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Length-Weight Relationship of 11 Fish Species from Three Natural and Two Artificial Lakes in the Former Yugoslav Republic of Macedonia (FYROM)

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Abstract: Data on the length-weight relationships (LWR) of 11 fish species from three natural (Prespa, Ohrid and Dojran) and two artificial lakes (Debar and Tikveš) in the Former Yugoslav Republic of Macedonia (FYROM) are presented. These are the first comprehensive LWR data for six (including three endemic) freshwater fish species for the above mentioned lakes, previously unavailable in Fish Base. The values of parameter *b* range from 1.641 to 4.188, and of *a* range from 0.0003 to 0.187. The model of growth for all examined species are determined.

Key words: Fisheries, model of growth, FishBase, Lake Ohrid, Lake Prespa, Lake Dojran, Lake Tikveš, Lake Debar

Introduction

Length-weight relationship (LWR) provides useful information for management of fisheries for both applied and basic purposes (Pitcher & Hart 1982). Furthermore, LWR can be a useful tool in environmental monitoring programmes, especially for calculation of fish weight at a certain length (and vice versa) as well as for calculation of a condition index in order to allow comparisons between populations from different regions (Petrakis & Stergiou 1995). The morphometric relationship between length and weight can be used to assess the well-being of individuals and to determine possible differences between stocks of the same species (King 2007). In addition, this index may also help to determine whether somatic growth is isometric or allometric (Ricker 1975) as well as for describing seasonal variations of growth within a species (Bobori et al. 2010).

About 80 fish species have been recorded on the territory of the FYROM (Talevski & Talevska 2010). Data on LWR of many fish species from the FYROM are still unavailable.

The aim of the present paper is to report the first comprehensive LWR data for 11 freshwater species from the FYROM. Six of these freshwater species (including three endemic) had no LWR information available in Fish Base (Froese & Pauly 2014).

Materials and Methods

Samples were collected from three natural lakes in the FYROM, i.e. Prespa, Ohrid and Dojran, as well as from the artificial lakes Debar and Tikveš (Figure 1). The Lake Prespa is a cyprinid eutrophic lake; its fish fauna consists of 11 species, including nine (82%) endemic species. The Lake Ohrid is oligotrophic and, out of the 20 autochthonous fish species, 35% are endemic for the lake. There are 15 autochthonous and allochthonous fish species in Lake Dojran; of these, two species (14%) are endemic. Lake Debar is an artificial lake constructed in the valley of the Crn Drim River; its ichthyofauna is identical to the ichthyofauna of Ohrid Lake except for the composi-

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tion of salmonid species. Lake Tikveš is an artificial lake constructed in the valley of the Crna River, with fish fauna consisting of 14 autochthonous and six allochthonous species.

Samples were collected between November 2008 and August 2014 using gillnets. The number of studied individuals of each species and locality are presented in Table 1. Species were identified in the field, measured to the nearest 1 mm (total length, TL) and weighed to the nearest 0.1 g (weight, W).

The following mathematical function was used to estimate LWR: $W = aL^b$ (Ricker 1975), where W is the total body weight (g), L is the total body length (cm), and *a* and *b* are the coefficients of the functional regression between *W* and *L*. The 95% confidence intervals (CI) of the parameters and the statistical significance of the regression relationship (r^2) were estimated. An allometric coefficient *b*, larger or smaller than 3.0, is an indication of allometric growth. If the coefficient value is equal to 3.0, that is an indication of isometric growth (Bagenal & Tech 1978). The values of parameters (*a* and *b*) were estimated by linear regression model with logarithmic transformation $\log w = \log a + b (\log l)$ (Ricker 1975). The determination coefficient (r^2) was used as an indicator of the quality of the linear regressions.

Results

The sample size, the minimum, maximum and mean lengths and weights, the values of *a* and *b* with their respective 95% confidence limits and the coefficient of determination r^2 for each species are presented in Table 1. Based on FishBase (Froese & Pauly 2014), it is noteworthy that for six species (*Alburnus scoranza, Alburnoides prespensis, Pachychilon pictum, Pelasgus prespensis, Rutilus ohridanus* and *Perca fluviatilis* from Lake Tikveš), the data represent the first description of LWR. The values of parameter *b* ranged from 1.641 to 4.188, and those of *a* varied from 0.0003-0.187.

Fig. 1. Map showing the approximate locations of five lakes from which studied species were sampled

The value of *b* indicated negative allometric growth for *Alburnus scoranza* (from lakes Ohrid and Debar), *Perca fluviatilis* (Lake Dojran), *Rutilus ohridanus* and *Rutilus prespensis*, positive allometric growth for *Alburnus belvica*, *Chondrostoma prespense*, *Pachychilon pictum* (lakes Ohrid and Debar) and *Perca fluviatilis* (Tikveš Lake), and isometric growth for *Cyprinus carpio* and *Alburnoides prespensis*.

Discussion

Data on length-weight (L-W) relationships of 11 species from the FYROM were previously lacking. For six of these species, LWRs were not recorded in Fish Base. Our results are in agreement with Froese (2006), who reported that *b* values for teleost fish should fall within the expected range of 2.5 and 3.5, except for the *Pelasgus prespensis* (*b* =1.641) and *Squalius prespensis* (*b*=4.188). Carlender (1977) demonstrated that values of $b<2.5$ or $b>3.5$ are often derived from samples with narrow size ranges. Differences in fish LWRs may be attributed to several factors, such as number and length range of the sampled specimens, gonad maturity, sex, diet, stomach fullness, and growth phase (Bagenal & Tesch 1978; Wootton 1990; Froese 2006). In four cases (species/lake combinations), the *b* values were higher than 3 (t-test; $p<0.05$), in three cases the *b* values were lower than 3 (t-test; $p<0.05$), while for the rest of the species/lake combination the *b* values of the L-W relationships did not differ significantly.

Froese (2006) demonstrated through a meta-analysis involving LWR data of 1773 species that 90% of the intercept values ranged between 0.001 and 0.05. In our study, all species showed *a* value within the range presented by Froese (2006), except for *Pelasgus prespensis* and *Squalius prespensis.*

The *b* value for *Alburnus scoranza* (from lakes Ohrid and Debar), *Perca fluviatilis* (Lake Dojran), *Rutilus ohridanus* and *Rutilus prespensis* indicated negative allometric growth, while the *b* value for *Alburnus belvica*, *Chondrostoma prespense*, *Pachychilon pictum* (lakes Ohrid and Debar) and *Perca fluviatilis* (Lake Tikveš) indicated positive allometric growth. The L-W relationship in fish can be affected by several factors including habitat, area, seasonal effect, degree of stomach fullness, gonad maturity, sex, health, preservation techniques and

differences in the observed length ranges of the specimen caught (Tesch 1971) but these factors were not accounted for in the present study.

We found negative allometric growth for *R. prespensis* from Lake Prespa. This result differs from the available results of both Bobori *et al*. (2010) and Milošević *et al*. (2012) who reported a positive allometric growth in *R. prespensis*. Their results were respectively *a*=0.0060 and *b*=3.283 from Mikri Prespa (Greece) and *a*=0.0046 and *b*=3.3589 from Lake Skadar. This variation in the *b* exponents for the same species is obviously attributed to the differences in age and stage of maturity. Growth increment, food, as well as environmental conditions such as temperature, salinity and seasonality can also affect the *b* value for the same species (Weatherley, Gill 1987). Our results related to *Perca fluviatilis* from Lake Dojran (*b*=2.795) are in line with data from Babori *et al*. 2010 who reported a *b* value of 2.991. These values indicate negative allometric growth. The results related to *Alburnus belvica* from Lake Prespa confirm available data from Fish Base for Lake Micri Prespa (*b*=3.230; *b*=3.300), which indicate positive allometric growth.

When species growth from two ecosystems was compared, we found that *Alburnus scoranza* and *Pachychilon pictum* had the same growth rate in both Lake Ohrid and Lake Debar (which can be attributed to similar ecological conditions). *Perca fluviatilis* which exhibited a negative growth rate in Lake Dojran and positive growth rate in Lake Tikveš. These differences were caused by changed ecological conditions inLake Dojran: lowered water level/ lake water volume and exponential growth of phytoplankton and macrophyte vegetation. This, in turn, affected the qualitative composition of fish populations in the lake; it altered the population structure of *Perca fluviatilis* (in terms of growth, sex, length and weight) and the introduced *Carassius gibelio* became a commonly caught species. The composition of fish populations was also affected by overfishing of *Perca fluivatilis* and *Rutilus rutilus*, some 20 years ago (Kostov & van der Knaap, 2009).

On the other hand, *Perca fluviatilis*, as an introduced species in Lake Tikveš, has acclimatised well. Studies on *Perca fluviatilis* in this ecosystem clearly show a stable length and weight growth and gonad development. In addition, the qualitative composition of fish in Tikveš Lake indicates that *Perca fluviatilis* does not compete for its food resources (Official Gazette of FYROM 2012/148).

In conclusion, this study provides information on length-weight relationships of 11 freshwater fish from the FYROM. The length-weight relationship

Table 1. Descriptive statistics and estimated parameters of LWR for 11 freshwater fishes from FYROM; *:indicates difference of *b* value from 3 (t-test; $p<0.005$)

			Length (cm)		Weight (g)		Regression parameters				
Species	**Lake**	**N**	**Min**	**Max**	**Min**	**Max**	***b***	**95% CI of *b***	***a***	**95% CI of *a***	r^2
Alburnoides prespensis (Karaman, 1924)	Prespa	167	7.4	10.8	4.3	15.1	3.016	2.7162-3.3159	0.006	0.0040-0.0079	0.702
Alburnus belvica Karaman, 1924	Prespa	230	8.4	19.0	5.2	61.4	3.154	3.0834-3.2246	0.006	0.0040-0.0079	0.972
Alburnus scoranza Heckel et Kner, 1857	Ohrid	60	10.4	12.9	5.2	14.9	2.884*	2.0804-3.6876	0.009	-0.0086-0.0266	0.460
Alburnus scoranza Heckel et Kner, 1857	Debar	44	11.5	15.7	5.8	23.6	2.949	2.3042-3.5938	0.009	-0.0086-0.0266	0.657
Chondrostoma prespense Karaman, 1924	Prespa	20	10.2	26.8	8.4	192.8	3.259*	3.1532-3.3648	0.004	-0.0068-0.0088	0.997
Cyprinus carpio Linnaeus, 1758	Prespa	91	6.5	34.4	4.3	602.8	3.085*	3.0418-3.1281	0.010	0.0080-0.0119	0.997
Pachychilon pictum (Heckel et Kner, 1858)	Ohrid	620	3.9	16.7	0.35	58.8	3.285*	3.2399-3.3301	0.005	0.005-0.005	0.971
Pachychilon pictum (Heckel et Kner, 1858)	Debar	350	6.7	17.5	2.2	59.3	3.110*	3.0355-3.1845	0.008	0.0060-0.0099	0.951
Pelasgus prespensis Karaman, 1924	Prespa	56	6.2	9.4	3.4	8.2	1.641	1.4195-1.8625	0.187	0.1008-0.1877	0.795
Perca fluviatilis Linnaeus, 1758	Dojran	60	15.9	25.2	49.1	194.3	2.795	2.403-3.187	0.021	-0.0045-0.0465	0.771
Perca fluviatilis Linnaeus, 1758	Tikveš	60	15.3	21.8	44.3	148.5	3.104	2.8335-3.3745	0.010	0.0022-0.0178	0.895
Rutilus ohridanus (Karaman, 1924)	Ohrid	52	10.5	16.7	13.2	53.5	2.972*	2.7642-3.1797	0.014	0.0061-0.0218	0.978
Rutilus prespensis Karaman, 1924	Prespa	56	15.4	19.5	50.6	95.7	2.657*	2.5884-2.7256	0.035	-0.0101-0.0801	0.847
Squalius prespensis (Fowler, 1977)	Prespa	20	16.9	23.3	38.5	161.3	4.188	3.3609-5.0151	0.0003	0.0002-0.0004	0.908

for six of those 11 species is provided for the first time (*Alburnoides prespensis* and *Pelasgus prespensis* are endemic to the Lake Prespa and *Rutilus ohridanus* is endemic to Lake Ohrid). These results may be considered by biologists and fishing engineers when fish populations are subjected to management activities for sustainable exploitation. In addition, the results could provide some insight into the conservation of these species, especially those that are threatened by loss of habitat, water pollution, overfishing and non-native fish introduction. Finally, the results of this study, being the first for the FYROM, will significantly contribute to the evaluation of the relative condition of fish populations, biology, species and fisheries management in the studied lakes.

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