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LENGTH-WEIGHT RELATIONSHIPS AND FULTON CONDITION FACTOR (K) OF FRESHWATER FISH SPECIES FROM THE RUSCOVA RIVER, SPAWNING GROUND OF DANUBE SALMON *HUCHO HUCHO,* LINNAEUS, 1758 (PISCES: SALMONIDAE)

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Abstract

This study is the first reference regarding the length-weight relationships of freshwater fishes inhabiting one of the most important spawning waters of the endemic endangered Danube salmon (Hucho hucho). Fulton condition factor (K) was calculated for 1366 individuals belonging to 16 species from Ruscova River, north of Romania. Length-weight relationships were determined for 1362 specimens from 14 species. The smallest slope value (b) was determined for Romanogobio uranoscopus (b=2.2437) and the highest value for Telestes souffia (b=3.6058). The Danube salmon (Hucho hucho) showed positive allometric growth, having the calculated value of the slope of 3.3879. The mean values of Fulton condition factor (K) for the captured specimens were: Cottus gobio (1.161), Alburnus alburnus (0.3726), Alburnoides bipunctatus (0.8142), Barbus barbus (0.9434), Barbus carpathicus (0.9202), Chondrostoma nasus (0.8867), Romanogobio uranoscopus (0.8196), Phoxinus phoxinus (0.9888), Squalius cephalus (1.137), Telestes souffia (0.898), Barbatula barbatula (0.6693), Eudontomyzon danfordi (0.1293), Hucho hucho (0.8454) and Thymallus thymallus (0.9522).

Key words*: allometry, electrofishing, endangered species, ichthyofauna, LWR.*

INTRODUCTION

The abundance of the Danube salmon *Hucho hucho,* the largest salmonid inhabiting the Danube basin (montane and submontane rivers) is decreasing due to anthropic activities such as pollution, poaching, habitat fragmentation, riverbed regulations, and hydro-power plants (Bănărescu, 1964; Holčik, 1990; Bănăduc, 2008; Bănăduc et al., 2013; Witkowski et al., 2013; Ihuț et al., 2014; Freyhof et al., 2015; Cocan et al., 2020). The knowledge on Danube salmon spawning sites regarding fish composition is crucial for the conservation of the species. Young Danube salmon specimens remain in the spawning tributaries feeding on invertebrates, but when they reach 50-90 mm they start feeding on fish (Holčik, 1990). Bănărescu (1964) stated that juveniles start preying on fish when they are a few months old, especially on common nase (*Chondrostoma nasus*), and feed on insects and larvae only when prey fishes are missing. Šubjak (2013) studied the stomach content of Danube salmon from Slovak rivers during the winter season and mentioned that the species' main food source consisted of brown trout (*Salmo trutta*), rainbow trout (*Oncorhynchus mykiss*), European grayling (*Thymallus thymallus*), European chub (*Squalius cephalus*), common nase (*Chondrostoma nasus*), common barbel (*Barbus barbus*), bream (*Abramis brama*), spirlin (*Alburnoides bipunctatus*), bleak (*Alburnus alburnus*), perch (*Perca fluviatilis*) and frogs

(*Rana* sp.). Habitat alteration affects all the trophic levels (producers = plants; aquatic insects and non-predatory fish = primary consumers; invertebrate consumers = secondary consumers and vertebrate predators = tertiary consumers) (Amila & Suhaila, 2017). In the current study, on Ruscova River, fish species (primary, secondary and tertiary consumers) length-weight relationships and condition factor were analyzed through allometric growth and Fulton condition factor K (Le Cren, 1951, Froese, 2006; Nash et al., 2006; Rawat et al., 2014; Jisr et al., 2018; Borga et al., 2019).

MATERIALS AND METHODS

STUDY AREA

Ruscova River (Figure 1) is situated in the Northern part of Romania and it is tributary to Vișeu River, one of the most important habitats of the Danube salmon *Hucho hucho*. It has a total length of 39 km and it crosses four localities: Poienile de sub Munte, Repedea, Ruscova, and Leordina, where it flows in Vișeu River. Ruscova River is considered one of the most important spawning grounds for the Danube salmon, the most enigmatic freshwater fish species of the Salmonidae family. A total number of 15 sampling stations were analysed in terms of fish species composition and length-weight relationships.

FISH SAMPLING

Fish sampling was carried out from June 2013 to July 2013 by single-pass electrofishing techniques using a SAMUS 725G apparatus powered by 12V and 24 A rechargeable battery (Reid et al., 2009). Each captured fish was photographed, weighed, measured, and released back into the river. Total length (TL) was digitally measured using ToupView software version 3.7 (ToupTek Photonics) based on the fish images taken on laminated graph paper to the nearest 0.1 mm. Wet body weight (BW) was measured using a digital scale to the nearest 1 g (Brosset et al., 2015).

DATA ANALYSIS

The relationship between total length and body weight (LWR) was estimated by fitting the exponential curve to the data ($BW=aTL^b$, where *BW* is body weight, *TL* the total length, *a* the intercept and *b* the slope) (LeCren, 1951). To detect the strong deviation from isometric growth ($b=3$) 95% confidence intervals of *b* were determined and also determination coefficient R^2 was calculated.

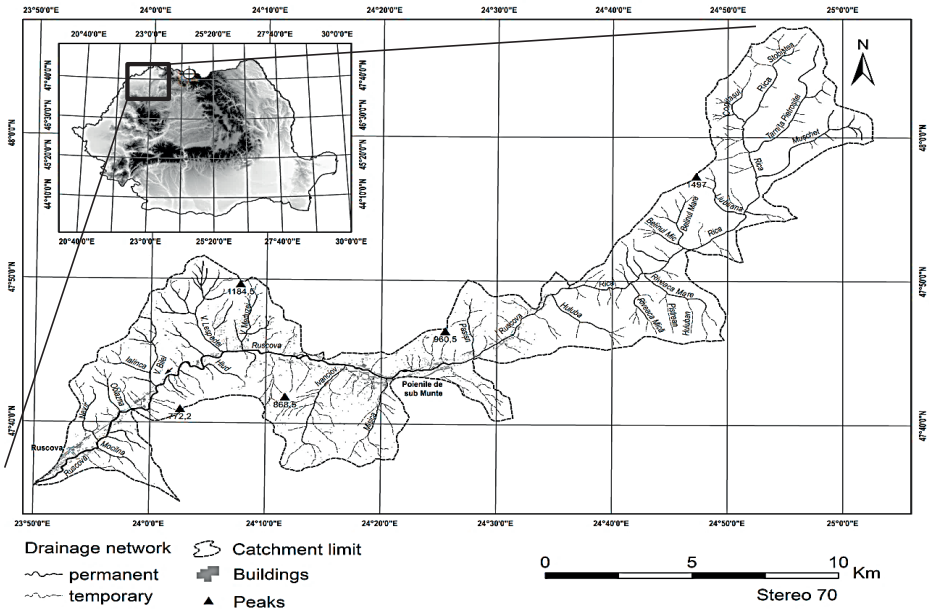

Figure 1. Ruscova River catchment (Source: Cocan et al., 2020)

When the slope value b=3, the weight increase is considered isometric. When the value of b is higher than 3, the weight increase is allometric positive, and when b is lower than 3 the weight is allometric negative. Fulton condition factor (K) for each individual was calculated based on the formula:

$$K = \frac{BW \cdot 100}{TL^3}$$

where:
K – Fulton condition factor
BW – wet body weight (g)
TL – total length (cm)

RESULTS AND DISCUSSIONS

The altitude of the 15 sampling stations ranged from 401 m to 616 m. A total number of 1366 individuals from 16 species and 9 families were sampled (Leuciscidae: *Alburnoides bipunctatus, Alburnus alburnus, Phoxinus phoxinus, Squalius cephalus, Chondrostoma nasus, Telestes souffia*; Cyprinidae: *Barbus barbus, Barbus carpathicus*; Gobionidae: *Romanogobio uranoscipus*; Cottidae: *Cottus gobio*; Cobitidae: *Sabanejewia balcanica*; Nemacheilidae: *Barbatula barbatula*; Lotidae: *Lota lota*; Salmonidae: *Hucho hucho, Thymallus thymallus* and Petromyzontidae: *Eudontomyzon danfordi*) (Figure 2). Allometric growth of the burbot *L. lota* and the Balkan spined loach *S. balcanica* was not calculated in this study because of their small number (1 *L. lota* and 3 *S. balcanica* specimens).

Mean Fulton's condition factor (K) ranged from 0.1293 in the case of *E. danfordi* to 1.1607 for *C. gobio*. The mean value of K for the other species was as follows: *S. cephalus* – 1.1370, *P. phoxinus* – 0.9888, *T. thymallus* – 0.9522, *B. barbus* – 0.9434, *B. carpathicus* – 0.9202, *T. souffia* – 0.8980, *C. nasus* – 0.8867, *H. hucho* – 0.8454, *R. uranoscopus* – 0.8196, *A. bipunctatus* – 0.8142, *A. alburnus* – 0.6726, *B. barbatula* – 0.6693 and *L. lota* – 0.5722, *S. balcanica* – 0.4771 (Figure 3).

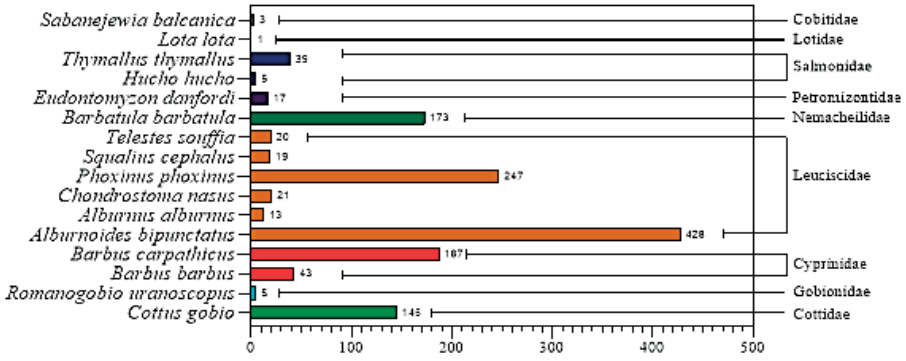

Figure 2. Fish species abundance from Ruscova River

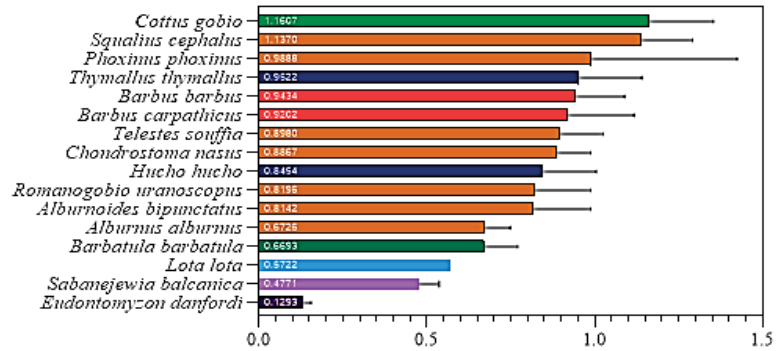

Figure 3. Fulton Condition Factor (K) determined for fish species from Ruscova River

In the case of the analyzed species, the LWRs were significant ($p<0.05$) and the coefficient of determination R^2 ranged from 0.638 in the case of *P. phoxinus* to 0.995 in the case of *H. hucho*. In addition, the calculated values of R^2 values were larger than 0.90 for 8 species (58%), larger than 0.8 for 4 species (28%), between 0.6 and 0.7 for 2 species (14%). The slope values (*b* values) ranged from 2.2437 for *G. uranoscopus* to 3.6058 for *T. souffia*. The growth type of the studied species showed isometric growth (b=3) in two cases: *C. nasus* and *C. gobio*. The following 6 species showed positive allometric growth (b>3): *A. alburnus, S. cephalus, T. souffia, B. barbus, B. carpathicus* and *H. hucho.* The remaining 6 species showed a negative allometric growth (b<3) type (*A. bipunctatus, P. phoxinus, G. uranoscopus, B. barbatula, T. thymallus* and *E. danfordi*) (Table 1).

The data regarding LWRs in the case of Danube salmon are similar to those of Simonovic et al. (2011) where the *b* values of adult Danube salmon from Drina River (Serbia) ranged from 2.187 to 3.910. It is worth mentioning that the authors used standard length. In terms of Fulton's condition factor K, the same authors obtained values between 1.074 to 1.190, slightly higher than the values from our study caused by the use of standard length. Ratschan (2012) and Treer et al. (2013) mentioned that the size of Danube salmon is dependent on its habitat size. Four out of five captured specimens in this study were small-sized fish (39-92 g). The largest specimen caught had 1150 g. Treer et al. (2013) obtained a condition factor of 1.1559 but for much larger specimens (4.5-18 kg).

Table 1. Length-weight relationship of fish species from Ruscova River, Romania.

Family	Species	N	Weight (g) Mean ± SD (Min-Max)	Length (cm) Mean ± SD (Min-Max)	Equation $BW=a\ TL^b$	R^2	S.E. of b (95% C.I. of b)	Growth Type
Leuciscidae	*Alburnoides bipunctatus*	428	5.22±2.63 (1.00-20.00)	8.48±1.28 (5.81-13.96)	$BW = 0.0155\ TL^{2.6829}$	0.709	0.0831 (2.519-2.846)	Allometric (-)
	Alburnus alburnus	13	11.00±5.86 (4.00-21.00)	11.41±2.00 (8.37-14.75)	$BW = 0.0042\ TL^{3.1942}$	0.968	0.1744 (2.810-3.578)	Allometric (+)
	Chondrostoma nasus	21	99.95±72.80 (23-294)	21.12±5.58 (13.96-31)	$BW = 0.0096\ TL^{2.9694}$	0.974	0.1121 (2.735-3.204)	Isometric
	Phoxinus phoxinus	247	3.58±1.33 (1.00-9.00)	7.12±0.96 (2.49-10.31)	$BW = 0.0344\ TL^{2.3365}$	0.638	0.112 (2.115-2.558)	Allometric (-)
	Squalius cephalus	19	125.47±79.70 (11.00-329.00)	21.16±4.89 (10.02-30.38)	$BW = 0.0081\ TL^{3.106}$	0.97	0.132 (2.826-3.386)	Allometric (+)
	Telestes souffia	20	18.65±11.37 (3.00-42.00)	12.18±2.22 (8.06-15.58)	$BW = 0.0019\ TL^{3.6058}$	0.976	0.134 (3.323-3.887)	Allometric (+)
Cyprinidae	*Barbus barbus*	43	32.00±31.07 (4.00-194.00)	13.98±3.71 (7.80-27.68)	$BW = 0.0061\ TL^{3.1605}$	0.956	0.1063 (2.946-3.375)	Allometric (+)
	Barbus carpathicus	187	30.99±28.39 (2.00-163.00)	13.63±4.25 (5.96-24.41)	$BW = 0.0069\ TL^{3.1081}$	0.976	0.0358 (3.037-3.179)	Allometric (+)
Gobionidae	*Gobio uranoscopus*	5	3.80±1.30 (2.00-5.00)	7.71±1.20 (6.43-9.24)	$BW = 0.0375\ TL^{2.2437}$	0.827	0.593 (0.356-4.131)	Allometric (-)
Cottidae	*Cottus gobio*	145	10.74±4.98 (3.00-30.00)	9.54±1.40 (6.64-13.41)	$BW = 0.0106\ TL^{3.0348}$	0.895	0.087 (2.863-3.207)	Isometric
Nemacheilidae	*Barbatula barbatula*	173	7.68±2.59 (3.00-19.00)	10.36±1.20 (7.50-16.89)	$BW = 0.0098\ TL^{2.8311}$	0.809	0.1052 (2.623-3.038)	Allometric (-)
Salmonidae	*Hucho hucho*	5	287.20±482.80 (39.00-1150)	25.96±11.99 (17.37-47.03)	$BW = 0.0024\ TL^{3.3879}$	0.995	0.141 (2.937-3.838)	Allometric (+)
	Thymallus thymallus	39	73.59±50.89 (3.00-195.00)	18.60±5.53 (5.83-26.87)	$BW = 0.0152\ TL^{2.8193}$	0.885	0.167 (2.481-3.157)	Allometric (-)
Petromyzontidae	*Eudontomyzon danfordi*	17	9.23±4.21 (3.00-17.00)	18.90±3.43 (13.41-23.02)	$BW = 0.0031\ TL^{2.6877}$	0.908	0.2208 (2.217-3.158)	Allometric (-)

CONCLUSIONS

This paper represents a uniquely comprehensive data set on the length-weight relationship and condition factor of the fish species community from Ruscova River, one of the most important spawning habitats of the endangered Danube salmon.

The growth type of Danube salmon was allometric positive (b=3.3879), while the growth of the second Salmonidae species, *T. thymallus* was allometric negative (b=2.8193). Fulton condition factor of the Danube salmon was K=0.8454.

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