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Short note

Length–Weight Relationships and Condition Factors of Three Sturgeon Species (Acipenseridae) from the Danube River

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Abstract. Length–weight relationships (LWRs), Fulton (*K*) and relative (K_{rel}) condition factors for *Acipenser ruthenus* Linnaeus, 1758, *Acipenser gueldenstaedtii* Brandt & Ratzeburg, 1833 and *Acipenser stellatus* Pallas, 1771 from the Danube River were estimated. Fish were captured by bottom drifting trammel nets in the period June – August, 2015–2019. A total of 790 specimens were measured and analyzed. More than 80% of the specimens were young of the year (YOY) fish with total length (TL) up to 35 cm. The values of the parameter *b* of the weight – length relationship for fish with lengths up to 35 cm ranged from 2.433 (*A. ruthenus*) to 2.859 (*A. gueldenstaedtii*). For specimens with TL > 35 cm the values of parameter *b* ranged from 3.227 (*A. stellatus*) to 3.668 (*A. ruthenus*). Relative condition factor (K_{rel}) ranged from 1.003 ± 0.020 (*A. gueldenstaedtii*) to 1.144 ± 0.018 for *A. ruthenus*. Fulton's condition factor (*K*) ranged from 0.300 ± 0.003 for *A. stellatus* to 0.514 ± 0.011 for *A. gueldenstaedtii*.

Key words: Sterlet, Stellate sturgeon, Russian sturgeon, Fulton factor, relative condition factor, allometric growth, Danube River.

Introduction

The fish family Acipenseridae includes some of the most endangered fish species worldwide (IUCN, 2010). Historically, six members of the family were widely distributed throughout the Danube River and Black Sea: Beluga (*Huso huso* Linnaeus, 1758), Russian sturgeon (*Acipenser gueldenstaedtii* Brandt & Ratzeburg, 1833), Stellate sturgeon (*Acipenser stellatus* Pallas, 1771), Sterlet (*Acipenser ruthenus* Linnaeus, 1758), Atlantic sturgeon (*Acipenser sturio* Linnaeus, 1758) and Ship sturgeon (*Acipenser nudiventris* Lovetzky, 1828), yet the last two are now considered extinct from the region. In the past these species constituted the main part of the traditional fishing in the Lower Danube River (Kynard et al., 2002). However, in the last 50 years, their populations have been drastically reduced due to habitat degradation, overexploitation, disturbance of the river longitudinal connectivity, loss of spawning sites, and water pollution (Bristein et al., 1997; Raischi et al., 2017). Danube sturgeons are anadromous, except the Sterlet that spends its entire life in the river (Bacalbasa-Dobrovici, 1997). All sturgeon species have been listed in the IUCN Red list as threatened or endangered (IUCN 2009), and in Annex I and II of the CITES (Bristein et al., 1997). Since 1999, support for Danube sturgeons has been initiated

through restocking and catch-limiting bans (Hubenova et al., 2009, WSCS & WWF, 2018). The maintenance and restoration of self-sustaining sturgeon populations will require knowledge of their biology and life history (Bristein et al., 1997). The length–weight relationships (LWRs) help to determine biomass from length observations, and the conversion of growth-in-length equations to growth-in-weight, it is also applied when assessing the well-being of individuals and comparing life histories of separated populations of the same species in different water bodies and regions (Craig et al., 2005; Froese, 2006). Body condition indices are commonly used in fisheries biology because they provide information on the stock condition. These indices can be very useful to fisheries management, especially as an alternative non-lethal method of providing information on rare and protected species without the need to sacrifice specimens (Le Cren, 1951, Froese et al., 2011). Currently, the knowledge on the length–weight relations of the sturgeon fishes in the Danube River is limited.

The aim of this work was to determine the length – weight relationships (LWRs) and condition indices for three representatives of wild sturgeon species inhabiting the Lower Danube River.

Material and Methods

The study was carried out in the Lower Danube River section, near Vetren Village (44.141538° N, 27.029863° E), Bulgaria. Sturgeons were caught as bycatch during the annual fish monitoring conducted by WWF-Bulgaria; they were captured in the period from June until August during five-year monitoring carried out from 2015 to 2019. YOY specimens of Stellate sturgeon (up to 35 cm TL) were captured in the Danube, while the specimens with TL > 35 cm were caught in the Danube and the Black Sea. The weight and length data of 18 specimens of the Stellate sturgeon species caught along to the Black Sea coast, near to Krapets Village (43.38493° N, 28.34325° E) were provided by professional fishermen. The sampling in Danube River were conducted using bottom drifting trammel nets. The nets were 100 m long × 2 m wide, with three different finer-meshed central layers, with mesh size of 20, 50 and 70 mm. Five to nine nets per day were used with an average 30 min. exposition. All individuals were identified *in situ* according Kottelat & Freyhof (2007). The fish were subsequently photographed, weighed, and immediately released back into the river. Total weight (W) was measured to the nearest 0.1 g using a digital portable balance Kern EMS 6K0.1 and the total length (TL) was measured to the nearest 0.1 mm. The Ministry of Food, Agriculture and Forests and the Executive Agency of Fishery and Aquaculture of Bulgaria authorized field samplings performed in this study.

The LWR parameters were estimated according to the formula: $W = aL^b$ (Le Cren 1951) by the least squares method through the transformed equation: $\log W = \log a + b \log TL$. The statistical significance level of the coefficient of determination (r^2) and 95% confidence limits of a and b were computed for all equations. Obvious outliers were identified and removed, according to the plot of the log W over log TL (Froese 2006). The differences between the value of b of the LWR and the value of isometric growth (b = 3) were compared by t-test (Froese et al. 2011). Fulton (K) and relative (K_{rel}) condition factors (Le Cren 1951, Sutton et al. 2000), were computed as $K=100*W/TL^3$ and $K_{rel} = W/aTL^b$ respectively, where a and b are the parameters from the LWR equations. Length and weight data were pooled together for each species without sex differentiation. All analyses were performed using Statistical Package SPSS version 22 (SPSS Inc. Ltd.) and Excel software (Microsoft Office, 2016).

Results

A total of 772 sturgeon specimens were caught on the Danube River and 18 specimens in the Black sea. Descriptive statistics and estimated parameters of the LWR are shown in Table 1. All length–weight relations were statistically significant ($P < 0.001$).

For *A. ruthenus* and *A. stellatus* with length up to 35 cm, the estimated growth type was negative allometric, while at *A. gueldenstaedtii* was isometric. Larger specimens of *A. ruthenus* (> 35 cm TL) (b=3.668) and *A. stellatus* (b=3.227) exhibited positive allometric growth.

Table 1. Descriptive statistics and length–weight relationships (LWRs) for three sturgeon species from the Danube River. Abbreviations: a - intercept, b - slope, CI - confidence interval, n - sample size, r^2 - coefficient of determination; SD - standard deviation. * All length–weight relations were statistically significant (P < 0.001).

Species name	n	Total length [cm]		Body weight [g]		LWR Parameters					
		Range	Mean±SD	Range	Mean±SD	*a*	*b*	SE *b*	95% CI of *b*		r^2
Acipenser ruthenus (< 35 cm TL)	546	14.8-29.0	21.9±2.7	12.0-98.0	43.8±13.6	0.023	2.433	0.037	2.36	2.51	0.886
Acipenser ruthenus (> 35 cm TL)	67	35.2-68.0	45.5±6.3	180.0-2015.0	457.5±286.2	0.0003	3.668	0.119	3.43	3.91	0.936
Acipenser stellatus (< 35 cm TL)	130	16.7-30.0	21.9±2.7	14.0-74.0	32.3±11.4	0.010	2.609	0.070	2.47	2.75	0.916
Acipenser stellatus (> 35 cm TL)	25	36.0-139.0	62.0±21.5	140.0-10200.0	1047.1±2136.8	0.001	3.277	0.186	2.89	3.66	0.931
Acipenser gueldenstaedtii	22	12.6-33.0	24.4±6.2	13.0-168.0	86.1±53.8	0.008	2.859	0.074	2.70	3.01	0.987

Relative condition factor (K_{rel}) and Fulton's condition factor (K) for four sturgeon species are shown in Table 2. In this study, the K_{rel} ranged from 1.003 ± 0.020 (*A. gueldenstaedtii*) to 1.144 ± 0.018 (*A. ruthenus*). The minimum and maximum of Fulton's condition factors (K) were 0.300 and 0.514 ± 0.011 for *A. stellatus* and *A. gueldenstaedtii* respectively.

Table 2. Fulton's condition factor (K) and relative condition factor (K_{rel}) for three sturgeon species from the Danube River. Legend: max - maximum; min - minimum; n - sample size; SE - standard error.

Species name	n	Fulton's condition factor (K)			Relative condition factor (K_{rel})		
		mean	SE	min - max	mean	SE	min - max
Acipenser ruthenus (< 35 cm TL)	546	0.404	0.0025	0.263-0.682	1.006	0.0048	0.669-1.438
Acipenser ruthenus (> 35 cm TL)	67	0.439	0.0085	0.303-0.641	1.144	0.0178	0.869-1.527
Acipenser stellatus (< 35 cm TL)	130	0.300	0.0028	0.237-0.418	1.009	0.0084	0.800-1.350
Acipenser gueldenstaedtii	22	0.514	0.0113	0.434-0.650	1.003	0.0201	0.880-1.244

Discussion

In our study we examined the parameters of the LWRs of juveniles (immature) and adult Sterlet and Stellate sturgeon specimens separately, to determine more rigorously the slope *b*. Sterlet mature at 35 cm TL for male specimens (Muus & Dahlström 1968). All captured Russian sturgeon were YOY specimens up to 35 cm TL. We suspect that the origin of this specimens were most likely from a restocking carried out in 2019 in the Lower Danube.

The parameters of LWRs for *A. ruthenus* (b = 2.94, n = 285) obtained in the present study was similar to those that have been observed by Lenhardt et al. (2004) under morphological analysis of Sterlet population from the Serbian part of the Danube River. Froese (2006) observed ontogenetic changes in body shape related with size.

In the present study a positive allometric growth (b= 3.227) was observed in the case of *A. stellatus* (> 35 cm TL). The results obtained for the same species from Caspian Sea (Fazli & Moghim 2014, Mousavi & Ghafor 2014) show isometric growth, while Ceapa et al. (2002) found out that the Stellate sturgeon brood fish collected during reproductive migration in the Romanian part of Danube River had a negative allometric growth (b = 2.284 for males, n = 128). The observed differences might be due to the different sample size (number of specimens used), sex of specimens or sampling periods. Therefore, extrapolation of LWR parameters of *A. stellatus* to different length ranges should be handled with caution. Isometric growth (b=2.859) was observed for *A. gueldenstaedtii*, which corresponds to the results reported by Mousavi & Ghafor (2014) for the same species from the Caspian Sea.

For the Stellate sturgeon, the Fulton's condition factor (K) has the lowest value (0.300 ± 0.003), while the Russian sturgeon has a higher value (0.514 ± 0.011), which may be due to the fact that the Russian sturgeon specimens were probably hatched on a farm for restocking purposes where they were fed *ad libitum* in their first three months.

Conclusion

This study provided the basic information on the length–weight relation parameters and condition indices for the YOY and juvenile specimens of *A. ruthenus, A. stellatus* and *A. gueldenstaedtii* from the Lower Danube. Such data is valuable for establishing a monitoring program and enforcing management solutions for the protection of the natural stocks of these endangered species.

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