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Original Research Article

Patterns of the growth of soft-shell clam *Mya arenaria* L. (Bivalvia) in shallow water estuaries of the southern Baltic Sea

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ABSTRACT

We explored the shell shape and growth performance of the soft-shell clam *Mya arenaria* L. in two shallow brackish water estuaries of the southern Baltic Sea – Darss-Zingst and Ruegen lagoons. Observed clams ranged from 2 to 50.1 mm in length with detected age up to 6 years old. The growth patterns of the clams were analyzed using the von Bertalanffy growth function (VBGF). An isometric relationship was found between shell length and shell height or shell thickness. Asymptotic length and weight were predicted according to von Bertalanffy equation as L_∞ = 82.75 mm and W_∞ = 10.9 g. The relationship of wet weight to length was allometric, with exponent b = 3.09. Observed shell lengths were close to values predicted by the model. Our study distinguished patterns of the molluscan growth in estuarine transitional environment of the southern Baltic Sea in comparison with other coastal habitats with pronounced spatial environmental heterogeneity.

1. Introduction

In the Baltic Sea and its estuaries, water salinity is one of the key factors determining the occurrence, distribution, and abundance of species via its effect on the functional ecology of aquatic animals (e.g. growth rate, life cycles, production, and energy flows) (Kullenberg, 1991; Gogina and Zettler, 2010; Ojaveer et al., 2010; Bleich et al., 2011). In coastal waters such as estuaries, lagoons, and bays, salinity acts as both external ecological factor, and as a physiological characteristic of the internal environment of aquatic organisms. Moreover, a considerable part of the central Baltic Sea and estuaries is a horohalinicum (“zone of critical salinity”), which occurs at a water salinity of 5–8 PSU (Cognetti and Maltagliati, 2000; Telesh and Khlebovich, 2010).

The ecophysiological performance of organisms is reflected in their growth and energy budget: on the one hand, growth rate and its shifts are strongly determined by the genotype during the ontogeny; on the other hand, it may be influenced by the local environmental conditions (Cardoso et al., 2006a, 2006b; Caill-Milly et al., 2012). At a large geographic scale, the length of the growing season declines with latitude, and so does the annual growth (Jansen et al., 2009). Some marine bivalves, in particular *Mythilus edulis*, *Macoma balthica*, *Mya arenaria* and others which are abundant in the Baltic Sea and one of the main component of the estuarine fauna, exhibit strongly

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reduced growth rates associated with the Baltic salinity gradient (Kautsky, 1982).

The soft-shell clam *M. arenaria* is a well-known bivalve mollusk, which is widely distributed over the northern hemisphere (Laursen, 1966; Golikov et al., 1985; Petersen, 1999; Naumov, 2006; Conde et al., 2010). It occurs both on the Atlantic and Pacific coasts of North America, where it is a native species, and in the seas of the Arctic region (Sea of Barents, White Sea) and East Atlantic (Baltic, Black and Mediterranean Seas) (Maximovich, 1979; Carlton, 1992; Strasser, 1999; Obolewski and Piesik, 2005; Crocetta and Turolla, 2011), where it is non-native. In the Baltic Sea and associated estuarine ecosystems, soft-shell clam is one of the largest and longest-living bivalves, producing a high biomass. Clams are important in coastal waters as filter feeders, linking suspended organic matter of the water column and sediment accumulation in the bottom and thus utilizing primary production and improving water quality (Pedersen, 1992; Riisgård and Seerup, 2003; Forster and Zettler, 2004).

The growth patterns of soft-shell clam have been studied in some parts of its geographical range. The lifespan of *M. arenaria* varies up to 28 years, with maximum length ranging from 27 to 125 mm (Zenkevich, 1963; MacDonald and Thomas, 1980; Winther and Gray, 1985; Emerson et al., 1988). Brousseau (1979) and Appeldoorn (1983) summarized the data on soft-shell clam growth from different areas of the North American Atlantic and Pacific coasts. Maximovich and Guerassimova (2003) described the exponential growth of *M. arenaria* in the White Sea. Schäffer and Zettler (2007) used clam sipho-width in combination with age and shell length to study the growth performance of clams in the southern Baltic Sea.

Coastal lagoons Darss-Zingst and Ruegen located at the southern Baltic are tideless transitional shallow water estuaries where a salinity range includes the horohalinicum zone (Schiewer, 2008). Pronounced spatial heterogeneity and environmental gradients in both water bodies make them an applicable model to study the aspects of functional shifts in brackish water estuarine transition. This study aims to evaluate the patterns of shell shape, size and weight growth of *M. arenaria* in brackish water estuaries of the southern Baltic Sea, focusing on the impact of salinity on clam growth traits.

2. Material and methods

2.1. Study area

The study area was located in the German coastal waters of the southern Baltic Sea. Darss-Zingst lagoon (196 km^2; sampling stations from 1 to 7) is an extended water body containing a chain of connected coastal lagoons and bays. Ruegen lagoon (160 km^2; sampling sites from 8 to 14) is located between Ruegen and Hiddensee islands (Fig. 1).

Both water bodies are semi-tideless shallow water estuaries, where the mean water depth is 3–4 m (maximum 16 m). Wind-driven water exchange with the Baltic Sea takes place in both water bodies and determines the seasonal, temporal, and spatial fluctuations of water salinity in the estuaries. A salinity gradient extends from the most sheltered freshened western parts of Darss-Zingst lagoon to the north-eastern semi sheltered Ruegen lagoon. Mean salinity varies from a low of 1–3 PSU in the western parts of Darss-Zingst and reaches 4–7 PSU in central and eastern areas. Mean salinity in Ruegen lagoon is 8–9 PSU, owing to more exposure to the Baltic Sea, and does not vary significantly during seasons (Schlungbaum et al., 1994; Chubarenko et al., 2005; Schiewer, 2008).

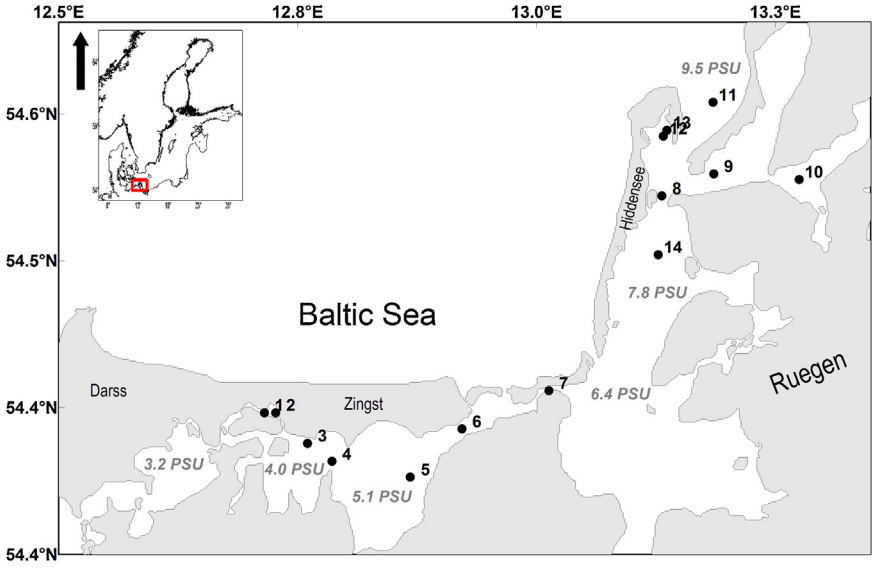

Fig. 1. Sampling sites in Darss-Zingst Bodden chain lagoon (sites 1–7) and Ruegen lagoon (sites 8–14) of the southern Baltic Sea coast. Mean values of salinity (PSU) are marked by the gray color.