Palaeogeography, Palaeoclimatology, Palaeoecology 350–352 (2012) 91–100

Contents lists available at SciVerse ScienceDirect

Palaeogeography, Palaeoclimatology, Palaeoecology

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

Eurhomalea exalbida (Bivalvia): A reliable recorder of climate in southern South America?

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ARTICLE INFO

Article history:
Received 26 March 2012
Received in revised form 17 June 2012
Accepted 24 June 2012
Available online 2 July 2012

Keywords:
Oxygen isotopes
Bivalve sclerochronology
Temperature
Disequilibrium
Paleoclimate

ABSTRACT

Due to the lack of suitable high-resolution archives, regional and continental-scale climate dynamics of southern South America are not well understood. Shells of the long-lived, shallow-marine bivalve mollusk, *Eurhomalea exalbida* (Dillwyn), are likely to contain information on the past water temperatures. As yet, however, no rigorous calibration study has been presented so that growth history traits and the reliability of shell oxygen isotope-based temperature estimates remain unknown. Shell growth patterns and oxygen isotope ratios of four young specimens of *E. exalbida* from the Falkland Islands (Southwest Atlantic) were analyzed and cross-calibrated with environmental parameters. Results indicate that *E. exalbida* likely captured the full seasonal temperature amplitude in its shell. Annual growth line formation occurred between fall and early winter. The most remarkable finding, however, was that *E. exalbida* formed its shell with an offset of −0.48 to −1.91‰ from expected oxygen isotopic equilibrium with the ambient water. If this remained unnoticed, paleotemperature estimates would overestimate actual water temperatures by 2.1–8.3 °C. With increasing ontogenetic age, the discrepancy between measured and reconstructed temperatures increases exponentially, irrespective of the seasonally varying shell growth rates. We attribute this finding to a pH increase in the extrapallial fluid during ontogeny favoring a dominance of the (isotopically lighter) carbonate ions over (isotopically heavier) bicarbonate ions. When this disequilibrium fractionation effect is taken into account, *E. exalbida* can serve as a high-resolution paleoclimate archive for mid to high latitudes of southern South America providing quantifiable temperature estimates, even from single fossil specimens.

1. Introduction

Well-constrained numerical climate models require a detailed understanding of the forcing and feedback mechanisms operating within the Earth system. For this purpose, it is necessary to document the dynamics of key aspects of climate, such as temperature, at high spatiotemporal resolution, i.e., on inter-annual to seasonal and regional to global scales. Such data can be used to assess the human impact on climate and ecosystems and, in turn, to evaluate how regional climates and seasonal extremes might have influenced migration, mobility and subsistence practices of past human populations.

Instrumental data of environmental parameters are extremely scarce prior to about AD 1860 and often only cover the few most recent decades, namely the remote sensing era. Therefore, our knowledge of the pre-industrial (= natural) variability of environmental parameters is almost entirely based on climate proxy archives such as tree rings, speleothems or varved sediments (e.g., Jones et al., 2001). Specifically, the dense dendrochronological network of the northern hemisphere has provided a profound insight into changing frequencies and amplitudes of natural climate modes as well as inter-annual temperature and precipitation patterns on various spatial scales during the last 2000 years (e.g., Schweingruber et al., 1991; Briffa et al., 1994; Büntgen et al., 2011).

However, due to the limited number of appropriate high-resolution proxy records, much less is known about regional paleoclimate dynamics of the southern hemisphere (e.g., Vimeux et al., 2009; Neukom et al., 2011). This is particularly true for southern South America, a key climatic region that is affected by decadal climate modes of global significance including the El Niño-Southern Oscillation, the Pacific Decadal Oscillation and the Southern Annular Mode (Garreaud et al., 2009). The few existing well-dated, annually resolved paleotemperature data from this region largely come from Andean trees (Neukom et al., 2009). Naturally, dendrochronological records are strongly biased toward summer, i.e., the main vegetation period. Clearly, there is a strong need for additional quantifiable paleoclimate proxy archives of annual resolution or better from southern South America.

The long-lived bivalve mollusk *Eurhomalea* spp. is a potential candidate for high-resolution paleoclimate reconstructions of southern South America. This genus inhabits shallow waters along both coasts of South America (south of 36° [Buenos Aires] along the Atlantic coast and south of 42° [Chiloe Island] along the Pacific coast; e.g., Keen, 1954; Powell,

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doi:10.1016/j.palaeo.2012.06.018