APPLYING FOURIER ANALYSES TO ASSESS INFLUENCE OF ENVIRONMENTAL FACTORS ON SHELL MORPHOLOGY OF MEDITERRANEAN ENDEMIC BIVALVE *PINNA NOBILIS*

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Abstract
Environmental factors such as depth or hydrodynamics can influence the morphology of *Pinna nobilis*. In the present work the variation in shape morphology was studied by Fourier analysis according to different environmental conditions. Important differences were found within juveniles and adults. Discriminant analysis with elliptical Fourier descriptors was able to classify with high accuracy 97.1% of the individuals according to the factors studied.

Keywords: Bivalves, Balearic Islands, Sampling methods, Coastal systems

Introduction The pen shell *P. nobilis* is one of the largest mollusc species, reaching total anteroposterior lengths of up to 1.2 m [1]. Shell morphology is described as triangular, with a pointed anterior end and a more developed posterior part which has a broad and rounded shape. The shell shape is strongly influenced by local environmental factors. This study aims to (1) apply Fourier analysis to determine shell morphology discarding any subjectivity on the size; (2) identify different morphologies among adults and juveniles linked to environmental factors such as depth and degree of exposure to wave action.

Material and methods
For the analyses, digital photographs of *P. nobilis* shells were taken. A total of 136 photos for right valves were chosen because they were more abundant left ones from dead individuals of *P. nobilis* collected in *P. oceanica* seagrass meadows of the Balearic Islands. But when the right valves were absent, then the left one was used. All images of the shells were slightly modified, using Adobe® Photoshop® CS5, to prepare them for digitization. Fourier analysis was calculated with the SHAPE package Iwata and Ukai, 2002 [2]. A principal component analysis (PCA) (PRIMER 6 package) was used to summarize the variance in shape captured by the elliptical Fourier. Followed statistical analysis with SPSS software to verify the correctly classified according to the factors studied by discriminant analyses.

Results and discussion
Results showed two differentiated groups according to their morphology: juveniles and adults (Fig. 1). Moreover, morphologies on juveniles and adults were different within groups according to environmental factors assessed by Fourier analysis. For areas where exposure to hydrodynamics is null, the adults present a more elongated shaped. In contrast, in exposed areas its morphology is fan-shaped. This might be related to wave exposition since at unexposed areas shells can derive energy into growth without having to cope with hydrodinamical forces. However, this pattern does not apply to the juveniles since all have a similar morphology. Regarding discriminant analysis with elliptical Fourier descriptors, four main subgroups were distinguished for juveniles and adults (Table 1) and the 97,1% of individuals were correctly classified through the cross-validation procedure.

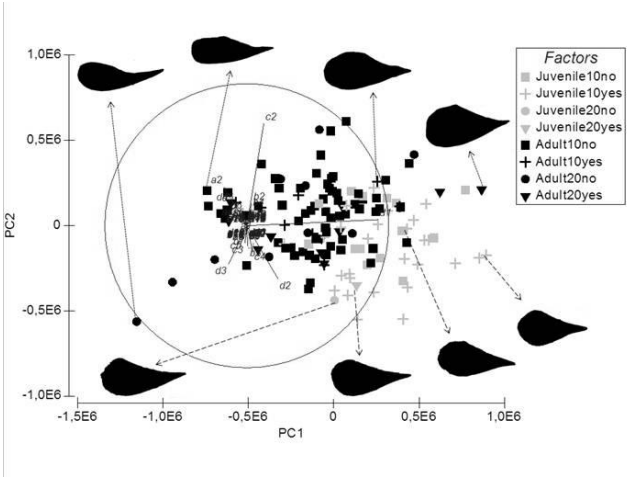

Fig. 1. PCA of the Fourier coefficients of an elliptical Fourier analysis of juveniles and adults according to environmental factors. Adult pictures presented at the top and juveniles pictures at the bottom.

Tab. 1. Discriminant analysis classification with the cross-validation testing procedure, expressed in percentages for juveniles and adults according to environmental factors.

		Predicted group membership (%)								
		Juvenile				Adult				
		10m-NO	10m-YES	20m-NO	20m-YES	10m-NO	10m-YES	20m-NO	20m-YES	n
Correctly classified: 97,1%										
Juvenile	10m-NO	100	0	0	0	0	0	0	0	14
	10m-YES	0	96,4	0	0	3,6	0	0	0	28
	20m-NO	0	0	100	0	0	0	0	0	1
	20m-YES	0	0	0	100	0	0	0	0	1
Adult	10m-NO	0	0	0	0	96,8	0	1,6	1,6	63
	10m-YES	0	0	0	0	0	100	0	0	8
	20m-NO	0	0	0	0	0	0	100	0	10
	20m-YES	0	0	0	0	9,1	0	0	90,9	11
n, sample size										

Conclusion
Image analysis technique allows us to clearly identify a wide arrange of *P. nobilis* shell morphologies related to environmental factors. This represents a useful tool to apply *P. nobilis* shell morphology as a bioindicator of the degree of exposure of the location.

References
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