Paleobiology, 45(3), 2019, pp. 405–420
DOI: 10.1017/pab.2019.20

PALEOBIOLOGY
A PUBLICATION OF THE Paleontological SOCIETY

Evaluating the influences of temperature, primary production, and evolutionary history on bivalve growth rates

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Abstract.—Organismal metabolic rates reflect the interaction of environmental and physiological factors. Thus, calcifying organisms that record growth history can provide insight into both the ancient environments in which they lived and their own physiology and life history. However, interpreting them requires understanding which environmental factors have the greatest influence on growth rate and the extent to which evolutionary history constrains growth rates across lineages. We integrated satellite measurements of sea-surface temperature and chlorophyll-a concentration with a database of growth coefficients, body sizes, and life spans for 692 populations of living marine bivalves in 195 species, set within the context of a new maximum-likelihood phylogeny of bivalves. We find that environmental predictors overall explain only a small proportion of variation in growth coefficient across all species; temperature is a better predictor of growth coefficient than food supply, and growth coefficient is somewhat more variable at higher summer temperatures. Growth coefficients exhibit moderate phylogenetic signal, and taxonomic membership is a stronger predictor of growth coefficient than any environmental predictor, but phylogenetic inertia cannot fully explain the disjunction between our findings and the extensive body of work demonstrating strong environmental control on growth rates within taxa. Accounting for evolutionary history is critical when considering shells as historical archives. The weak relationship between variation in food supply and variation in growth coefficient in our data set is inconsistent with the hypothesis that the increase in mean body size through the Phanerozoic was driven by increasing productivity enabling faster growth rates.

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Accepted: 21 May 2019

Data available from the Dryad Digital Repository: https://doi.org/10.5061/dryad.t32st70

Introduction

Several lines of evidence suggest that the mean energy requirements and metabolic rates of metazoans have generally increased through time (Bambach 1993; Payne and Finnegan 2006; Finnegan et al. 2011; Payne et al. 2014; Smith et al. 2016). A variety of potential intrinsic (e.g., physiological/behavioral/ecological)