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Melanoides tuberculata and *Zootecus insularis* gastropod shells provide a snapshot into past hydroclimatic conditions of arid environments: New perspectives from Oman

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ABSTRACT

Shells of the aquatic gastropod *Melanoides tuberculata* and the terrestrial gastropod *Zootecus insularis* were analysed using high-resolution isotope sampling (up to 274 samples per shell) to assess their potential use as a proxy for hydroclimatic and palaeoenvironmental reconstruction in drylands. A total of 169 snails (fossil and modern) were collected from 37 sites in Northern Oman and Dhofar, with each site selected for its specific geomorphological, archaeological or ecological context. This included fluvial terraces, playa environments, modern oasis gardens, irrigation channels and archaeological sites from the Neolithic (6,000–3,200 BCE) and Early Bronze Age (3,200–2,000 BCE) periods. The $\delta^{18}O$ data obtained from these gastropods could be classified into eight different patterns, three for the aquatic snails (Type 1 A–C) and five for the terrestrial snails (Type 2 A–E), which were linked to the environmental context of their habitat. Furthermore, the use of the aquatic snails enabled us to distinguish between groundwater and surface water signals, whereas the terrestrial snails were employed to reconstruct changes in rainfall origin, humidity, evaporation, regular wet-dry cycles, and meteorological events. According to the results, gastropods can be used to elucidate the long-term, local evolution of rain-fed floodplain ecosystems in drylands and to identify the hydrological resources present in the vicinity of archaeological sites, particularly with regard to type 1 A-C (e.g., surface water vs groundwater).

1. Introduction

Throughout the Quaternary, the climate of Oman was characterised by alternating periods of arid and humid conditions, which have been attributed to fluctuations in the mean latitude of the Intertropical Convergence Zone (ITCZ) over time (Fleitmann et al., 2007). In periods when the ITCZ migrated further southward (e.g., today), summer monsoon precipitation was weakened and only reached as far north as the Dhofar region (Weyhenmeyer et al., 2000). In periods when it moved further northward (e.g., Holocene Humid Period; Fontes et al., 1993; Fig. 1) much of northern Oman received increased mean annual precipitation (Fleitmann et al., 2003). This would have led to the emergence of *khareef*-like conditions (*kharīf* = local Arabic term for the southeastern monsoon from June to early September) characterised by high humidity, moderate temperatures, increased rainfall, and fog throughout the region, transforming the Arabian Desert into verdant landscapes with permanent lakes or wetlands (Rosenberg et al., 2012; Matter et al., 2015; Parker et al., 2016). Such periods have been documented in the Pleistocene and the Holocene (10,500 to 6,000 years ago; Fleitmann et al., 2003, 2007). Wadis benefited from more intense and regular flow (Blechschmidt et al., 2009; Woor et al., 2022) and vegetation density increased (Parker et al., 2004). This has been associated with greater accessibility of local water resources, which is believed to play an important role in the dispersal of hominins both within and

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