patterns, respectively. Recent investigations have shown that the gastropod *Phorcus lineatus* (da Costa, 1778) forms its shell in conditions of near equilibrium with the oxygen isotope signature of the seawater environment, demonstrating the utility of this species for reconstruction of sea surface temperature and determination of the season of harvest in archaeological studies. In contrast, the shell growth patterns of this species have received virtually no attention despite providing information on the rate and timing of shell growth that is crucial for correctly interpreting environmental proxies derived from shell geochemistry. In this paper, we compare microgrowth patterns and isotopic profiles of four modern individuals of the gastropod *P. lineatus* from northern Iberia to determine the timing and periodicity of subannual growth markers within the shells. Results of this sclerochronological study showed the presence of two types of growth lines/increments: i) large-scale accretionary units formed with variable periodicity, and ii) small-scale accretionary units formed by micro growth lines and increments determined by semidiurnal tidal cycles. Results suggest that shells grew uninterruptedly during early ontogeny. However, older specimens exhibited growth cessation/slowdown during summer and winter/spring. Therefore, shell growth rate is not only controlled by environmental conditions, but also by ontogenetic age and/or endogenous rhythms. A high correlation was found between seawater temperature derived from shell oxygen isotopes and instrumental seawater temperature (r^2 = 0.88–0.98; p-values < 0.0001). This study shows that establishing accurate growth patterns of the topshell *P. lineatus* is essential for correctly reconstructing past seawater temperature conditions in palaeoclimate studies and for determining with higher precision the season(s) when the subfossil shells were collected by humans.

1. Introduction

Reconstruction of environmental conditions is crucial in geoarchaeological studies to determine the evolution of climate conditions prior to the instrumental era and to better understand human behaviour during prehistoric times. Despite the importance of this topic in current research, it is not a straightforward task, because accurate and precise climate proxies are needed. Stable oxygen isotope ($\delta^{18}O$) data is one of the most used methods to decipher palaeotemperatures (Dorf, 1960; Emiliani et al., 1964; Schöne et al., 2004; Wang et al., 2012) and determine the season when shells were harvested by humans (Burchell et al., 2013a; Colonese et al., 2017; Deith, 1983a; Hausmann and Meredith-Williams, 2016). However, sclerochronological analyses (including geochemical and growth patterns analyses, see Oschmann,

* Corresponding author at: Instituto Internacional de Investigaciones Prehistóricas de Cantabria, Universidad de Cantabria, Gobierno de Cantabria, Santander. Edificio Interfacultativo, Avda. de los Castros s/n, 39005 Santander, Spain.
E-mail addresses: a.garcia.escarzaga@gmail.com (A. García-Escárzaga), fernandoigor.gutierrez@unican.es (I. Gutiérrez-Zugasti), schoeneb@uni-mainz.de (B.R. Schöne), adolfo.cobo@unican.es (A. Cobo), martinch@ucm.es (J. Martín-Chivelet), manuelramon.gonzalez@unican.es (M.R. González-Morales).

https://doi.org/10.1016/j.chemgeo.2018.03.017
Received 17 July 2017; Received in revised form 8 February 2018; Accepted 8 March 2018
Available online 20 March 2018