

ALLOMETRIC SOMATIC GROWTH PATTERNS AND OTOLITH SHAPE CHANGES IN *DIPLodus SARGUS* (LINNAEUS, 1758) DURING METAMORPHOSIS

Nikolaos Nikolioudakis *, Sotirios Kiparissis , George Koumoundouros and Stylianos Somarakis
Laboratory of Zoology, Department of Biology, University of Patras, 26 500 Patras, Greece - nnikolioud@upatras.gr

Abstract

A mean length at metamorphosis (L_{juv}) is defined for *Diplodus sargus* using a multivariate analysis of morphometric characters. The L_{juv} corresponds well to significant changes in relative otolith growth and otolith shape (coefficients of Elliptic Fourier Analysis).

Keywords : *Biometrics, Fishes, Larvae, Ionian Sea.*

Introduction

In comparative studies of fish development an ontogenetic index is usually used, $OL = \log(L) / \log(L_{juv})$, where L is the larval length and L_{juv} the length at which the species completes metamorphosis [1]. However the definition of metamorphosis is debatable. Recently, a multivariate approach, taking into account a large set of characters has been proposed as more appropriate [1]. In this study, we determine morphometrically a mean length at metamorphosis (L_{juv}) in *Diplodus sargus* and compare its consistency with changes in otolith relative growth and shape.

Materials and Methods

A sample of 145 settled *Diplodus sargus* individuals was collected using a hand-net at depths ranging from 0.5 m to 1 m at a coastal site in the Ionian Sea, in May 2006. Fishes were anesthetized and individually photographed under a stereomicroscope. Morphometric measurements (Pre-orbital length, Eye diameter, Head length, Pre-pelvic length, Pre-dorsal fin length, Pre-anal length, Pre-anal fin length, Post-dorsal fin length, Post-anal fin length, Standard length, Fork length, Eye depth, Head depth, Body depth, Caudal peduncle depth) were taken as defined in [2]. Logarithmic values of measurements were subjected to Principal Components Analysis (PCA) using the covariance matrix [3]. According to the analysis of [3], in an ontogenetic series where shifts in allometric growth patterns between sequential stages exist, these shifts would be reflected in a multi-stage PCA as divergent PC2 trajectories (changes in oblique orientation). This point during metamorphosis (inflection point) was defined by plotting PC2 on fish standard length (SL) and fitting of a piecewise regression. The right sagitta was removed from each fish, photographed and measured for otolith area (OA) and perimeter (OP). The outlines of the otoliths were also extracted from the digital images and their 2D shape was studied with Elliptic Fourier Analysis (EFA) (invariant of size, position and rotation) [4]. Canonical Variate Analysis of the coefficients corresponding to the first 24 harmonics was used to study otolith shape changes during metamorphosis. Otolith size - fish size relationships were compared with ANCOVA models for the stages before and after the inflection point defined by the analysis of body morphometrics.

Results and Discussion

The plot of the second component of the multi-stage PCA on SL (Fig. 1) showed a marked change in orientation during metamorphosis. The inflection point defined by fitting the piecewise regression was 15.11 mm SL. This length was considered as the mean length at metamorphosis (L_{juv}) of *D. sargus* [5]. The slopes of the OP-on-SL and OA-on-SL relationships differed significantly before and after the L_{juv} ($F=44.74$, $p<0.001$ and $F=19.23$, $p<0.001$, respectively). Furthermore, otolith shape differed significantly for fish smaller (Group 1) and larger (Group 2) than L_{juv} (Wilk's $\lambda = 0.25$, $p<0.001$). The results presented here, show a good correspondence between allometric changes defined with the multivariate approach and changes in relative otolith growth and shape in *D. sargus*, which furthermore support the use of morphometrics for defining a mean size at metamorphosis. Good agreement has also been observed between morphological-osteological changes (not presented here) and L_{juv} [5], which provide additional support to the approach used. The definition of a mean length at metamorphosis is useful for comparative studies which express development as a logarithmic function of L_{juv}.

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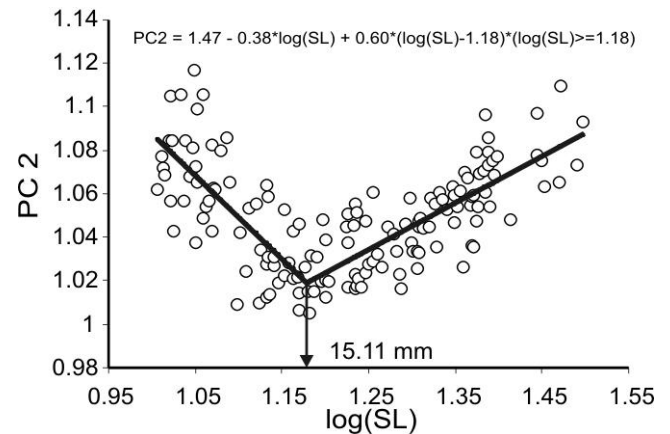


Fig. 1. Plot of PC2 of morphometric characters on log(SL). -: piecewise regression model.

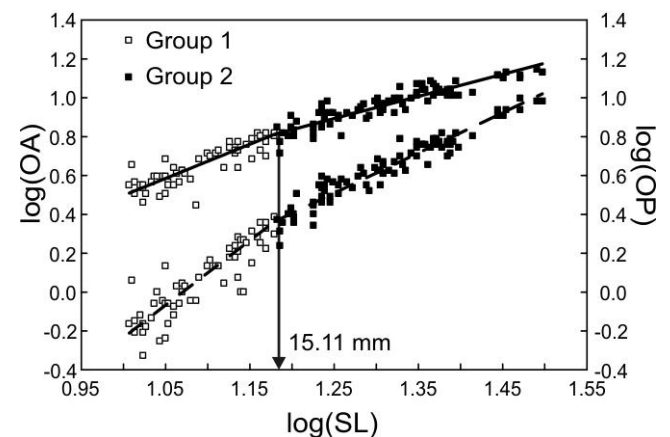


Fig. 2. OA-on-SL, OP-on-SL relationships and their respective piecewise regression models for fish smaller (Group 1) and bigger (Group 2) than L_{juv}.

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