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Morphometric Comparison of Cultured and Lagoon Caught Gilthead Seabream (*Sparus aurata* L. 1758)

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Abstract: Shape differences were analyzed in cultured and lagoon (Homa Lagoon in İzmir Bay, Turkey; 38°33′23′N-26°50′42′E) caught sea bream, *Sparus aurata*. Specimens in group A (n = 35, 19.71 ± 1.43 cm TL) were collected from nature, while cultured fish in group B (n = 32, 15.12 ± 0.44 cm TL) were propagated in a private hatchery. In order to reveal shape differences in the fish, 13 landmarks was determined in specimens of both groups and the computer programs Tpsdig, Tpsrelw, Tpssplin, and Morpheus were used to demonstrate differences in the selected landmarks. No significant differences were found in terms of geometrical morphometry between lagoon caught and cultured fish (P > 0.05). It is thought that the similar shape formation in specimens of both groups was related to similarities in conditions between culture and lagoon environments due to feeding and stocking.

Key Words: *Sparus aurata*, seabream, shape variation, geometric morphometry

Dalyan ve Kültür Çipurasının (*Sparus aurata*, L. 1758) Morfometrik Açıdan Karşılaştırılması

Özet: Kültür koşullarında yetiştirilen ve İzmir Körfezinde bulunan Homa dalyanında tamamen doğal koşullarda büyüyen çipura (*Sparus aurata*) balıklarının şekilsel farklılıkları çalışılmıştır. A grubuna ait balıklar tamamen doğal koşullarda yetişirken (n = 35, 19,71 ± 1,43 cm TL), B grubuna ait balıklar tamamen kültür koşullarında yetişmiştir (n = 32, 15.12 ± 0,44 cm TL). Balıklarda şekilsel olarak farklılığı ortaya koymak için her iki orijinli balıklarda 13 adet işaret belirlenmiş ve bu işaretler üzerinden tpsdig, tpsrelw, tps splin ve morpheus isimli progmlar kullanılarak şekilsel farklılıklar ortaya çıkarılmaya çalışılmıştır. Yapılan çalışmada dalyan orijinli balıklar ile kültür koşullarında yetiştiriciliği yapılan balıklar arasında şekilsel açıdan farklılık önemsiz bulunmuştur (P > 0,05). Balıkların şekilsel olarak birbirine benzemesi kültür koşullarındaki beslenme ve stok yoğunluğunun dalyan orijinli balıklara benzer olmasıyla ilişkilidir.

Anahtar Sözcükler: *Sparus aurata*, çipura, şekil değişimi, geometrik morfometri

Introduction

The general body shape of an organism is determined not only by its genetics, but also by its ecology and environment (Sara et al., 1999). In fish, a direct relationship exists between swimming behavior and feeding habits, and the development of body shape is dependent on the type and on the manner in which it is obtained (Keast and Webb, 1966). Culture conditions play a key role in allometric and morphological variation in fish, which in turn are highly dependent on parameters such as stock density, the tank volume, the swimming performance, and the amount, type, and quality of food (Sara et al., 1999).

Current areas of aquaculture research thus include studies of correlation and variation between rearing typology, water parameters, growth performances, and market value (Divanach et al., 1996). Market value is crucial, as it refers not only to the size and taste of the fish, but also to its shape (Sara et al., 1999). Deformations may downgrade the product and negatively affect its market value. Fish reared in culture typically have a stockier body shape than those reared in the wild, which have longer and narrower bodies (Loy et al., 1996).

Geometric morphometrics is considered a new approach in the analysis of body shape (Bookstein, 1991;

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Marcus et al., 1996). Its application to fish shape has been reported (Favaloro, 1999; Sara et al., 1999; Loy et al., 2000), and it is considered a promising tool in assessments of fish quality. This methodology describes organisms geometrically, in terms of x and y (and also z) coordinates, obtained from a set of landmarks (Favaloro and Mazzola, 2003).

This article describes by a new ecological and biological approach the shape variation in cultured and lagoon caught gilthead seabream (*Sparus aurata*) using geometric morphometrics.

Materials and Methods

Group A comprised lagoon caught specimens of gilthead seabream collected from Homa Lagoon (38°33′23′N-26°50′42′E) in İzmir bay (n = 35, 19.71 ± 1.43 cm TL). Reared specimens were collected from a commercial marine fish farm in Muğla (n = 32, 15.12 ± 0.44 cm TL). The left side of each fish was photographed using a digital camera (Nikon Coolpix 5500) and the images were saved on computer. Geometric morphometrics were developed to quantify and visualize deformations of morphometric points (landmarks) in coordinate space, as conceptualized much earlier by D'Arcy Thompson (1917). Landmarks are defined as homologous points that bear information on the geometry of biological forms (Bookstein, 1991). Thirteen landmarks were determined on the gilthead seabream and X and Y coordinates were recorded using TpsDig2 (Rohlf, 2005). The landmarks are illustrated and described in Figure 1.

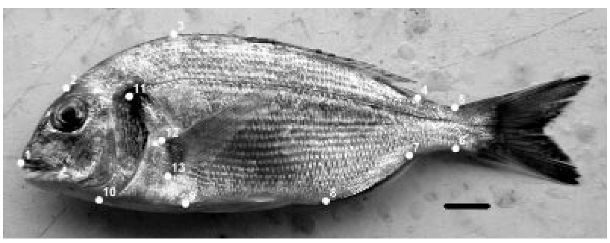

Figure 1. Landmarks used in the analysis of morphometric comparison of gilthead seabream: 1, tip of premaxillary; 2, top of eye; 3, anterior base of the dorsal fin; 4, posterior base of the dorsal fin; 5, 6, points of maximum curvature of the caudal peduncle; 7, posterior base of the anal fin; 8 anterior base of anal fin; 9, base of the pelvic fin; 10, ventral tip of cleithrum; 11, dorsad tip of cleithrum; 12,13, insertion of pectoral fin. Scale bars = 1.0 cm.

Landmark configurations for each specimen of each group were aligned, translated, rotated, and scaled to a unit centroid size by the Generalized Procrustes Analysis (GPA, 12) using the consensus configuration of all specimens for each species as the starting form. Residuals from the fitting were modeled with the thin-plate spline interpolating function (for complete coverage of the geometric morphometric techniques sees Bookstein, 1991; Rohlf and Bookstein, 1990; Rohlf and Slice, 1990; Marcus et al., 1996; Rohlf, 2000). In order to explore the overall within-sample shape variability, relative warp analysis (analogous to principal component analysis for this kind of data) was performed (using the software TpsRelw, Rohlf, 2001).

This method quantifies change in shape, and patterns of morphometric variations within and among groups can be quantified if each individual is considered to deviate from an average shape, i.e. the consensus configuration (Cadrin, 2000). In addition, a randomization test using the software Morpheus (Slice, 1998) was performed in order to establish the effect of unequal sample size. In order to test for the significance of differences in shape between samples, MANOVA was performed on non-uniform and uniform shape components using Morpheus. All specimens were scaled to unit centroid size before alignment by the GLS (Procrustes generalized orthogonal least-squares superimposition procedure).

Results

Figure 2 shows the scatter of residuals at each landmark relative to the consensus configuration after the superimposition with the generalized least-square method. Shape variability is not found at landmarks in either group of species.

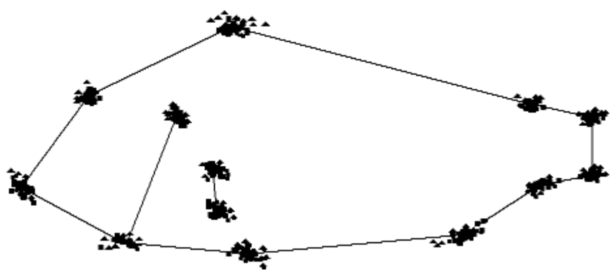

Figure 2. Scatter of residuals of the generalized least-square fitting for each landmark relative to consensus configuration (■, cultured seabream; ▲, lagoon captured seabream).

The scattergram of specimens plotted by relative warps analysis, including the uniform component of shape, is shown in Figure 3. The gilthead seabream from the lagoon (group A) were not well separated from the cultured ones, which were found together. Deformation in shape, from the general consensus, and associated with 2 relative warps (RW 1-2), was shown as thin-plate spline grids in Figure 4. These allowed us to visualize the spatial displacements of landmarks, which were greatest when moving from a middle point on the graph (no displacement) to the end of each axis. Along the RW2, extreme changes in shape (positive on the right and negative on the left) lie on landmarks 3 and 9 and secondarily on 5 and 6.

Randomization tests between the groups were performed using Morpheus (Slice, 1998). Shape analyses showed that there was no significant differentiation between groups of gilthead seabream ($P > 0.05$).

Discussion

Morphometric analysis has been significantly enhanced by image processing techniques and is a powerful tool that can complement other approaches to stock identification (Cadrin, 2000). After the initial development of imaging systems and skills, image processing is fast and inexpensive. Images can be easily re-analyzed, and audit trails can be developed for sensitive assessments (Friedland et al., 1994). In the current study, this technique was applied to reveal variations in body shape between cultured and wild (lagoon caught) sea bream. Briefly, the results obtained showed that there were no differences between the groups in terms of body shape.

The reason for selecting lagoon caught fish was to minimize the effect of feeding on shape variation in this species. The morphological characteristics of farmed and wild fish are also quite different. At the same age, wild sea bass have a slimmer body shape and a smaller abdominal circumference than reared sea bass; the farmed fish present a modified morphology, which appears to be a consequence of altered lifestyle conditions (Roncarati et al., 2001). Roncarati et al. (2001) compared mesocosm and intensive rearing techniques and reported that there was no difference in growth rate in sea bass. Moreover, this finding indicated that it is possible to minimize the effect of feeding on shape variation in these culture techniques. Lagoons are fairly rich and abundant regions in terms of nutritional quality and quantity (Whitfield, 1999; Mariani et al., 2002). It is commonly known that growth of lagoon fish is higher than that of wild fish (Warburton, 1979; Mariani et al., 2002). It is possible that insignificant differences between cultured and lagoon captured sea bream confirmed this phenomenon by the geometric morphometry method used in this study. Results from

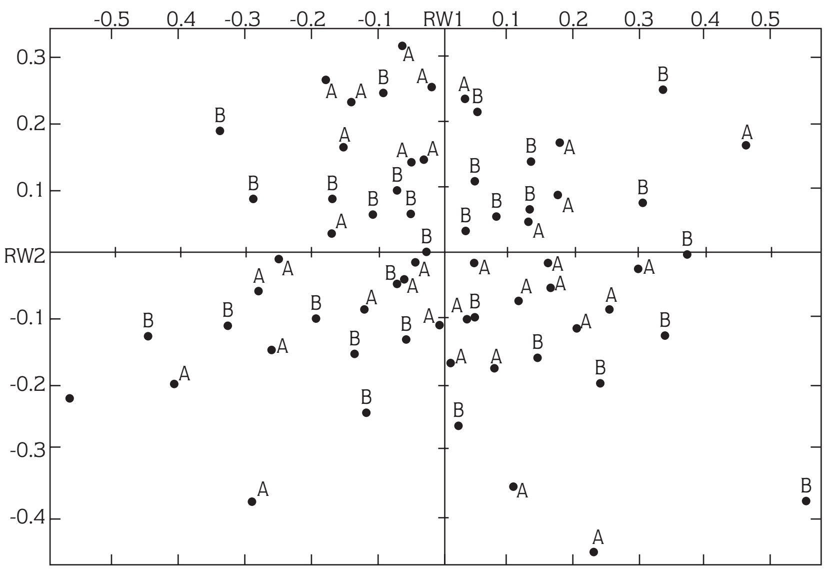

Figure 3. Relative warp analysis of 67 specimens in group A (n = 35) and group B (n = 32).

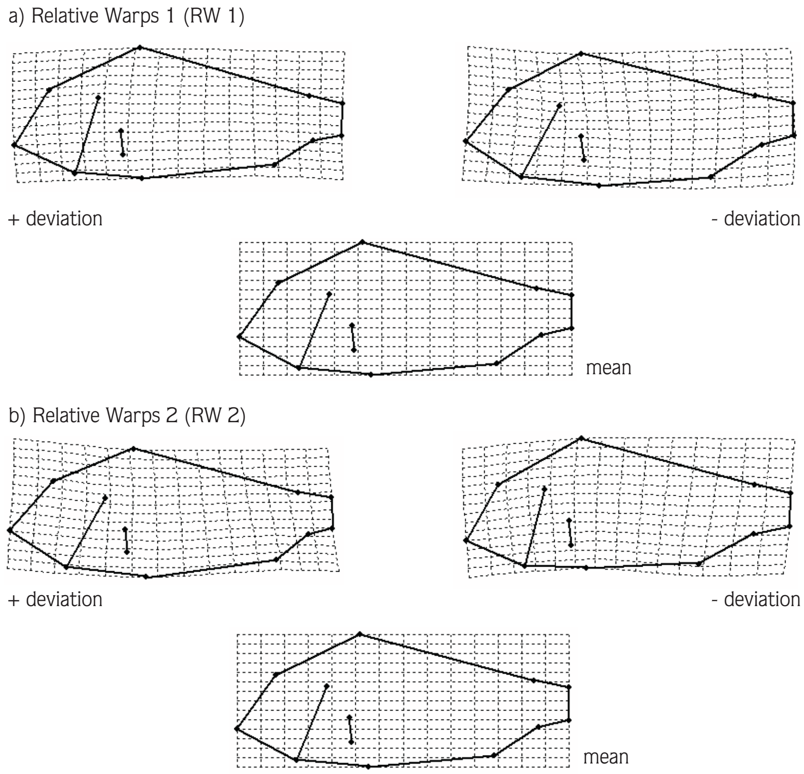

Figure 4. Thin plate spline grids shows the extreme shape deformations of gilthead seabream individuals. Each grid corresponds to one RW axis extremity of Figure 3.

this study demonstrated that fish in a lagoon, which is a richer nutritional area than the marine environment, were similar to cultured fish when compared morphometrically and it is emphasized that this result supports the success of high technology aquacultural techniques.

Several studies pointed out that culture techniques play a major role in the formation of body shape and some differences could be observed under culture conditions compared to the natural habitats in terms of geometric morphometry (Friedland, 1994; Cadrin, 2000). In addition, these morphological variations indicated that it is possible to culture fish similar to natural specimens. Favaloro and Mazzola (2003) reported that differences were found in the caudal peduncle area and ventral zone in sharpsnout sea bream reared under different culture techniques (monoculture and polyculture). Furthermore, Loy et al. (1998) estimated that shape differences, especially in the dorsal and ventral fin zone, were recorded in the early life stages of *Diplodus vulgaris* depending on habitat. Similarly, Sara et al. (1999) determined that extreme shape variations mainly occurred in the dorsal and anal fins of sharpsnout seabream reared in tank and off-shore systems. In conclusion, in the current study no significant differences were found in the caudal peduncle area or ventral zone in which morphological variations were frequently recorded. Moreover, these results indicated that feeding played an effective role in shape variation in both culture and natural conditions and that fish similar in quality to natural ones in terms of morphological shape could be reared under culture conditions.

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