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Drivers of shell growth of the bivalve, *Callista chione* (L. 1758) – Combined environmental and biological factors

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ABSTRACT

Seasonal shell growth patterns were analyzed using the stable oxygen and carbon isotope values of live-collected specimens of the bivalve *Callista chione* from two sites in the Adriatic Sea (Pag and Cetina, Croatia). Micromilling was performed on the shell surface of three shells per site and shell oxygen isotopes of the powder samples were measured. The timing and rate of seasonal shell growth was determined by aligning the $\delta^{18}O_{shell}$-derived temperatures so that the best fit was achieved with the instrumental temperature curve. According to the data, shells grew only at very low rates or not at all during the winter months, i.e., between January and March. Shell growth slowdown/shutdown temperatures varied among sites, i.e., 13.6 °C at Pag and 16.6 °C at Cetina, indicating that temperature was not the only driver of shell growth. Likely, seasonal differences in seawater temperature and food supply were the major component explaining contrasting growth rates of *C. chione* at two study sites. Decreasing shell growth rates were also associated with the onset of gametogenesis suggesting a major energy reallocation toward reproduction rather than growth. These results highlight the need to combine sclerochronological analyses with ecological studies to understand life history traits of bivalves as archives of environmental variables.

1. Introduction

Shells of bivalve mollusks are increasingly used to reconstruct past climates. Environmental variables are encoded in shells in the form of geochemical properties, shell growth rate, and shell microstructure. To make use of these proxy records, it is crucial to properly align them in time. In turn, this requires knowledge of the timing and rate of seasonal shell growth and identifies causes thereof. Previous studies identified several drivers that influence the timing and rate of shell growth of bivalves including temperature (Brocas et al., 2013; Goodwin et al., 2001a; Jones et al., 1983; Royer et al., 2013; Schöne et al., 2005a), food supply and quality (Brey, 1995; Broom and Mason, 1978; Sato, 1997; Witbaard, 1996), salinity (Koike, 1980; Marsden and Pilkington, 1995) and latitude (Chauvaud et al., 2012; Hall et al., 1974; Jones et al., 1989), but also reproduction (Jones, 1980; Okaniwa et al., 2010; Sato, 1995), and genetically determined thresholds (Hall et al., 1974). Depending on species and habitat, environmental or physiological factors are more relevant for shell growth (Jones, 1980; Nishida et al., 2012; Richardson, 2001; Vihtakari et al., 2016; Witbaard, 1996).

In iteroparous (multiple reproductive cycles) marine bivalves, there is no clear rule on how much energy is allocated toward growth (Jokela and Mutikainen, 1995). Whereas most species maximize growth at the expense of reproduction (Sebens, 1987), others do the opposite and preferentially allocate energy resources to gamete production instead of growth, e.g., *Chlamys islandica*, *Anodonta piscinalis* or *Arctica islandica* (Jokela and Mutikainen, 1995; Jones, 1980; Schöne et al., 2005b; Vahl, 1981). Still others such as *Cerastoderma edule* (Seed and Brown, 1978, 1977) gain sufficient energy for both growth and reproduction provided there is an adequate food supply. Seasonal shell growth patterns should therefore not only record changes in temperature, food, spawning or other stressful factors (Cardoso et al., 2007), but potentially also the seasonal energy allocation to gamete production. A comprehensive study of the main drivers of shell growth, considering the physical and chemical environment as well as the ecology and biology, in particular physiological factors, is therefore a research priority to interpret the geochemical proxy record of bivalve shells.

In the present study we studied the limiting drivers for shell growth of *Callista chione*. This iteroparous burrowing venerid bivalve inhabits Atlantic and Mediterranean waters and is of high commercial importance and plays an important role in benthic ecosystems. According

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