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A clockwork mollusc: Ultradian rhythms in bivalve activity revealed by digital photography

David L. Rodland *, Bernd R. Schöne, Samuli Helama, Jan K. Nielsen, Sven Baier

INCREMENTS Research Group, Institute for Geology and Paleontology, Johann Wolfgang Goethe University — Frankfurt am Main, Senckenberganlage 32, 60325 Frankfurt am Main, Germany

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Abstract

Time-lapse digital images can be acquired and archived using web-cameras, allowing non-invasive analysis of behavior patterns of bivalve molluscs at ultradian (sub-daily) time-scales over long intervals. These records can be analyzed directly by a human operator or through properly calibrated image analysis software. Preliminary results using species of marine and freshwater bivalves identify several ultradian biological rhythms of similar duration. Wavelet analysis indicates strong periodicity in mantle and siphon activity in the 3 to 7 min range, with longer duration shell contraction periods at 60–90 min. The recurrence of these rhythms among marine and freshwater bivalve species maintained under constant (but differing) conditions suggests the influence of common intrinsic drivers (chemico-physical mechanisms or biological clocks). Sub-daily growth increments preserved in the shells of rapidly growing bivalve species are potentially related to these biological rhythms, with implications for shell growth, biomineralization, and the temporal resolution of paleoclimate proxy data.

Keywords: *Anodonta cygnea*; *Arctica islandica*; *Mytilus edulis*; Sclerochronology; Wavelet analysis

1. Introduction

The periodicity of growth increments in the skeletons of bivalve molluscs has been documented extensively ranging from tidal cycles to seasonal variability and annual reproduction breaks, and can even preserve decadal climatic oscillations (e.g., Richardson, 1988; Goodwin et al., 2001; Schöne et al., 2004). Because of their periodicity, these increments have played a critical role in studies that depend on establishing growth chronologies. Examples include: establishing the organic origin of fossils (e.g., Leonardo da Vinci's Leicester codex; see Gould, 1997), reconstructing paleoclimate records (e.g., Schöne, 2004), determining the seasonality of shellfish predation at prehistoric human settlements (e.g., Deith, 1983), determining modes of evolutionary change (e.g., Jones and Gould, 1999), and estimating changes in the distance from the Earth to the Moon over geologic time (e.g., Barker, 1968).

While the identification of annual bands is well documented (e.g., Clark, 1974), the precise nature and origin of smaller growth increments remains a matter of some dispute. Early work in the field suggested that these were produced by circadian cycles, entrained by daily light variations (e.g., Pannella and MacClintock,

* Corresponding author. Tel.: +49 69 798 22974; fax: +49 69 798 22958.
E-mail address: d.rodland@em.uni-frankfurt.de (D.L. Rodland).

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