Estuarine, Coastal and Shelf Science 136 (2014) 119–128

Contents lists available at ScienceDirect

Estuarine, Coastal and Shelf Science

journal homepage: www.elsevier.com/locate/ecss

Size at the onset of maturity (SOM) revealed in length–weight relationships of brackish amphipods and isopods: An information theory approach

Emanuela Longo, Giorgio Mancinelli*

Department of Environmental and Biological Sciences and Technologies, University of Salento, S.P. Lecce Monteroni, 73100 Lecce, Italy

ARTICLE INFO

Article history:
Received 14 May 2013
Accepted 9 November 2013
Available online 18 November 2013

Keywords:
length–weight relationships
standard allometric model
information theory
crustaceans
sexual maturity

ABSTRACT

In amphipods and other small-sized crustaceans, allometric relationships are conventionally analysed by fitting the standard model $Y = a \cdot X^b$ (X and Y are, e.g., body length and weight, respectively) whose scaling exponent b is assumed to be constant. However, breakpoints in allometric relationships have long been documented in large-sized crustaceans, ultimately determined by ontogenetic, abrupt variations in the value of b. Here, the existence of breakpoints in length–weight relationships was investigated in four amphipod (i.e., *Gammarus aequicauda*, *Gammarus insensibilis*, *Microdeutopus gryllotalpa*, and *Dexamine spinosa*) and three isopod species (i.e., *Lekanesphaera hookeri*, *Sphaeroma serratum*, and *Cymodoce truncata*) from three Mediterranean lagoons. The power of two candidate linear models fitted to $\log_{10}$-transformed data – a simple model assuming a constant exponent b and a segmented model assuming b to vary after a breakpoint - was compared using a parsimonious selection strategy based on the Akaike information criterion. The segmented model with a breakpoint provided the most accurate fitting of length–weight data in the majority of the species analysed; non-conclusive results were obtained only for *D. spinosa* and *C. truncata*, of which a limited number of specimens was examined. Model parameters were consistent for amphipod and isopod species collected across the three different habitats; the generality of the results was further supported by a literature search confirming that the identified breakpoints corresponded with ontogenetic discontinuities related with sexual maturation in all the species investigated. In this study, segmented regression models were revealed to provide a statistically accurate and biologically meaningful description of length–weight relationships of common amphipod and isopod species. The methodological limitations of the approach are considered, while the practical implications for secondary production estimates are discussed.

1. Introduction

In the 1960s, the emphasis placed by the International Biological Program on theoretical and practical productivity issues popularized an approach for the indirect estimation of the biomass of aquatic macroinvertebrates relying on the use of dimension-weight (hereafter length–weight, abbreviated as LW) conversion relationships (Edmonson and Winberg, 1971; Holme and McIntyre, 1971). Conversions between the dimensions of two body parts Y and X are most commonly based on the standard allometric equation $Y = a \cdot X^b$ (Huxley, 1932; see, among others, Benke et al., 1999; Robinson et al., 2010; Rigolet et al., 2012 for some examples), where the coefficient a defines the value of Y at $X = 1$ dimension unit, while the scaling exponent b is a constant expressing the relative difference between Y and X growth rates. Noticeably, the existence of breakpoints in bivariate morphological data due to abrupt variations in b during ontogeny has been recognized since the allometric model was first proposed (Huxley, 1932) and is to date generally acknowledged in fish (Froese, 2006 and literature cited), and in invertebrates as diverse as cephalopods, bivalves and crustaceans (e.g., Shea and Vecchione, 2002; Katsanevakis et al., 2007; Émond et al., 2010).

Specifically, in large-sized crustaceans the occurrence of sudden changes in the relative growth rates of body parts during the life cycle is well documented (e.g., brachyurans: Corgos and Freire, 2006; Barón et al., 2009; astacideans: Wahle and Fogarty, 2007; Queirós et al., 2013). In these arthropods growth is essentially a continuous process, while the increase in external dimensions proceeds by a discontinuous series of moults; after ecdysis, water ingestion causes an abrupt increase in body size, determining

* Corresponding author.
E-mail address: giorgio.mancinelli@unisalento.it (G. Mancinelli).

0272-7714/$ – see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.ecss.2013.11.013

sudden transitions in the relationship between the linear dimensions of an individual and its weight (Hartnoll, 1983, 1985, 2001). The strongest variations usually correspond with morphometric sexual maturity (Hartnoll, 1982, 1985; Easton and Misra, 1988; Corgos and Freire, 2006). Gonadal maturation induces a strong metabolic and physiological trade-off between investment in somatic or reproductive tissues (e.g., Spicer, 2001; Glazier, 2005; Corgos and Freire, 2006; Émond et al., 2010) reflecting significantly in morphology, to the point that allometric analyses are preferred to the direct examination of primary sexual characters in commercially-exploited species to estimate the size at the onset of maturity (SOM hereafter; Queirós et al., 2013 and literature cited).

No comparable efforts have been made for amphipods and other small-sized crustaceans playing a key ecological role in lagoons and in other shallow coastal habitats world wide (e.g., see Mancinelli, 2012b and literature cited for gammarideans). For this group of crustaceans the occurrence of ontogenetic discontinuities in LW relationships is virtually unexplored, and standard allometric models are generally used for the exclusive identification of morphometric predictive relationships (e.g., Kevrekidis et al., 2009; Robinson et al., 2010). Here, LW data were analysed in a number of amphipod and isopod species from three Mediterranean lagoons located in Southern Italy. A simple model assuming a constant *b* and a segmented linear model with *b* varying after a breakpoint were compared using a parsimonious selection strategy. In the last decade, model selection procedures based on parsimonious approaches and information theory-related indices (Burnham and Anderson, 2002) have been successfully used in a number studies (e.g., Mancinelli et al., 2005; Katsanevakis et al., 2007; Mancinelli, 2010; Potenza and Mancinelli, 2010), and to date are recommended in ecological studies as a more robust methodology alternative to approaches based on null hypothesis testing (Beninger et al., 2012).

To assess the biological significance of the results, species-specific body length data were compiled from published studies presenting SOM values obtained by direct examination of sexual characters, and compared with body lengths corresponding with the breakpoints identified by segmented models in LW relationships.

2. Materials and methods

2.1. Study sites

The study was carried out in three coastal habitats of the Salento Peninsula (SE Italy): the Acquatina and Le Cesine lagoons, located on the Adriatic Sea, and the Torre Colimena basin, located on the Ionian Sea (40°27′22″N – 18°12′24″E, 40°21′05″N, 18°23′05″E, and 40°17′ 59″ N; 17°44′57″ E, respectively; Fig. 1). Exhaustive information on their morphology and oceanography are provided in Mancinelli et al. (2009, 2013a, 2013c) and in Mancinelli, (2012a); briefly, they are shallow (average depths: 1.2 m for both the Acquatina lagoon and Torre Colimena basin; 0.8 m for Le Cesine lagoon) coastal water bodies with an area <1 km^2 [Acquatina:

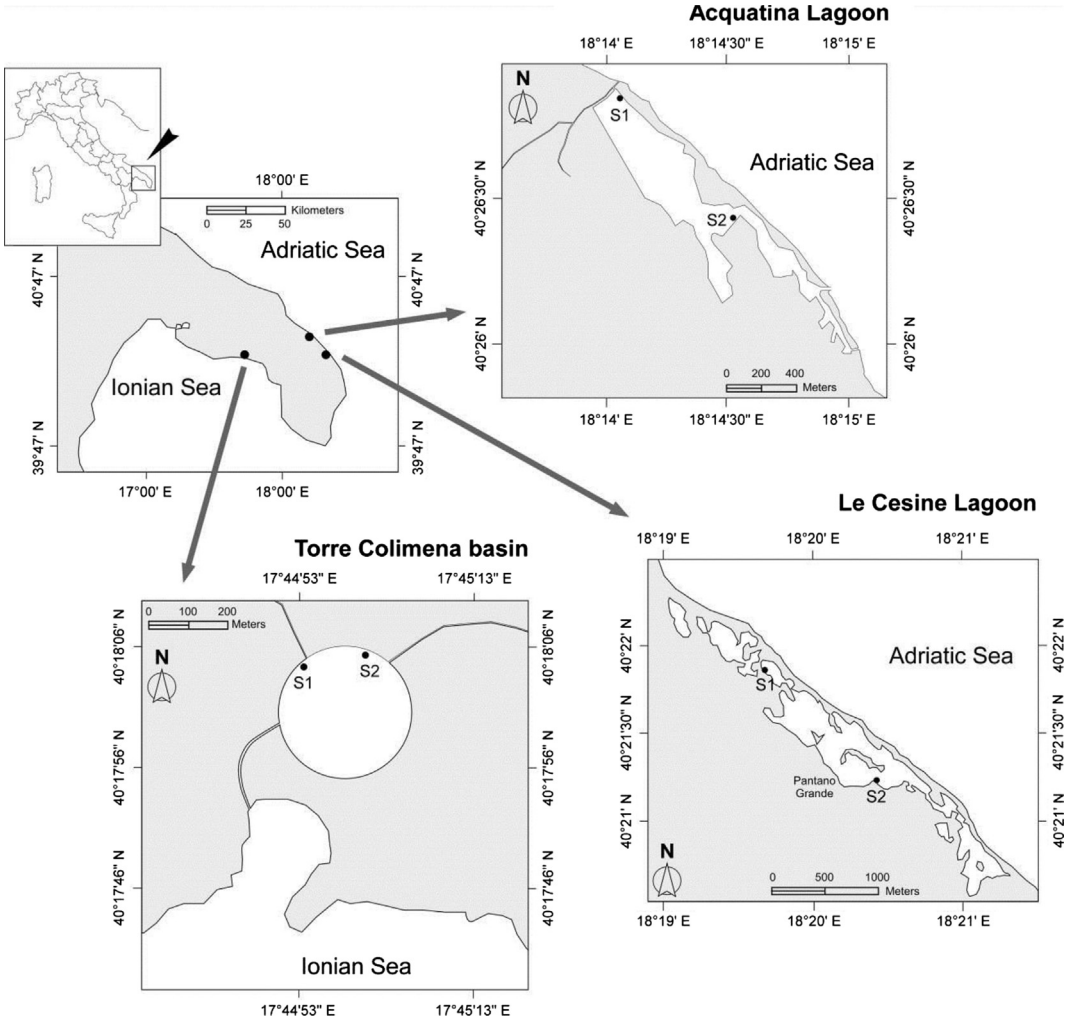

Fig. 1. Location of the three coastal habitats sampled during the study.