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Shell sclerochronology of the limpet *Patella ferruginea* Gmelin, 1791: Implications for growth patterns and reconstruction of past sea surface temperatures

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ABSTRACT

Understanding the environmental conditions faced by past human populations is essential to understand their behaviour, and the subsistence strategies that they adopted for survival. The study of oxygen isotope ratios in limpet shells ($\delta^{18}O_{shell}$) can provide important information on sea surface temperature (SST), shell growth patterns and the season of shell collection by human populations. Following this approach, in this paper, we assessed $\delta^{18}O_{shell}$ values of three modern limpets *Patella ferruginea* Gmelin, 1791 collected alive in Ceuta (northern Africa) as proxies for past SST and to determine the season of shell collection at archaeological sites. Studied shells showed fast growth rates without long periods of growth stops. However, results suggested that the shells did not grow during all tidal immersions. Results also showed higher growth rates between winter and summer, although each shell exhibited its own distinctive patterns. According to the isotope data, studied limpets deposited calcium carbonate to form their shells with an average offset of +0.34 ‰ from expected equilibrium. This offset was higher in summer (0.56 ‰) and lower in winter (0.18 ‰). Reconstructed sea surface temperature ($SST_{\delta 18O}$) exhibited high correlation with satellite temperature. Considering the variability of the oxygen isotope composition of the seawater ($\delta^{18}O_{sw}$), past $SST_{\delta 18O}$ can be calculated with an uncertainty of +2 °C and −1.4 °C. Our study demonstrates that $\delta^{18}O$ values of *P. ferruginea* can be used to reconstruct SST provided that the $\delta^{18}O_{sw}$ is known. Furthermore, the season of shell collection can be estimated from $\delta^{18}O_{shell}$ curves, which has deep implications for future archaeological investigations.

1. Introduction

Marine molluscs have been collected by humans since the Pleistocene and their shells are found at archaeological sites worldwide (Colonese et al., 2011; Gutiérrez-Zugasti et al., 2011; Ramos-Muñoz et al., 2016). Archaeological molluscs can provide significant information on past human behaviour (e.g., Zilhão et al., 2010; Cortés-Sánchez et al., 2019) and likewise on past climate conditions (Wang et al., 2013; García-Escárzaga et al., 2022). Mollusc shells are mainly composed of calcium carbonate ($CaCO_3$) and are precipitated close to oxygen isotopic equilibrium with the surrounding environment (Epstein et al., 1951, 1953; Grossman and Ku, 1986). Hence, during growth, environmental conditions are encoded in the shells, e.g., in the form of stable oxygen isotope ratios ($\delta^{18}O_{shell}$) (Epstein et al., 1951; Dettman et al., 1999).

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