

OTOLITH SHAPE ANALYSIS FOR THREE CLOSELY COMMERCIAL SPARID FISH IN MORPHOLOGICAL FEATURES FROM NORTHERN TUNISIA

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Abstract

Otolith shape analysis was used on three commercial Sparid fish characterized by a misleading morphological resemblance (*Pagellus acarne*, *Pagellus erythrinus* and *Pagrus caeruleostictus*), in order to evaluate the magnitude of form variation and to identify species. A combination of sagittal otolith shape descriptors and Wavelet coefficients are analysed by multivariate statistical procedures. Regarding the shape descriptors, the differences were best described by all variables principally between *Pagellus acarne* and the remaining species. Canonical discriminant analysis showed that fish were successfully discriminated with otolith shape data and gives more than 70% of classification rate.

Keywords: *Mediterranean Sea, Teleostei, Analytical methods*

Otolith shape examination and measurements are commonly used to differentiate fish stocks, but also to identify species and to evaluate the ontogeny and evolutionary relationship among them. Samples were captured from the Northern Tunisia and were obtained from commercial fishing landings during the spring over three years (2006-2008). A total of 20 *Pagellus acarne*, 47 *Pagellus erythrinus* and 7 *Pagrus caeruleostictus* were retained for this study. For each fish, standard length was measured to the nearest mm and then the sagittae were extracted for analysis. Digital images of otoliths were obtained in standardized conditions to minimize distortion errors. Each right otolith was placed on a dark background with the sulcus side facing down and the rostrum to the left in a horizontal line and digitized with a high-resolution video camera.

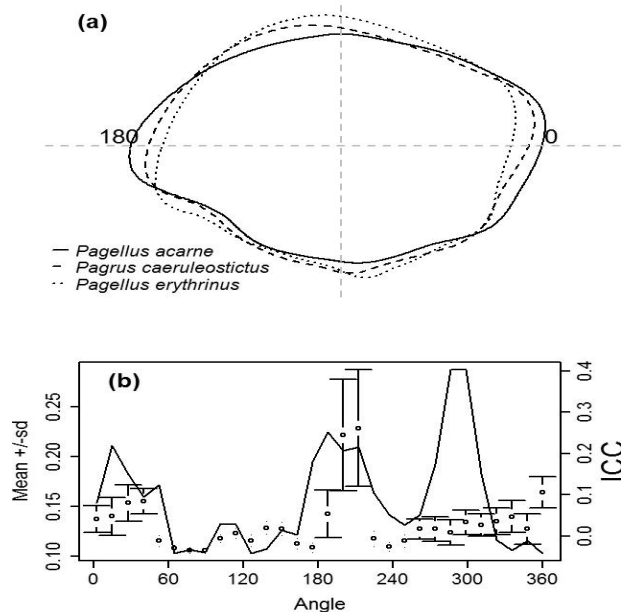


Fig. 1. (a) Mean shape of otoliths based on Wavelet reconstruction for the three sparid species collected from northern Tunisia. (b) Mean and standard deviation (sd) of the wavelet coefficients for all otoliths represented by the open circles and vertical whiskers respectively, and the proportion of variance within species or the intraclass correlation (ICC), which is illustrated by the solid line.

All statistical analyses were performed with R (R Core Team 2015) using shapeR package [1]. Four univariate sagittal descriptors including otolith length, width, perimeter and area were determined. Measurements were standardized in relation to the standard length to remove otolith size effect. To better describe the variation in sagittal shape among species, the mean and standard deviation of the Wavelet coefficients was plotted against the angle. The proportion of

variation within species along the outline was summarized with intraclass correlation (ICC). Canonical analysis of principal coordinates (CAP) based on Wavelet coefficients was used to determine differences between species and an ANOVA-like permutation test to assess the significance of constraints using 1000 permutations. Linear discriminant analysis on the standardized Wavelet coefficients was performed to classify individuals to their sampling origin using cross-validation testing procedure.

The shape descriptors are considerably different among the three species. The lowest values for all variables were recorded in *Pagellus acarne*, which is significantly different from the others indicating the small size of the otolith in this species. However, no significant differences in otolith descriptors were observed between *Pagellus erythrinus* and *Pagrus caeruleostictus*. The mean shape and the proportion of variation within species groups along the outline summarized with ICC are illustrated in Figure 1. Plots of individuals on the first two axes of the CAP showed a clear separation between species and gave a cumulative percentage of the variance of more than 99% (Figure 2). This result is in accordance with that obtained by means of an ANOVA-like permutation test ($F = 86.904, p = 0.001$). Overall, the discriminating analysis with cross-validation procedure correctly classified 86% in combined species samples. The proportions of specimens correctly classified into their original population were as follow: 90% for *Pagellus acarne*, 87% for *Pagellus erythrinus* and 71% for *Pagrus caeruleostictus*.

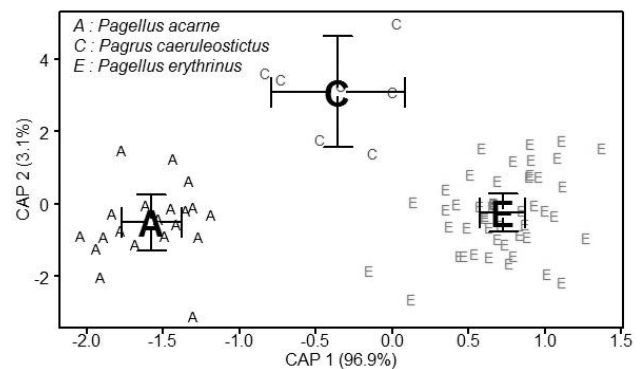


Fig. 2. Canonical Analysis of Principal coordinates based on Wavelet coefficients for the three sparid species collected from northern Tunisia.

This study summarizes the evidence in the otolith variations among the three morphological closely sparid species. The sagittal size and shape analysis as described in this study provides a technique capable to identify specimens at the interspecific scale.

References

1 - Libungan L.A. and Pálsson S. 2015. ShapeR: an R package to study otolith shape variation among fish populations. PLoS One, 10(3): e0121102.