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Reliability of Multitaxon, Multiproxy Reconstructions of Environmental Conditions from Accretionary Biogenic Skeletons

Bernd R. Schöne,[1] *David L. Rodland, Jens Fiebig, Wolfgang Oschmann, David Goodwin,*[2] *Karl W. Flessa,*[3] *and David Dettman*[3]

Institute for Geology and Paleontology, INCREMENTS Research Group, Goethe University, Senckenberganlage 32-34, 60325 Frankfurt am Main, Germany
(e-mail: b.r.schoene@em.uni-frankfurt.de)

ABSTRACT

Evaluation and quantification of climate change require data on subseasonal to daily environmental extremes from those periods before instrumental records were available. This study employs a high-resolution, multitaxon, multiproxy approach and analyzes how faithfully accretionary biogenic skeletons record environmental extremes. Six specimens of two bivalve mollusks (*Chione fluctifraga*, *Mytella guyanensi*) and one barnacle species (*Chthamalus fissus*) from a single habitat (northern Gulf of California, Mexico) were collected. Contemporaneous shell portions from these specimens were analyzed for shell growth rates (sclerochronology) and stable isotopes ($\delta^{18}O$, $\delta^{13}C$) and were compared to instrumental records. The results of these analyses included some significant observations. First, shell $\delta^{18}O$ values overestimate winter temperatures and underestimate summer temperatures. Second, the actual diurnal temperature range is not recorded in the biogenic skeletons. Third, skeletal growth is biased toward a species-specific optimum growth temperature (24°–30.9°C). Therefore, higher sampling resolution will not necessarily capture actual environmental extremes. Despite measured temperature extremes of 37.8° and 4.5°C, none of the studied species recorded temperatures above 30.9° or below 12.2°C. Duration and timing of the annual growing period is species specific as well. Faster shell growth occurred at higher temperatures. Up to 58% (*C. fissus*) of the variability in shell growth can be explained by water temperature during growth. Contemporaneous trends in shell $\delta^{13}C$ show a weak correlation with pigment concentration ($R^2 = 0.17$). Higher levels of chlorophyll appear to increase shell production rates. Our study highlights the difficulties inherent in using biogenic skeletons for the reconstruction of paleoenvironmental extremes and demonstrates the power and utility of multiproxy and multitaxon approaches.

Introduction

Subseasonal and daily environmental extremes have recently become a focal point of studies on climate change (Kiktev et al. 2003; Klein Tank et al. 2005). During the past 3 decades, the number of global daily warm temperature extremes has increased more than twice as fast as the corresponding decrease in cold temperature extremes. This resulted in a significant rise in the seasonal temperature spread (Klein Tank and Können 2003). Evaluation and quantification of the anthropogenic impact on climate extremes and seasonality require data from preindustrial times. However, instrumental records of environmental parameters cover only the past 150 yr or so (Jones et al. 2001). Consequently, high-resolution proxy archives of environmental variables would be of great benefit. Such records have been available since the early 1960s. However, in spite of recent theoretical studies (Goodwin et al. 2003; Ivany et al. 2003), it is still barely understood how reliable such proxy records really are.

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[1] Author for correspondence.
[2] Department of Geosciences, Denison University, 100 Sunset Hill Drive, Granville, Ohio 43023, U.S.A.
[3] Department of Geosciences, University of Arizona, Tucson, Arizona 85721, U.S.A.

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