

Geographical variation in shell shape of the pod razor shell *Ensis siliqua* (Bivalvia: Pharidae)

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Received: 3 November 2011 / Revised: 14 March 2012 / Accepted: 27 March 2012
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Abstract The present study assessed the existence of variation in the shell shape of the pod razor shell (*Ensis siliqua*) throughout its distributional range in the north-eastern Atlantic. Shells of *E. siliqua* caught at seven collecting sites (three in Portugal, three in Spain and one in Ireland) were studied by geometric morphometric methods, using both landmark- and contour-based methods. Both approaches (landmarks inside the valves and shell outline) discriminated the shells from Aveiro (centre of Portugal) and Strangford Lough (Ireland) from those caught in the nearby localities (remaining Portuguese and Spanish sites,

maximum distance of 550 km by sea). Landmark analysis revealed that shells from Aveiro were more similar to shells from Ireland (~1,500 km far away). Contour analysis revealed that shells from Aveiro had a shape with a comparatively larger height-to-width ratio, whereas shells from Ireland showed a slightly more curved outline than in the remaining sites. Landmark- and contour-based methods provided coherent complementary information, confirming the usefulness of geometric morphometric analyses for discerning differences in shell shape among populations of *E. siliqua*. A brief review of previous applications of geometric morphometric methods to modern bivalve species is also provided.

Communicated by Heinz-Dieter Franke.

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Keywords Pod razor shell · *Ensis siliqua* · Shell shape ·
Geometric morphometrics

Introduction

The comparison of anatomical features of organisms has been a central element in biology for centuries (Adams et al. 2004). Shell morphology, which preserves the ontogenetic record of growth, is now the principal subject of a subfield of morphometrics (Madec et al. 2003), namely theoretical morphology, which since the initial mathematical modelling of Raup (1966) has led to convincing studies on the formal and historical determinants of shell forms, as well as functional interpretations of their observed distributions in theoretical morphospaces (e.g. Stone 1996, 1999; McGhee 1999; Samadi et al. 2000). Several models of theoretical morphology of molluscan shells have been successfully developed in previous studies (Savazzi et al. 1982; Savazzi 1989, 1990; McClain et al. 2004). In more traditional approaches, the shape of molluscan shells has