Age, growth and mortality of Caspian Spirlin, *Alburnoides eichwaldii* (De Filippi, 1863), from Aras River Basin in Turkey

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Introduction

The genus *Alburnoides* belongs to the Leuciscine cyprinids and is distributed in Europe and eastern parts of Asia. Only two subspecies have been consistently reported for *Alburnoides bipunctatus* (Heckel, 1858) from Turkey (Kuru, 2004), *A. bipunctatus eichwaldii* and *A. bipunctatus fasciatus*. Just a few years ago, some taxonomic work focusing on the genus *Alburnoides* reported 4 new species from Turkey (Turan *et al*., 2013; 2014).

Alburnus eichwaldii (De Filippi, 1863), described from the Kurpresso Tiflis (Kura River near Tbilisi, Georgia), is usually regarded as a Caspian Sea basin subspecies of *A. bipunctatus* (Bogustkaya, 1997; Nazari *et al*., 2009). Recently, the species was considered to be a full species (Fricke *et al*., 2007).

A. eichwaldii inhabits both lentic and lotic water bodies, with well-oxygenated clear water (Stepanyan *et al*., 2013). Because of low tolerance to water pollution it is considered as a good biological indicator of environmental quality (Abbasi *et al*., 2013a). *A. eichwaldii* does not have economic value however it plays an important role because it is an important prey item of many predator fish species while its main food items are plankton and some invertebrates, mostly diptera and ephemeroptera (Abbasi *et al*., 2013a).

There are several papers dealing with the Karyotype (Stepanyan *et. al*., 2013) in Armenia and diet (Abbasi *et al*., 2013a), hematological parameters (Kohanestani *et al*., 2013), body shape (Eagderi *et al*., 2013), some population parameters (Seifali *et al*., 2012; Abbasi *et al.*, 2013b; Monajjemi *et al.*, 2014; Nowferesti *et al.*, 2014) in Iran. However, there has not been any study conducted on population dynamic parameters of the species in Turkey. Therefore this study aimed to investigate population parameters including age, growth, mortality and exploitation rates of *A. eichwaldii* from Aras River basin in Turkey.

Material and methods

This investigation was carried out on August 2-6, 2014 and September 25-29, 2014 from Aras River Basin at stations in both rivers and lakes (Çıldır, Balik and Aygir). A total of 162 specimens were caught using a backpack electrofisher (SAMUS 725MP) in the river and 90 specimens were caught using multi-mesh gillnets (5, 6.25, 8, 10, 12.5, 15.5, 19.5, 24, 29, 35, 43, 55 mm, knot to knot) in the lakes. Collected specimens were fixed in 10% formalin, transferred to the laboratory and stored in 70% ethanol for further processing. Five of the specimens were cataloged (NHVIC 201408080) in the Ichthyology Collections of Nevsehir Haci BektasVeli University, Department of Biology, Nevsehir, Turkey.

Morphometric measurements and meristic counts based on Bogutskaya and Coad (2009) were made for comparison with other studies. The taxonomic key given by Berg (1949a, b), Bogutskaya and Coad (2009), Coad and Bogustkaya (2009) were used to identify the samples to the lowest taxonomic level. Morphometric characters were taken with digital calipers to the nearest 0.1 mm and meristicones were counted under magnifier or stereo microscope. All measurements and counts were made on the left side of the fish.

In order to determine the population parameters, the total length and weight were determined to the nearest 1 mm and 0.01 g respectively. The scale samples were removed from the left side of the fish body, from ventral to the dorsal fin for the age determination. Scales were soaked in water and examined under the stereo binocular microscope, independently twice with no reference to the previous readings and without any knowledge of the length or weight of the fish. The precision was measured by the percentage of agreement between the two readings (Chang, 1982). The assessment of age was based on the determination of the number of annuli on each scale.

The length-frequency data were plotted with 1 cm length intervals. The length-weight relationships were determined according to the power equation given by Sparre and Venema (1998): $W=a*L^b$. In this equation, W is total weight, a and b are regression constants and L is total length. Growth in length and weight were expressed in terms of the von Bertalanffy equation $L_t=L_\infty[1-e^{-k(t-to)}]$.The growth parameters L_∞, k and t_o were estimated using the Least Squares Method recommended by Sparre and Venema (1998).

Correspondence between empirical data and an expected distribution was tested by Khi^2 test. The *b* value was tested by t-test to verify whether it was significantly different from the isometric growth (*b*: 3).

The growth performance index (Φ') was calculated using the formula (Pauly and Munro, 1984): $\Phi'=\log k+2\log L_\infty$. Fulton's condition factor (K) was calculated by the following equation: $K=100\frac{W}{L^b}$ where; *W*: total weight, *L*: total length, *b:* regression constant (Sparre and Venema, 1998).

The instantaneous rate of total mortality coefficient *Z* was estimated using Beverton and Holt's Z Equation (1956): $Z=k\frac{(L_\infty-\bar{L})}{(\bar{L}-L')}$, where; $\bar{L}$ is the mean length of the entire catch, L' is the lower limit of corresponding length intervals (Sparre and Venema, 1998). The natural mortality coefficient (*M*) was estimated following Pauly's empirical formula (Pauly, 1980), linking the natural mortality with the von Bertalanffy parameters, L_∞(cm), *k* and mean annual temperature (T,°C) of water in habitat (in this case 9.3°C): $\log10M=-0.0152-0.279\log10L_\infty+0.6543\log10k+0.463\log10T$. Fishing mortality rates (*F*) was calculated as the difference between *Z* and *M* ($F=Z-M$). The value of the average annual exploitation rate (*E*) was obtained by $E=F/Z$ (Sparre and Venema, 1998).

Wilcoxon signed-rank test was performed to compare river and lakes samples. Chi-Square test (χ^2) was used to compare observed and estimated parameters.

Results and discussion

Age, frequency distributions in length and weight of *A. eichwaldii* are presented in Table 1. There were significant differences in the parameters between the specimens of river and lake ($p<0.05$). Therefore, all analyses and evaluations were performed separately for river samples and lake samples.

Age of *A. eichwaldii* varied from 0 to III year age groups and most frequent groups for river and lakes were 0 (42.0%) and I (33.3%) year age groups, respectively. The total length ranged between 3.2 and 13.0 cm (8.98±2.11 cm) for river and 7.3 and 13.0 cm (9.63±2.08 cm) for lake samples. It was evident that *A. eichwaldii* grew rapidly in their first year after which growth rate declined (Table 1).

Monajjemi *et al*. (2014) reported that age of *A. eichwaldii* varied from 0 to III year age groups and the most frequent groups was the age group 0 in Shirud River (Iran). The maximum total length and weight observed was 111.4 mm and 15.5 g with the mean of 68.33±16.92 mm and 4.9±3.2 g, respectively in this study. Age distribution has been revealed as 0-II, and the length distribution as 2.53-11.02 cm according to Abbasi (2013b) in Tilaban Creek. In another study the length range was reported as 2.5-11.02 cm (n: 47) in Tilaban Creek, 4.06-11.68 cm (n: 66) in Shirabad Creek and 5.47-11.15cm in Kaboodval Creek (Abbasi *et al*., 2013a).

Table 1: Age, length and weight-frequency distribution of Caspian spirlin, *Alburnoides eichwaldii*, in Aras River Basin.

Age	N	%n	Total Length (cm)			Total Weight (g)	
			Mean	Range	Growth rate (%)	Mean	Range
River Samples							
0	68	42.0	6.97±1.33	3.2-9.8		3.85±2.43	0.21-9.20
I	44	27.2	9.48±0.67	8.0-11.6	36.00	9.13±2.05	5.15-15.52
II	30	18.5	10.90±0.62	9.9-12.3	14.96	14.33±2.65	9.77-19.94
III	20	12.3	11.77±0.85	10.0-13.0	7.90	18.16±3.39	11.12-23.17
Σ	162		8.98±2.11	3.2-13.0		8.99±5.68	0.21-23.17
Lake Samples							
0	9	16.7	5.54±0.91	7.3-9.0		2.50±1.28	4.01-7.39
I	30	33.3	9.45±0.82	9.0-10.5	17.28	12.12±3.26	7.47-13.58
II	24	26.7	11.25±0.81	9.5-12.0	13.43	20.05±4.73	8.12-24.28
III	21	23.3	14.75±2.33	11.6-13.0	11.22	39.31±15.27	19.51-27.67
Σ	90		9.63±2.08	7.3-13.0		13.96±7.91	4.01-27.67

Growth performance, condition factor, mortality and exploitation rate of the Caspian spirlin have been reported in a few studies.

Growth performance index (Φ') was estimated as 4.11 by Seifali *et al*. (2012) and 4.24 Abbasi *et al*. (2013b).The index was not estimated for this species previously.

There is a striking similarity among all river populations whereas the parameters estimated for lake were quite different from others. The results showed a significant difference in *A. eichwaldii* population inhabiting the river and the dam in terms of body shape.

The observed differences were related to head, snout, caudal peduncle regions and eye diameter that could be an adaptation to altered habitat and hydrological conditions of upstream and downstream due to damming (Eagderi *et al*., 2014).

For a long time, the influence of environmental factors on fish has been studied in respect to their effects on fish growth. Because fish are ectotherms, growth of fish is highly dependent on temperature. But other factors are also involved in the control of physiological functions (Boeuf and Le Bail, 1999). Consequently, all of these factors have impact on population parameters. The length-weight relationship and von Bertalanffy growth parameters for *A. eichwaldii* are presented in Fig. 1. The relationship is determined as W=0.00644$L^{3.2221}$ (95% CI of *b:* 3.151-3.293) for rives and W=0.00651$L^{3.3714}$ (95% CI of *b:* 3.225-3.518) for lakes. The *b* value was not significantly different than 3.0 (p<0.001), which indicates isometric growth of *A. eichwaldii.*

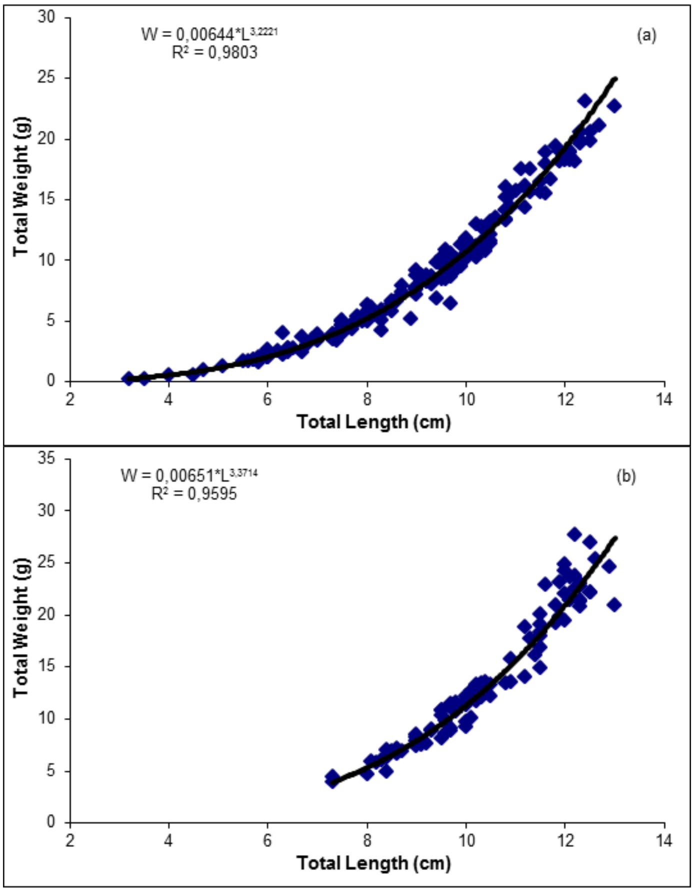

Figure 1: Length-weight relationship of Caspian spirlin, *Alburnoides eichwaldii*, sampled from the stations of river (a) and lakes (b) in Aras River Basin.

Table 2: Length-weight relationship and von Bertalanffy growth parameters for Caspian spirlin, *Alburnoides eichwaldii* (*females, **males, ***combined sexes)

B	*a*	L_∞ (cm)	*k* (year^{-1})	t_0 (year)	*Φ'*	K	Habitat	Country	References
3.122***	0.000006	10.45	1.19		4.11		River	Iran	Seifali *et al*. 2012
2.919*	0.005	12.45	0.248	-0.39	4.24		River	Iran	Abbasi *et al*., 2013b
2.876**	0.005	11.66	0.281	-0.39			River	Iran	Abbasi *et al*., 2013b
2.944***	0.0145	12.08	0.55	-0.47			River	Iran	Monajjemi *et al*., 2014
3.290***	0.0046						River	Iran	Nowferesti *et al*., 2014
3.221***	0.0064	12.91	0.548	-1.41	1.96	1.08	River	Turkey	This study
3.371***	0.0065	16.36	0.237	-2.89	1.80	1.19	Lake	Turkey	This study

The length-weight relationship reported from Iran is given in Table 2. As can be seen in the table, *b* value was close to 3 or above 3. The highest value (3.371) was estimated to be lake population in this study. The length-weight relationship may be influenced by sex, maturity, geographical location and environmental conditions in the given year (Weatherley and Gill, 1987). Additionally, sampling bias due to the collection method could influence the size frequency distribution and finally the estimation of parameters.

Considering the values determined in the previous studies, all values were higher than that of this study (Table 2). When reporting as the annual average water surface temperature of 12.46 °C in Iran, it has been measured at approximately 5-6°C in this studied area. Certain environmental factors such as water temperature, food supply, poor water quality, physical disturbance and biology of fish such as maturity and hormones have an obvious and major influence on growth rate (Kapoor and Khanna, 2004). Therefore the difference among studies linked with these factors.

Instantaneous total (*Z*), natural (*M*) and fishing (*F*) mortalities were estimated as 0.88, 0.75 and 0.13 year^{-1}, respectively for river samples and 0.39, 0.37 and 0.02 year^{-1}, respectively for lake samples. The exploitation rate (*E*) was calculated as 0.15 and 0.05 for river and lake samples, respectively.

Mortality and exploitation rates were estimated by Seifali *et al*. (2012) and Monajjemi *et al*., (2014) given in Table 3. There was over fishing pressure on the population of *A. eichwaldii in* both of these studies. However over fishing pressure was not observed neither in the river nor in the lake station in this study. Indeed, *A. eichwaldii* population inhabiting in rivers or lakes is not commercially fished in Aras River Basin in Turkey.

Table 3: Mortality rates (year^{-1}) of Caspian spirlin, *Alburnoides eichwaldii.*

Z	*M*	*F*	*E*	Habitat	Country	References
3.40	0.97	2.43	0.71	River	Iran	Seifali *et al*. 2012
2.41	1.19	1.22	0.51	River	Iran	Monajjemi *et al*., 2014
0.88	0.75	0.13	0.15	River	Turkey	This study
0.39	0.37	0.02	0.05	Lake	Turkey	This study

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