



## Length-weight Relationships of Five Cyprinid Fish Species from Lake Ohrid

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**Abstract:** Length-weight relationships (LWR) were estimated for five species of cyprinid fishes from Lake Ohrid, including *Alburnus scoranza*, *Barbus rebeli*, *Pachychilon pictum*, *Rutilus ohridanus* and *Squalius squalus*. From the measured data of length and weight, the regression parameters  $a$  and  $b$  were calculated and ranged from 0.0028 to 0.0187, and from 2.7256 to 3.6038, respectively. The condition factor was also calculated and ranged from 0.95 to 1.34.

**Key words:** LWR, fish growth, condition factor, Cyprinidae.

### Introduction

The length-weight relationship and the parameters derived from it have important application in fish biology, fish ecology and fisheries management (LE CREN 1951, FROESE 2006). The length-weight relationships of fish are important for converting length observations, into weight and biomass estimates (FROESE 1998). Variance in length-weight relationships depends on the season, the population or annual differences in environmental conditions (FROESE 2006). Fulton's Condition Factor (K) is a mean of comparing the weight and the length in a particular fish sample and can indicate differences related to sex, season or place of capture (RICKER 1975). Differences in the condition factor have been interpreted from the point of various biological features, such as fatness, suitability of environment or gonad development. The expression of the length-weight relationship and the measurement of changes in condition are two rather different but interconnected aims in the analysis of length-weight data (LE CREN 1951). The aim of our study was to explore the length-weight relationships of five cy-

prinid fishes from Lake Ohrid: *Alburnus scoranza* Heckel & Kner, 1857, *Barbus rebeli* Koller, 1926, *Pachychilon pictum* Heckel & Kner, 1858, *Rutilus ohridanus* Karaman, 1924 and *Squalius squalus* Bonaparte, 1837. All of these species are endemic for the Western Balkans and inhabit mainly the basins of Lake Ohrid and Lake Skadar except for *S. squalus*, which also inhabits freshwater bodies in Italy (KOTTELAT & FREYHOF 2007). It is worthy to mention that none of the studied species from Lake Ohrid has encoded LWR data on FishBase (FORESE & PAULY 2019).

### Materials and Methods

Specimens of the mentioned fish species were collected in Lake Ohrid, which is an oligotrophic water body located on the Balkan Peninsula, shared between two countries, the Republic of North Macedonia and the Republic of Albania. For the taxonomical identification of the fish species, we followed KOTTELAT & FREYHOF (2007). The sampling took place in September 2018. A total of 646 specimens were collected using gillnets with mesh size of 12,

14, 24 and 26 mm knot to knot. The nets were planted in the littoral zone of the lake from 0-30 meters depth, at dusk and were left overnight in the water for approximately 12 hours. After catch, the fish were processed immediately. First, they were identified and divided by species, then total length (to nearest 1 mm) and body weight (to nearest 0.1 g) were measured using a ruler and laboratory scale, respectively. For the estimation of the length-weight relationship, the function  $W=aL^b$  was used (RICKER 1975).  $W$  represented the total body weight in grams (g),  $L$  was the total body length in centimetres (cm), while  $a$  and  $b$  were the coefficient and the exponent of the arithmetic form of the length-weight relationship and the intercept and the slope of the regression line of the logarithmic form of that relationship (FROESE 2006). The values for  $a$  and  $b$  were estimated with a linear regression of the logarithmic form of the length-weight relationship ( $\log w = \log a + b(\log l)$ ). In addition, the 95% confidence intervals of the parameters and the statistical significance of the regression relationship ( $r^2$ ) were estimated. The parameter  $b$  was an indicator of the type of growth of the fish. When  $b=3$ , it indicated isometric growth, in which weight increased as the cube of the length. When  $b>3$ , the fish was increasing in weight (presumably also in volume) at a greater rate than the required to maintain constant body proportions and vice versa when  $b<3$  (RICKER 1979). The  $b$  value was tested with t-test at the significance level of 0.05 to verify if it was significantly different from 3. From the values for weight and length, the Fulton's condition factor was calculated for every fish using the formula  $K = [\text{weight (g)} / (\text{length (cm)})^3] \times 100$  (RICKER 1975).

## Results

The size of the samples, minimum and maximum of the lengths and the weights, values for  $a$  and  $b$  parameters with their 95% confidence limits and the

coefficient of determination  $r^2$  for each of the studied species are presented in Table 1. LW plot for each fish species is presented on Fig. 1. The values for parameters  $a$  and  $b$  ranged from 0.0028 to 0.0187, and from 2.7256 to 3.6038, respectively. The  $b$  parameter indicated negative allometric growth ( $b<3$ ,  $p<0.05$ ) for *A. scoranza*, positive allometric growth ( $b>3$ ,  $p<0.05$ ) for *R. ohridanus* and *S. squalus* and isometric growth ( $b=3$ ) for *P. pictum* and *B. rebeli*. All the studied species had high  $r^2$  values with the only being below 0.9 (0.8890 – for *A. scoranza*). The condition factor ranged from 0.95 for *A. scoranza* to 1.34 for *R. ohridanus* (Table 2).

## Discussion

Here, we report the first ever LWR description for *B. rebeli*. Previous research data are lacking (FROESE & PAULY 2019). The data for *S. squalus* from Lake Ohrid represent its first LWR description from the Balkans, with previous data published for samples from Italy (GIANNETTO et al. 2014, CAROSI et al. 2017). There are available data for *A. scoranza*, *R. ohridanus* and *P. pictum* from Lake Ohrid (MILOSEVIC & TALEVSKI 2016) but they are not loaded in FishBase.

Our results for the parameter  $b$  are in agreement with the values for teleost fish ( $2.5 < b < 3.5$ , see FROESE 2006), except for *R. ohridanus* ( $b=3.6038$ ). MILOSEVIC & TALEVSKI (2016) found negative allometric growth for *R. ohridanus* ( $b=2.972$ ). Within-species variance in weight-length relationships can be substantial, depending on the season, the population or annual differences in environmental conditions (FROESE 2006). The same authors presented negative allometric growth for *A. scoranza* ( $b=2.884$ ) from Lake Ohrid and our results for the  $b$  parameter for this species are in agreement. Negative allometric growth was also presented by MILOSEVIC & MRDAK (2016) for *A. scoranza* ( $b=2.936$ ) from Lake Skadar. This could be a species trait

**Table 1.** Estimated parameters of length-weight relationships of five cyprinid fish species from Lake Ohrid.

Species	n	Length (cm)		Weight (g)		Regression parameters				
		Min	max	min	max	b	95% CL of b	a	95% CL of a	$r^2$
<i>Alburnus scoranza</i>	82	10	16.5	9.9	37.2	2.7256*	2.5113-2.9398	0.0187	0.0110-0.0319	0.8890
<i>Barbus rebeli</i>	79	10.4	25.6	10.6	190.6	3.0556	2.9928-3.1185	0.0085	0.0071-0.0101	0.9919
<i>Pachychilon pictum</i>	189	8.5	18.3	7.5	70.2	2.9492	2.8698-3.0285	0.0133	0.0110-0.0161	0.9664
<i>Rutilus ohridanus</i>	250	7.2	17.6	3.7	86.9	3.6038*	3.5645-3.6431	0.0028	0.0026-0.0031	0.9925
<i>Squalius squalus</i>	46	10.7	33.5	11.1	369.6	3.3194*	3.1890-3.4499	0.0044	0.0030-0.0063	0.9835

\*Significant difference of the value for parameter  $b$  from 3 (t-test;  $p<0,05$ )

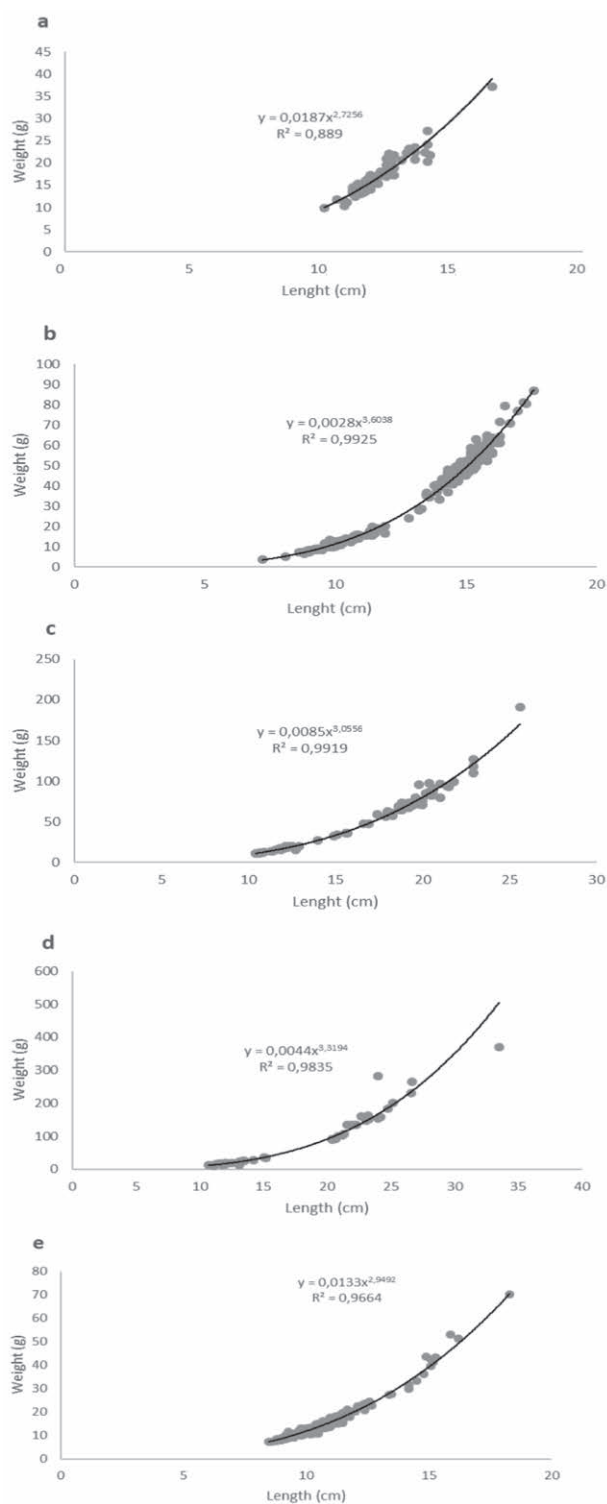
**Table 2.** Fulton's Condition Factor for five cyprinid fish species from Lake Ohrid.

Species	Condition Factor
	Av. $\pm$ SD
<i>Alburnus scoranza</i>	0.95 $\pm$ 0.07
<i>Barbus rebeli</i>	0.99 $\pm$ 0.07
<i>Pachychilon pictum</i>	1.18 $\pm$ 0.08
<i>Rutilus ohridanus</i>	1.34 $\pm$ 0.18
<i>Squalius squalus</i>	1.09 $\pm$ 0.21

(elongated body shape), taking in consideration that the Lakes Ohrid and Skadar have different environmental conditions. Positive allometric growth for *P. pictum* was presented by MILOSEVIC & TALEVSKI (2016), while our result indicated an isometric growth regarding this species. Differences in LWRs of fishes may be attributed to several factors, most notably the sample number and length range, also the age and sex of the fish, gonad maturity, feeding intensity, season and environmental conditions (WOOTTON 1990, FROESE 2006). However, not all of these factors were considered in the present study. We found positive allometric growth for *S. squalus*, results that are in line with the data for this species in Italy (GIANNETTO et al. 2014). Regarding the parameter  $a$ , FROESE (2006), by using the LWR data for 1773 species, demonstrated that 90 % of the values ranged between 0.001 and 0.05. In our study, all of the species showed values that fit in this range.

The results for the condition factor had values of around 1 besides those for *R. ohridanus* that was 1.34. Changes in the condition factor value of the fish may indicate gonadal maturation or changes in feeding intensity (WOOTTON 1990). The sampling for this study was conducted after the spawning period, so the latter would be the case. Although this factor assumes that the studied fish species grow without any change of its form ( $b=3$ ) (LE CREN 1951, FROESE 2006), it is the most popular and widely used condition factor in ichthyological research.

Our study gave the first LWR description for *B. rebeli* and *S. squalus* from Lake Ohrid. Further, we provided an update on the previous LWR data for the remaining three fish species. Nevertheless, taking in consideration the uniqueness of the ecosystem of Lake Ohrid and the importance of some of this fish species for the commercial and recreative fishing on this lake, we can say that LWR studies regarding these species are scarce. This kind of data is of great importance for fishery research and management and can have application in conservation

**Fig. 1.** Plot presentation of the LW relationships with the function  $W=aL^b$  and  $r^2$  for (a) *Alburnus scoranza*, (b) *Rutilus ohridanus*, (c) *Barbus rebeli*, (d) *Squalius squalus* and (e) *Pachychilon pictum*.

biology and ecology. In addition, our study can provide valuable data for FishBase, in which for none of the explored species from Lake Ohrid is included a LWR description.

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