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COMPARATIVE SHAPE ANALYSIS OF WILD AND REARED STERLET (*ACIPENSER RUTHENUS* L.)

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UPOREDNA ANALIZA OBLIKA PRIRODNIH I UZGAJANIH KEČIGA *(ACIPENSER RUTHENUS L.)*

Apstrakt

Usled ugroženosti kečige, brojni programi poribljavanja postoje, pa je od velikog značaja procena odgovarajućih primeraka za te programe. Metodom geometrijske morfometrije su analizirane promen oblika jedinki iz prirodnih populacija i iz uzgoja. ANOVA varijable veličine je pokazala da su jedinke iz uzgoja krupnije u odnosu na jedinke iz prirodnih populacija. Takođe, CVA varijable oblika je pokazala promene u predelu glave i repa kod jedinki iz prirodnih populacija. Ovi rezultati mogu predstavljati dobru osnovu kod procene odgovarajućih jedinki za poribljavanje otvorenih voda.

Ključne reči: geometrijska morfometrija, poribljavanje, recirkularni sistem uzgoja,
Keywords: geometric morphometrics, stocking, recirculating aquaculture system

INTRODUCTION

Sterlet (*Acipenser ruthenus* L.) populations have experienced a decline during 20th century, throughout Danube River basin, and their presence in Germany and Austrian sections is dependent on stocking efforts (Reinartz, 2002). To compensate decline of wild sterlet populations and boost their commercial harvest, countries in the Middle and Lower Danube also carried out stocking with larvae, fingerlings and juveniles (Smederevac-Lalić *et al*., 2011; Lenhardt *et al*., 2012). However, according to Neff *et al.* (2011), current breeding programs are too focused on genetic diversity and do not take into account complexities of the genetic architecture of wild populations fitness. Additionally, risk associated with (re) stocking include: increase competition and/or predation (Aprahamian *et al*., 2003), inbreeding or outbreeding depressions (Ludwig *et al*., 2009), while adaptation ability of stock specimens can be jeopardized if they are introduced in non-native areal (Ludwig, 2006). Some meristic and morphological differences between wild and reared sterlet were reported by Lenhardt *et al.* (2012), while various authors used shape analysis to asses body variations between wild and hatchery-reared specimens (von Cramon-Taubadel *et al*., 2006; Cvijanović *et al*., 2011; Arechavala-Lopez *et al*., 2012). Bearing all this in mind, careful selection of proper specimens for stocking programs should be mandatory.

The objective of this study is to assess the body variations between wild and farmed sterlet, as well as to assess differences in body shape between two different rearing systems.

MATERIAL AND METHODS

During July 2011, 68 specimens of sterlet were caught with gill nets by professional fishermen at the Tisza River (26 specimens near Bečej, N 45°37‘39.22” E 20°05‘40.01”) and the Danube River (42 specimens near Bačka Palanka, N 45°14‘05.22” E 19°22‘20.64”) sites. Acquiring samples from the aquaculture facility „FISH FARM“ (Vršac, N 45°07‘17.84” E 21°18‘08.25”) and Faculty of Fisheries and Protection of Waters (Vodňany, N 49°09‘38.15” E 14°10‘25.84”), was during January and February 2015, with collection of 35 and 32 specimens respectively. Both aquaculture facility represent recirculating aquaculture systems (RAS), with similar water flow regime ($7m^3/h$ and $6.5\text{-}7m^3/h$, respectively). Each fish was photographed from lateral (left side) and ventral aspect, with a Panasonic DMC-FZ40 digital camera mounted on tripod, at the same resloution and with ruler placed next to each specimen. In this study 11 landmarks defining the body outline were chosen (Fig. 1) for both landmark configuration (lateral and ventral). TpsDig software (Rohlf, 2005) was used to aquire morphometric data. Generalized Least Squares Procrustes superimposition (GLS) was applied for shape analyses, because it preserves all information about shape variability among the specimens and remove only information unrelated to shape (scale, position and orientation; Rohlf and Slice, 1990). For the analyses of size difference, we used the centroid size (CS, which represents the square root of the sum of the squared distances of a set of landmarks from the centre of gravity). Cordgen6 software (IMP series; Sheets, 2003) was used for calculation of the CS and GLS. An analysis of variance (ANOVA) was used to determine if CS differed significantly depending on location or age. Differences in shape between groups based on locations and between age classes were determen with the Canonical Variate Analysis (CVA). The purpose of CVA is to simplify the description of difference among groups (Zelditch et al., 2004), and analysis was carried out in CVAGen6 software (IMP series, Sheets, 2003). Age data were obtained from aquaculture, with sterlet from „FISH FARM“ (35 specimens) and Vodňany (32 specimens) beloging to 0+ age classe. All assessed indivduals from wild were immature, and based on the estimate age at first maturity in the Danube sterlet populations (Kolarević, 2004), they were 0+ (68 specimens).

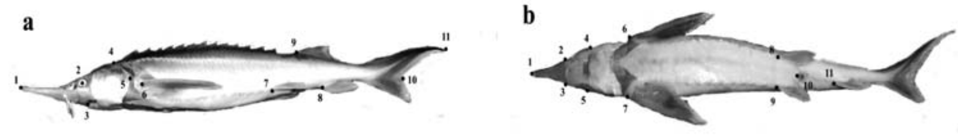

Figure 1. Position of the landmarks: a) lateral aspect: (1) snout tip, (2) eye, (3) front of mouth opening, (4) anterior insertion of the first dorsal scutum, (5) apex of the opercular spine, (6) dorsal insertion of pectoral fin, (7) anterior insertion of pelvic fin, (8) anterior insertion of anal fin, (9) anterior insertion of dorsal fin, (10) fork, (11) tip of caudal fin ; b) ventral aspect: (1) snout tip, (2)-(3) points where the line (connecting insertions of barbell) crosses the profile, (4)-(5) point where the line (connecting side of mouth opening) crosses the profile, (6)-(7) insertion of pectoral fins, (8)-(9) insertion of pelvic fins, (10) tip of anal opening, (11) insertion of anal fin.

RESULTS

All samples (n=135) in terms of size (expressed as CS) showed significant differences between groups based on locality. ANOVA of CS values for grouping based on locality show significant differences for both landmark configuration (F=272.87, $p<0.001$ and F=131.75, $p<0.001$ respectfully). A box-plot representing the distribution of CS show differences in CS values (Fig. 2). Tukey HSD post-hoc test show that differences of CS (lateral configuration) were higher between Vodňany and wild sterlet (p=0.000008 for both sampling sites), while differences between two rearing systems were also significant (p= 0.0377). Same differences for ventral landmark configuration was observed between Vodňany and wild sterlet (p=0.000008 for both sampling sites), while differences between two rearing systems were somewhere higher (p=0.000024).

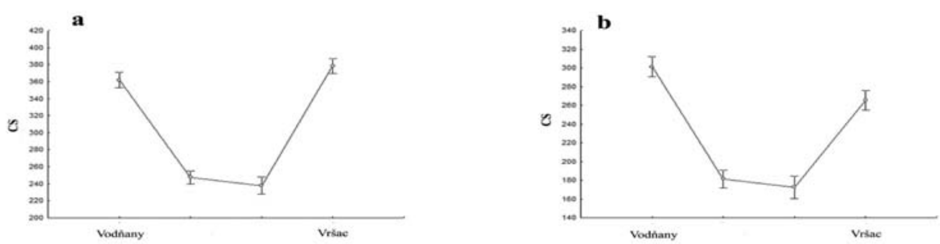

Figure 2. Box-plot of centroid size: a) grouping based on locality (lateral landmarks configuration); b) grouping based on locality (ventral landmarks configuration)

Canonical Variate Analysis (CVA) using partial warp scores show significant ($p<0.001$) differences between groups from different localities for both sets of landmarks configurations. For lateral landmarks configuration (Fig. 3), first CVA axes (λ=0.038, χ^2=400.61, d.f.=54) separated all sterlet from Vodňany specimens, while second CVA axes (λ=0.31, χ^2=145.46, d.f.=34) separated wild from „FISH FARM". For ventral configuration (Fig. 4), first CVA axes (λ=0.015, χ^2=513.33, d.f.=54) separated wild and reared specimens, while second CVA axes (λ=0.16, χ^2=226.87, d.f.=34) seperated speciemns from different rearing conditions. Eigenvalue for first two canonical axes (at lateral landmarks configurations) were 9.27 and 3.47 respectively, while the Eigenvalue for first two canonical axes (at ventral landmarks configurations) were 6.96 and 1.35 respectively.

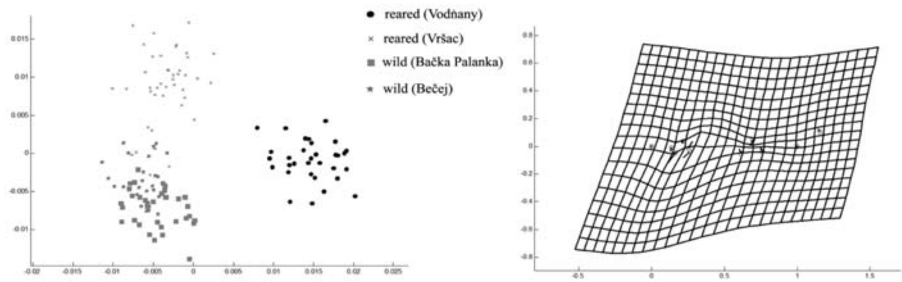

Figure 3. CVA score (lateral landmarks configuration) of first and second canonical variate analyses based on partial warps and uniform scores for all specimens (wild and reared) and partial warp grid for comparison between locality over first canonical variates.

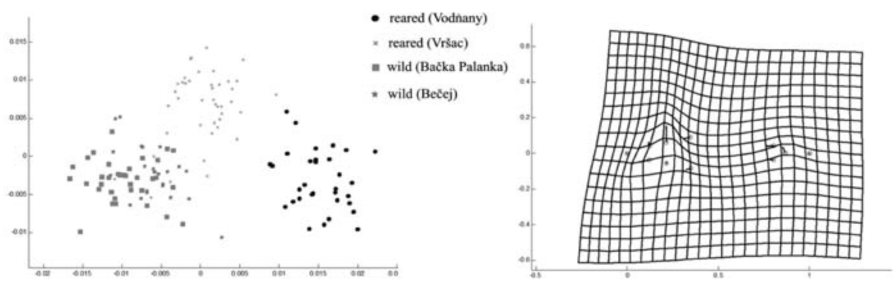

Figure 4. CVA score (ventral landmarks configuration) of first and second canonical variate analyses based on partial warps and uniform scores for all specimens (wild and reared) and partial warp grid for comparison between locality over first canonical variates.

DISCUSION AND CONCLUSION

Shape analysis performed in the present study indicated that there were differences between reared and wild sterlet, as well as body variations between both RAS systems.

In terms of centroid size, there was a significant difference between wild and reared sterlets. Also, difference was observed among both rearing systems and also among separate wild populations of sterlet. Fish from aquaculture have bigger body size, which can be attributed to better feeding conditions. Also, differences in CS value for both RAS systems can be attributed to different broodstock material.

Reinartz *et al.* (2011) produced clear evidence for a panmictic sterlet population across the entire Danube and its tributaries, so the question of whether local adaptations exist is something that has to be address in restocking programs. Shape analysis suggests that there is a significant difference between reared and wild starlet for both landmarks configurations. CVA show that tail region of Vodňany sterlets is narrowed if compared with other samples, when lateral landmarks configuration is applied. Since the conditions of rearing are similar in both Vodňany and Vršac RAS, this may be indicator of different broodstock material. In ventral landmarks configuration, both tail and head region of wild sterlets are thinned. Changes in head and tail region can be attributed to different flow conditions in wild and/or different food regime of wild sterlets. Still, future researches are needed, and especially detail evaluation of head and tail regions with additional landmarks and/or semi-lendmarks, defining body shape changes.

As Loy *et al*. (1999) stated, geometric morphometrics is a highly powerful tool and it's recommended in wild sturgeons populations, characterization of hybrids, and in quantifying within population variability and morphological plasticity. Also, this method can be good tool for optimization of breeding conditions for stocking specimens, but further research is needed.

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