Original Research Paper

Age, growth and mortality of *Pseudophoxinus fahrettini* Freyhof and Özuluğ, 2009 in Aksu stream - Köprüçay River (Isparta, Turkey)

Habil Uğur *KOCA
and
Murtaza ÖLMEZ

Süleyman Demirel University, Eğirdir Faculty of Fisheries, Eastern Campus, 32200, Isparta, Turkey.

*Corresponding author
E-mail: ugurkoca@sdu.edu.tr
Tel: +90 246 211 86 24
Fax: +90 246 211 86 97

The age, growth and mortality characteristics of *Pseudophoxinus fahrettini* Freyhof and Özuluğ, 2009 caught from Aksu Stream - Köprüçay River (Isparta - Turkey) between March 2009 and February 2010 were determined. The use of scales for age estimation and age composition varied between age groups 0 and IV. Mean fork length, weight and condition factor values of the individuals were calculated as FL= 14.14 ± 0.21 cm, W= 47.24 ± 1.98 g and Cl= 1.25 ± 0.04, respectively. Lenght - weight relationships and von Bertalanffy growth equations were estimated as $W = 0.03 * FL^{2.61}$ (r = 0.962) and $L_t = 31.50 [1 - e^{- 0.22 (t + 1.25)}]$ and $W_t = 384.25 [1 - e^{- 0.22 (t + 1.25)}]^{2.61}$, respectively. Survival rate, total mortality coefficient, natural mortality coefficient, fishing mortality coefficient, annual mortality rate, expectation of fishing mortality, expectation of natural mortality, and the exploitation ratio were estimated as S = 0.64 year $^{-1}$, Z = 0.44 year $^{-1}$, M = 0.34 year $^{-1}$, F = 0.10 year $^{-1}$, A = 0.36 year $^{-1}$, u = 0.08 year $^{-1}$ and v = 0.28 year $^{-1}$, respectively

Key words: *Pseudophoxinus fahrettini*, endemic, age, growth, mortality, Aksu stream,KöprüçayRiver,Turkey

INTRODUCTION

The genus *Pseudophoxinus* is found in a wide range of habitats in Turkey. There have been numerous taxonomical studies to solve phylogenetic relationships among the Central Anatolian species complex of *Pseudophoxinus* (Hrbek et al., 2004; Bogutskaya, 1992; Kottelat and Barbieri, 2004; Atalay, 2005; Freyhof and Özuluğ, 2006; Yeğen et al., 2007; Küçük, 2007; Dağlı, 2008; İlhan et al., 2009; Küçük et al., 2009; Dağlı and Erdemli, 2009; Ekmekçi and Kırankaya, 2010).

Until recently, the species *P. handlirschi* Pietschmann, 1933 has been erroneously reported from the Upper Köprüçay River (Küçük, 1998; Küçük and İkiz, 2004; Yeğen et al., 2006). It is in fact a closely related species, as suspected by Van Neer et al. (2008) and first explicitly mentioned by Küçük et al., (2009). Afterwards, same year Freyhof and Özuluğ, (2009) described the Köprüçay population as a new species, *P. fahrettini* (Küçük, 2012).

To the best of the authors knowledge, **t**his is the first study on population features (age, growth and mortality) of

P. fahrettini in Aksu Stream, the main branch of the Köprüçay River (Isparta, Antalya), to which the species is exclusively endemic.

MATERIALS AND METHODS

The study was carried out from March 2009 to February 2010 in Aksu Stream - Köprüçay River (Isparta, Turkey). A total of 771 *P. fahrettini* specimens were obtained by monthly sampling using portable electroshocker from the six stations Kasımlar Bridge: 37° 31' 08'' N - 031° 12' 00'' E [Station I]; İncedere Bridge: 37° 34' 57'' N - 031° 10' 31'' E [Station II]; Karacahisar Bridge: 37° 37' 00'' N - 031° 10' 17'' E [Station III]; Ayvalıpınar Location: 37° 39' 28'' N - 031° 03' 58'' E [Station IV]; Asak Bridge: 37° 44' 58'' N - 031° 01' 50'' E [Station V]; Başpınar Spring: 37° 49' 43'' N - 031° 06' 37'' E [Station VI] (Figure I).

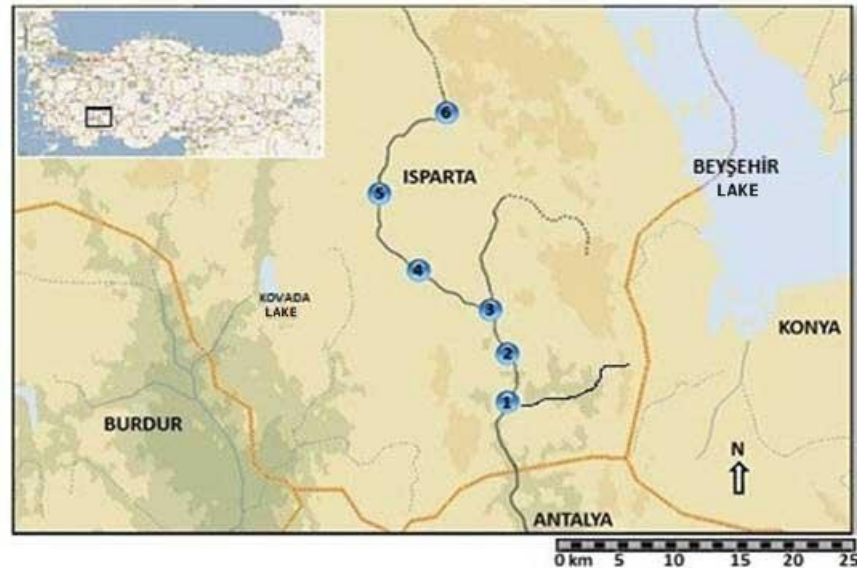The fork length (FL) of all fish was measured to the

Figure 1: Maps of the study area

Figure 2: *Pseudophoxinus fahrettini* Freyhof and Özuluğ, 2009

nearest 0.5 cm and weighed to the nearest 0.01 g. The scales were taken from above the lateral line, behind the pectoral fin. Scales were examined under the stereo binocular microscope for the age determination. Measured specimens were released back to their own environment, after measurements were completed (Figure II).

The absolute growth, the specific growth and the instantaneous growth were described by the equations: $AG = FL_t - FL_{t-1}$, $AG = W_t - W_{t-1}$; $SG = [(FL_t - FL_{t-1}) / (FL_{t-1})] * 100$, $SG = [(W_t - W_{t-1}) / (W_{t-1})] * 100$; $IG = [(\log_e FL_t - \log_e FL_{t-1}) / (\Delta t)]$, $IG = [(\log_e W_t - \log_e W_{t-1}) / (\Delta t)]$, where FL is the fork length in centimeter, W is the weight in grams and t is the age in year (Ricker, 1975).

Ricker (1975) suggested that, the length-weight relationship was described according to the allometric equation $W = a * FL^{b}$, where W is the weight in grams, FL the fork length in centimeter, b the growth exponent or length-weight factor, and a is a constant. The hypothesis of isometric growth (Ricker, 1975) was tested using a t-test ($p > 0.05$) (Hossain et al., 2013).

Ten to fifteen scales were removed from the right side of each fish body just between the lateral line and dorsal fine base. Scales were cleaned in the 5% sodium hydroxide solution for 2 hours. Non-regenerated scales were then mounted between two glass microscope slides. All scales were read twice and a third reading was made if the first two readings differed. The growth was expressed by employing von Bertalanffy's (1938) equation given as: $FL_t =$
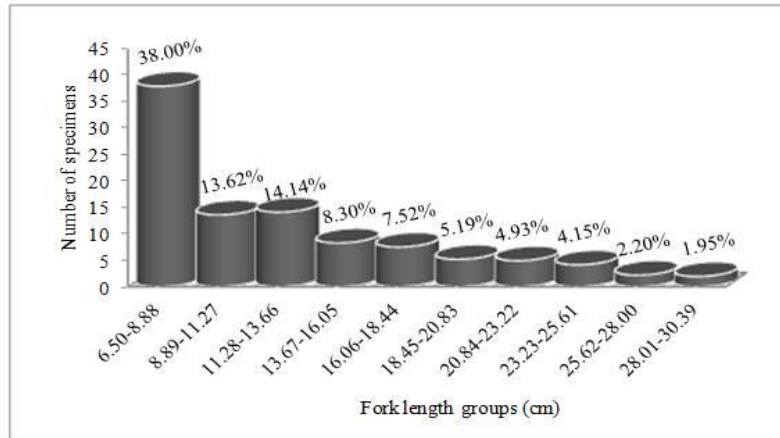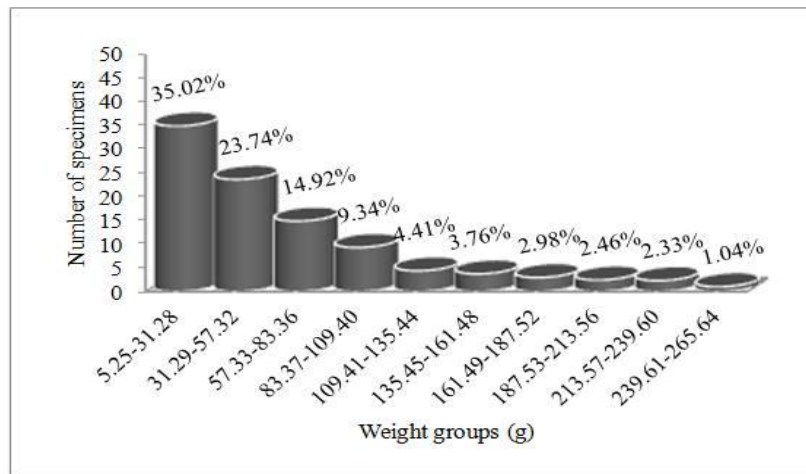
Figure 3: Fork length frequency distributions

Figure 4: Weight frequency distributions

[FL$_\infty$ (1 - e - $^{K (t - to)}$)], where FL$_t$ is the fork length at age t, L$_\infty$ is the asymptotic or maximum fork length that an average fish would achieve if it continued to live and grow, K is the growth coefficient, t_o is the theoretical age for FL$_t$ = 0 (Gulland and Holt, 1959).

Fulton's Condition Factor was calculated using the equation as follows; CF = (W / FL^3) *100, where W is the mean total weigt in grams, FL is the mean total length in centimeter (Fulton, 1904).

Natural mortality (M) was estimated using the empirical formula proposed by Pauly (1980); lnM = - 0.0152 - 0.279 * lnFL∞ + 0.6543 * lnK + 0.463 * lnT, where FL∞ and K are parameters from the von Bertalanffy equation, and T is the mean environmental temperature at the study area.

Survival rate (S) was estimated using Heincke's formula (Ricker, 1975; Heincke, 1913); S = (ΣN - N$_o$) / (ΣN), where N$_o$ is number at time zero. The instantaneous rate (Z), the fishing mortality coefficient (F), the total mortality rate (A), expectation of fishing mortality (u), expectation of natural mortality (v) and the exploitation ratio (E) were estimated as: Z = - Log$_e$S, F = Z - M, A = 1 - S; u = F * A / Z; v = M * A / Z; and E = F / Z respectively.

RESULTS

A total of 771 *P. fahrettini* individuals were examined throughout the sampling period. The caught specimens were composed of five age groups (0 to IV). According to the percentage of occurrence, age group 0 was dominant (279 - 36.19 %), which was followed by the age groups I (257 - 33.33 %), II (133 - 17.25 %), III (72 - 9.34 %) and IV (30 - 3.89 %) respectively. The distribution of the fork length ranged from 6.50 to 28.10 cm and the mean fork length was calculated as 14.14 ± 0.21 cm (Figure III).

The weight of the samples ranged from 5.25 to 245.64 g and the mean weight calculated as 47.24 ± 1.98 g (Figure IV).

Table 1. Summary of growth parameter estimates of *P. fahrettini* in Aksu Stream-Köprüçay River.

Parameters	Age groups			
	0 - I	I - II	II - III	III - IV
Absolute growth in length (cm)	1.85	7.58	2.24	2.17
Specific growth in length (%)	21.05	71.24	12.29	10.61
Instantaneous growth in length (year $^{-1}$)	0.19	0.54	0.12	0.10
Absolute growth in weight (g)	5.51	54.93	26.20	20.13
Specific growth in weight (%)	50.37	333.92	36.70	20.63
Instantaneous growth in weight (year $^{-1}$)	0.41	1.47	0.31	0.19

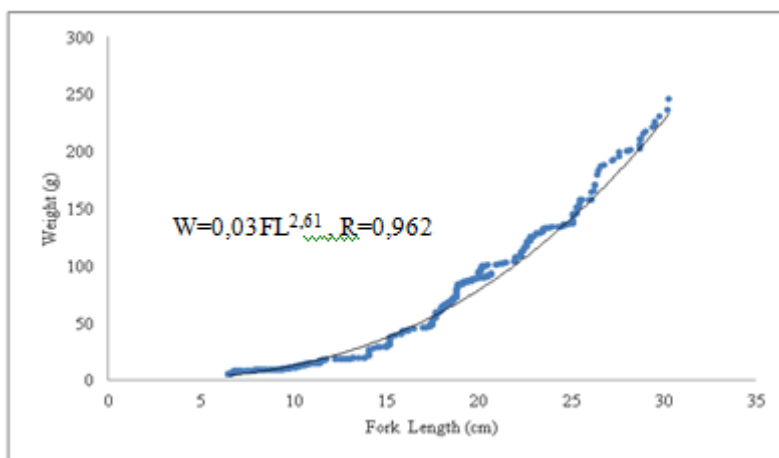$$W = 0.03FL^{2.61} \quad R = 0.962$$

Figure 5: Length - weight relationship of *P. fahrettini* in Aksu Stream - Köprüçay River

Table 2: Observed and estimated fork length and weight of *P. fahrettini* in Aksu Stream - Köprüçay River.

Age groups	Fork length (cm)			Weight (g)		
	Observed	Estimated	(p = 0.05)	Observed	Estimated	(p = 0.05)
0	8.79	7.56	p > 0.05	10.94	9.27	p > 0.05
I	10.64	12.29	p > 0.05	16.45	32.91	p > 0.05
II	18.22	16.07	p > 0.05	71.38	66.28	p > 0.05
III	20.46	19.22	p > 0.05	97.58	105.76	p > 0.05
IV	22.63	21.42	p > 0.05	117.71	140.43	p > 0.05

Results of *P. fahrettini* growth in length and weight are shown Table 1.

We calculated the length - weight equation for all individuals: $W = 0.03 * FL^{2.61}$ (R = 0.962) (Figure V).

The von Bertalanffy growth parameters were estimated as $L_t = 31.50 [1 – e^{-0.22(t+1.25)}]$ and $W_t = 384.25 [1 – e^{-0.22(t+1.25)}]^{2.61}$. Measured and calculated fork length (cm) and weight (g) are presented in Table 2. The von Bertalanffy growth curves derived from age-at-length and age-at-weight in Figure VI and Figure VII.

Means Fulton's condition factor (Cl) of the captured *P. fahrettini* was calculated as 1.25 ± 0.04. According to age

the condition factors were calculated as 0 age= 1.61 ± 0.08, I age= 1.36 ± 0.09, II age= 1.15 ± 0.07, III age= 1.14 ± 0.07 and IV age= 1.02 ± 0.03. The value of mortality estimates of *P. fahrettini* were calculated in Table 3.

DISCUSSION

During our research, a total of 771 *P. fahrettini* specimens were examined. Age composition of specimens varied from 0 to IV. According to the percentage occurrence, age group 0 was dominant (36.19 %), and in the age pyramid majority
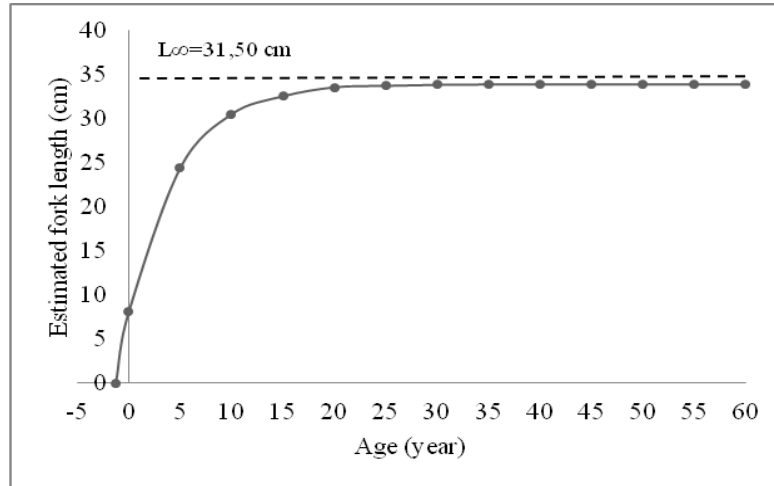
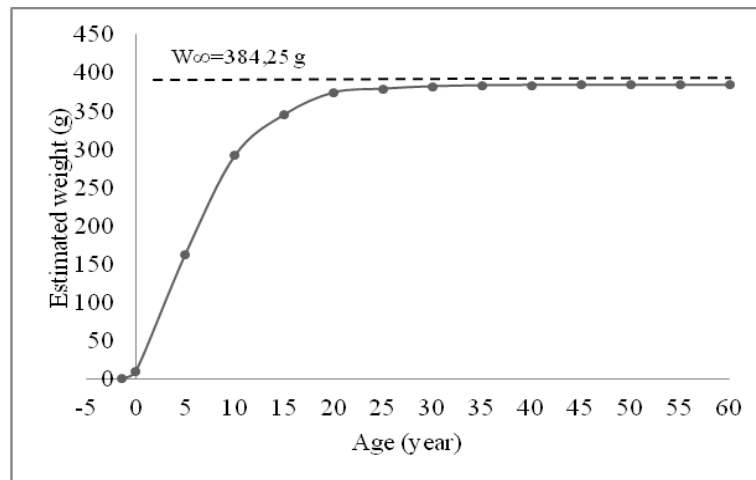**Figure 6:** The von Bertalanffy growth curves derived from age-at-length

Figure 7. The von Bertalanffy growth curves derived from age-at-weigth

Table 3: The results of mortality rate of *P. fahrettini* in Aksu Stream - Köprüçay River.

Parameters	Value (year $^{-1}$)
Natural mortality (M) (T= 11.72 °C)	0.34
Survival rate (S)	0.64
Instantaneous rate (Z)	0.44
Fishing mortality coefficient (F)	0.10
Mortality rate (A)	0.36
Expectation of fishing mortality (u)	0.08
Expectation of natural mortality (v)	0.28
Exploitation ratio (E)	0.22

was the age groups 0, I, and II (86.77 %), demonstrating that the population of *P. fahrettini* in Aksu Stream-Köprüçay River was young. Nikolsky (1980) suggested that, the situation in wide range of age distribution in a population are to accepted as a indication of enough level in the food of water system. The decrease of individual in old age groups

in the population will cause increase of individual in young age groups, decreasing the food competition.

The fork length and total weight distribution of *P. fahrettini* was determined. The minimum measured fork length and the maximum measured fork length of *P. fahrettini* were 6.50 cm and 28.10 cm respectively. The mean fork length was found to be 14.14 ± 0.21 cm (± SE). The most common repeated value of fork length groups was 6.50 - 8.88 cm with 38.00 % and, follows 8.89 - 11.27 cm (13.62 %) and 11.28 - 13.66 cm (14.14 %) respectively. The weight was ranged from 5.25 to 245.64 g, and mean weight were calculated as 47.24 ± 1.98 g. Dominant weight groups were 5.25 - 31.28 g (35.02 %), and follows 31.29 - 57.32 g (23.74 %) and 57.33 - 83.36 g (14.92 %) respectively. Depending on the age groups, an increase on regular basis in length and weight is observed. According to the growth parameter estimates of *P. fahrettini* in Aksu Stream-Köprüçay River, the highest values were in the range of age groups I - II. Many factors can affect growth rates of fish, environmental factors, amount and size of food, including differences in the seasonality of spawning and genetics. Genetic and morphological differentiation between geographical regions in the range of distribution of the *P. fahrettini,* may indicate that growth rates of the species also differ.

The *P. fahrettini* fork length-weight relationship from the Aksu Stream-Köprüçay River were calculated on the basis of the data on fork length and weight obtained by measurements of 771 individuals sampled during March 2009 - February 2010. The regression constants a and b were estimated as 0.03 and 2.61 respectively. Type of growth shows a negative allometric growth as the b value is below 3. The values of b were within the limits of 2.5-3.5 commonly reported for teleosts by Froese (2006). The relationships length-weight of *P. fahrettini* samples correlation coefficient R= 0,962. This situation exhibits unimportant deviation expected regulation increase in relationships total length-weight.

The von Bertalanffy growth parameters were calculated as follow: $L\infty$ = 31.50 cm, K = - 0.22 and t_0 = 1.25; $W\infty$ = 384.25 g, K = - 0.22 and t_0 = 1.25. The maximum condition factor of *P. fahrettini* in the study was 1.61 in the age groups 0. Pauly (1980) reviewed natural mortality rates for 174 fish stocks, and modal mortality was 0.2 - 0.3 (Vetter, 1988). Obtained values of the natural mortality of *P. fahrettini* in the Aksu Stream - Köprüçay River indicate a relatively low natural mortality M = 0.34 year $^{-1}$. Instantaneous rate, survival rate and fishing mortality coefficient was estimated as: Z = 0.44 year $^{-1}$, S = 0.64 year $^{-1}$ and F = 0.10 year $^{-1}$, respectively. Total mortality rate was estimated as A = 0,36 year $^{-1}$ because expectation of fishing mortality 8.00 % and expectation of natural mortality 28.00 %. Exploitation ratio were calculated as E = 0.22 year $^{-1}$. The exploitation rate indicates that, there is not any fishing pressure on the *P. fahrettini* in the Aksu Stream - Köprüçay River.

As a result, in this study given basic information for this species that is not yet available in the literature. Future research is needed to compare growth and mortality of *P. fahrettini* from different areas in their range of distribution.

ACKNOWLEDGEMENTS

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