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RESEARCH ARTICLE ARAŞTIRMA MAKALESİ

Age, growth, fecundity and mortality of *Aspius vorax* (Heckel, 1843) in Karakaya Reservoir (in Euphrates River), Turkey

Karakaya Baraj Gölü'nde yaşayan *Aspius vorax* (Heckel, 1843)'ın yaş, büyüme, üreme ve ölüm oranı

Erdal Duman* • Mustafa Remzi Gül

Faculty of Fisheries, Fırat University 23119, Elazığ, Turkey
**Corresponding author: eduman@firat.edu.tr*

Özet: Bu çalışmada, yüksek ekonomik önemine rağmen, Karakaya Baraj Gölü'nde yeterli düzeyde araştırılmamış olan *Aspius vorax* türünün bu ortamdaki mevcut durumunun belirlenebilmesi için bazı popülasyon parametreleri elde edilmiştir. Toplam olarak 249 birey (102 dişi, 147 erkek) incelenmiş ve eşey oranı erkekler yönüne 1:1,44 olarak tespit edilmiştir. Örnekler II- VII yaş grupları arasında dağılım göstermiştir. Her iki eşey için de büyümenin allometric olduğu anlaşılmıştır. Ortalama kondisyon faktörü tüm bireyler için KF=0,839 ± 0,005 olarak elde edilmiştir. von Bertalanffy büyüme parametreleri dişiler için L_∞ = 93,114 cm, K = 0,153 yıl^{-1} and t_o = -1,132 yıl, erkekler için L_∞ = 86,494 cm, K = 0,173 yıl^{-1} and t_o = -1,078 yıl ve tüm bireyler için L_∞ = 92,675 cm, K = 0,151 yıl^{-1} and t_o = -1,151 yıl olarak hesaplanmıştır. Ortalama yumurta veriminin 102873 olduğu görülmüştür. Yapılan hesaplamalar sonucu Karakaya Baraj Gölü'nde *A. vorax* stokunun aşırı şekilde sömürüldüğü (E=0,76) ve bu türün bahsedilen ortamda sürdürülebilir avcılığı için üzerindeki av baskısının azaltılması gerektiği anlaşılmıştır.

***Anahtar kelimeler*:** *Aspius vorax*, popülasyon parametreleri, Karakaya Baraj Gölü, büyüme özellikleri.

Abstract: Population structure studies of *Aspius vorax* (Heckel, 1843) are insufficient despite the species' commercial importance in Karakaya Reservoir. Thus, the main purpose of this study was to acquire data on some population parameters (age, length- weight relationship, growth, fecundity and mortality) to evaluate the current status of *A. vorax* for a successful management plan. A total of 249 specimens (102 female and 147 male) were caught and the sex ratio was 1:1.44 (female to male). The age data was estimated from vertebra and ranged between II and VII. Weight increase was allometrical for both sexes. Mean condition factor was CF = 0.839 ± 0.005. The von Bertalanffy growth parameter estimates were L_∞ = 93.114 cm, K = 0.153 yrs^{-1} and t_o = -1.132 yrs for females, L_∞ = 86.494 cm, K = 0.173 yrs^{-1} and t_o = -1.078 yrs for males and L_∞ = 92.675 cm, K = 0.151 yrs^{-1} and t_o = -1. 151 yrs for all individuals. The mean fecundity was 102873. It was found that the stock of *A. vorax* had been overexploited (E =0.56) in Karakaya Reservoir and the fishing pressure should be reduced to achieve a sustainable fishery.

***Keywords*:** *Aspius vorax*, population parameters, Karakaya Reservoir, growth.

INTRODUCTION

The Asp, *Aspius vorax* (Heckel, 1843) is a native and highly commercial cyprinid species inhabitıng Euphrates-Tigris Basin in Turkey, Syria and Iraq (Kuru, 1996; Coad, 1996; Geldiay and Balık, 2007, Oymak *et al*., 2011). On this species have been conducted at different localities in Iraq and Syria (Shafi and Jasim, 1982; Ali *et al*., 1986; Al-Dabical and Al-Daham, 1995; Epler *et al*, 2001; Al-Tameemi *et al*., 2010; Al-Saleh *et al*., 2012). Also, there are some studies in Turkish freshwaters that were carried out to attain information on biological characteristics of *A. vorax* (Özdemir *et al*., 1985; Oymak *et al*., 2011). Despite its commercial importance (Anonymous, 2009), the studies on population structure of the species are insufficient in Karakaya Reservior.

The main purposes of the fisheries biology studies are to obtain information belonging to population dynamics and benefit to get maximum yield from natural fish stocks. Achieving these goals is based on the estimation of realistic population parameters (Polat *et al*., 2009) such as reproduction (sex ratio, fecundity, gonadosomatic index, spawning time and area), growth (growth characteristics, length, weight, quantity increase, length and weight relationship, condition factor and growth formulas), mortality (natural mortality, fishing mortality, total mortality and annual mortality) and stock assessments (Aras *et al*., 2009).

The aim of this study was to acquire data on such population parameters (age, growth, length-weight relationship, condition fecundity and mortality) of *A. vorax* collected from Karakaya Reservoir in Malatya, Turkey (Southeastern of Anatolia) for the first time.

MATERIALS AND METHOD

The study area, Karakaya Reservoir, is located southeast of Anatolia in Turkey (38º8 –39º13' E, 38º47'-38º08' N) (Figure 1), that is the third largest dam lake in Turkey with a 268 km^2

surface. It came into operation in 1987 as a hidro-electric dam lake (Eroğlu and Şen, 2009). It was reported that the water temperature varied from 7,67 °C to 24,9 °C and average water temperature was approximately 10 °C (Küçükyılmaz *et al*., 2010). Samples were caught with gillnets in different mesh sizes (22, 30, 35, 38, 40, 45, 50, 55, 60, 65, 75, 90, 110 and 120 mm) monthly between July 2010 and April 2011. During the survey, a total of 249 samples was collected and processed individually to obtain data on length, weight, sex determination, certain fecundity properties and ageing.

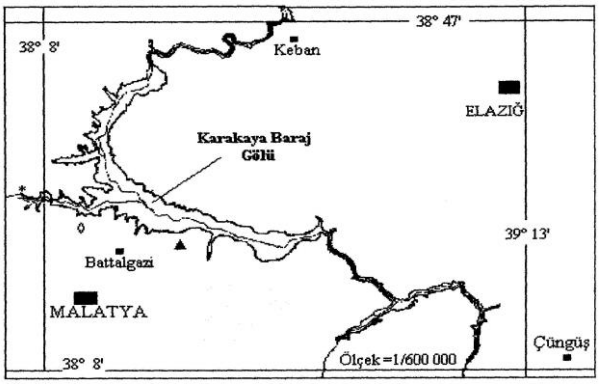


Figure 1. The sampling area, Karakaya Reservoir

The total length (TL) and the total weight (W) were measured to the nearest 1 mm and 0.1 g, respectively. The gonads were macroscopically examined to determine the sex. The gonad weight was measured to the nearest 0.01g. Sex ratio was analyzed by using chi-square test to determine if the sex ratio was different from 1:1 (Zar, 1996). Also, egg diameter was measured. After measurements, the vertebrae samples were removed from the fish and prepared for ageing. The vertebta samples were left in boiling water for 30 minutes. The bones are placed in absolute alcohol, finally dropped in to 3 % solution of chloralhydrate were examined. A binocular microscope with top lighting and 10-25 times magnification was used for age determination (Chugunova, 1963).

The length-weight relationship was estimated for males, females and all individuals by using formula: $W = a\ TL^b$, where W is the total weight in grams, TL the total length in cm, a and b are constants. The growth type was tested using t-test (Ricker, 1975). The von Bertalanffy growth equation for length was defined as follows (Beverton and Holt, 1957; Gulland, 1983): $L_t = L_\infty(1\text{-}e^{-K(t\text{-}to)})$, where L_t is total length at time t, L_∞ is the asymptotic length, K is the growth coefficient and t_o is hypothetical age when the length is zero. Absolute and rational growth in length and weight was calculated as follows (Erkoyuncu, 1991): Absolute growth: L_2-L_1 and W_2-W_1, Rational growth: $(L_2\text{-}L_1)/L_1)*100$ and $(W_2\text{-}W_1)/W_1*100$. The condition factor (CF) was calculated by using $CF= Wx100/TL^3$ (Fulton, 1904). Based on von Bertalanffy growth parameters, the performance index (Φ′) was calculated as $\Phi' = \log10\ K + 2\ \log10\ L\infty$ (Pauly and Munro,1984).

Absolute fecundity was estimated gravimetrically (Bagenal, 1978). The relationships between fecundity (F) and total length (TL), fecundity (F) and body weight (W) and fecundity (F) and gonad weight (GW) were obtained as follows $F = a + bW$, $F = a.TL^b$.

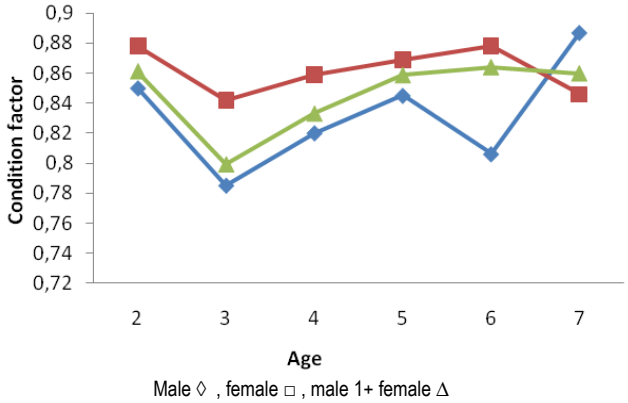
Natural mortality was estimated using the empirical formula (Pauly, 1980): Log (M)=(0.0066) -0.279 log (L_∞) + 0.6543 log(K) + 0.4634 log (T), where L_∞ and K are the VBGF parameters and T is the mean environmental temperature at the study area (10 °C for Karakaya Reservoir). The survival rate (S) was estimated as: $S = e^{-Z}$. Fishing mortality (F) using F= Z-M and exploitation rate using E= F/Z were obtained (Ricker, 1975).

Data were statistically analyzed by using Microsoft Office Excel 2007 and SPSS 15.00 programs.

RESULTS

Age and growth

A total of 249 *A. vorax* specimens (102 females and 147 males) were investigated during the sampling period. Female to male ratio was 1:1.44 and this ratio was significantly different from the theoretical 1:1 sex ratio ($p<0.05$). The ages ranged from II to VII and the dominant age group was IV for males and V for females. The von Bertalanffy growth equations and growth performance index for females, males and all individuals are shown in Table 1. The condition factors were calculated for age groups and sexes. The mean CF for all individuals was 0.839 (S.D. = 0.088), for females 0.865 (S.D. = 0.099) and for males 0.821 (S.D. = 0.074) (Fig. 2). The condition factor values between females and males were statistically different ($p<0.05$). The growth performance index was similar for both sexes. It was seen that absolute and relative growths were faster for early ages. Absolute and relative growth values are provided in Table 2.



Male ◊ , female □ , male 1+ female Δ

Figure 2. Condition factor of *A. vorax* in ages and sexes in Karakaya Resevoir

Table 1. Growth parameters (L_∞, K and t_o) and equations and growth performance index of *A. vorax* population in Karakaya Reservoir

Sexes	Φ´	L_∞ (cm)	k (years^{-1})	t_o(years)	von Bertalanffy growth equations
Females	3.12	93.114	0.153	-1.132	$L_t = 93.114\times[1-e^{-0.153(t+1.132)}]$
Males	3.11	86.494	0.173	-1.078	$L_t = 86.494\times[1-e^{-0.173(t+1.078)}]$
Females+Males	3.11	92.675	0.151	-1.151	$L_t = 92.675\times[1-e^{-0.151(t+1.151)}]$

Table 2. Absolute and relative length (A.L., R.L. %) and weight (A.W., R.W. %) increasing of *A. vorax* population in Karakaya Reservoir

		Age groups				
Sexes	**Growth rates**	**II-III**	**III-IV**	**IV-V**	**V-VI**	**VI-VII**
Male	A.L.	24	8.74	6.94	14.21	6.68
Female	A.L	25.14	7.97	4.16	1.81	0.78
All indiv.	A.L.	24.36	8.54	5.40	16.60	7.34
Male	R.L.	27.12	9.13	7.19	15.27	6.90
Female	R.L.	28.65	8.29	4.25	19.86	8.18
All indiv.	R.L.	27.94	8.92	5.54	18.06	7.62
Male	A.W.	64.15	30.09	24.32	20.16	18.69
Female	A.W.	73.89	23.49	13.45	5.69	1.84
All indiv.	A.W.	66.46	28.79	19.35	22	20.41
Male	R.W.	89.94	35.12	27.54	49.68	33.23
Female	R.W.	109.37	26.47	14.40	76.70	20.20
All indiv.	R.W.	94.31	33.36	21.35	18.20	22.64

Length-weight relationship

Total length ranged from 33.9 to 71.2 cm for females and from 30.7 to 67.1 cm for males. Difference between male and female in length frequency distribution was statistically significant ($p<0.05$). The body weight varied between 340.7 and 2963 g for females and from 215.4 to 2526.6 for males. Differences between male and female in weight frequency distribution was statistically significant ($p<0.05$). The length-weight equation for females was $W = 0.00987TL^{2.9682}$ ($r^2= 0.977$), for males $W = 0.0113TL^{2.9169}$ ($r^2= 0.963$) and for all individuals $W = 0.0094TL^{2.9706}$ ($r^2= 0.968$) (Table 3). The "b" values for males, females and all individuals are close to 3, indicating allometric or isometric growth for both sexes. The difference of b values between sexes were not statistically significant ($p>0.05$).

Fecundity

84 mature female specimens were taken into account to find out the fecundity characteristic of *A. vorax* in Karakaya Reservoir. Sexual maturity was found in the third year for both sexes. It is determined that the number of eggs varied from 19,951 to 273,569. The mean fecundity of these 84 females was 102873 (S.E. 5900). The total length and weight of mature females were between 44.7 cm, 715.8 g and 69.8 cm, 2691.8 g, respectively. The mean egg diameter was 1.021±0.019 mm. A significant correlation was determined between fecundity and total fish length, weight and gonad weight and age the equations are shown in Table 4.

Mortality

In this study, Survival rate was found as S=0,63 year^{-1}, annual mortality rate was estimated as A=0,37 year^{-1}.

Instantaneous mortality rate was calculated as Z=0,46 year^{-1}, natural mortality rate M=0,20 year^{-1} and fishing mortality rate F=0,26 year^{-1}. This population was characterized by about optimum explaitation rate (E=0,56).

DISCUSSIONS

Although, the sex ratio for fish populations depends on different factors like differences in mortality rates between sexes, spawning migration and differences in growth between sexes, this ratio is generally close to 1:1 (Nikolsky, 1969). The sex ratio was significantly different from 1:1 for *A. vorax* in Karakaya Reservoir as in some other populations in Atatürk Reservoir (Oymak *et al*, 2011). This difference can be due to sampling method and sampling area.

In this study, it was found that the oldest age was 7 for both female and male specimens. Similar age results were reported for the Habbaniyah Lake to be 7 years old (Shafi and Jasim, 1982). On the other hand, specimens up to 9 years old were reported for Atatürk Reservoir (Oymak *et al*., 2011). An age of 4 was reported in the Middle Reaches of the Euphrates River, Syria (Al-Saleh *et al*., 2012). This can be because of fishing pressure and sampling method. Like the results of Al-Saleh *et al*. (2012), we found that the total length and body weight ranged between 30.7 cm and 71.2 cm, 215.4 g and 2963 g, respectively. Higher lengths and weights were reported by Oymak *et al*. (2011) in Atatürk Reservoir . Al-Saleh *et al*. (2012) found 4 years lifespan comapred to 7 and 9 in Turkish reservoirs however similar total lengths and weights. These differences may depend on ecosystem differences. Al-Saleh *et al*. (2012) studied in Euphrates River conditions present study worked.

Table 3. L-W relationship of *A. vorax* in Karakaya Reservoir

Sexes	n	L(cm),mean ±SE (L_{min}-L_{max})	W(g),mean ±SE (W_{min}-W_{max})	L-W equation	r^2
Females	102	49.83±0.83 (33.9-71.2)	1158.5±58.3 (340.7-2963.0)	$W=0.00987TL^{2.9682}$	0.977
Males	147	47.20±0.54 (30.7-67.1)	910.31±30.2 (215.4-2526.6)	$W = 0.0113TL^{2.9169}$	0.963
All indiv.	249	48.73±0.48 (30.7-71.2)	1020.9±32.9 (215.4-2963.0)	$W = 0.0094TL^{2.9706}$	0.968

Table 4. The relationships between fecundity and total fish length, weight, gonad weight and age of *A. vorax* population in Karakaya Reservoir

Relationship					
Ordinate	**Abscissa**	**Value of a**	**Value of b**	**r^2**	**p**
Fecundity (F)	Total Length (TL)	0.4007	3.1161	0.5822	<0.05
Fecundity (F)	Total Weight (TW)	719.16	0.6815	0.5163	<0.05
Fecundity (F)	Gonad Weight (GW)	4639.2	0.6269	0.7477	<0.05
Fecundity (F)	Age (t)	6762.8	1.7656	0.9543	<0.05

The "b" values showed similarities in females and in males. Our "b" values were few lower than 3.That is allometric or isometric was found in females and in males. Higher "b" values were reported by Shafi and Jasim (1982) in the Habbaniyah Lake, Al-Dabical and Al-Daham (1995) in the Shatt Al Basrah Canal and Al-Saleh *et al*. (2012), 3.0601, 3.077 and 3.1304, respectively. Oymak *et al*.(2011) reported the "b" values 2.4297 for females and 2.9051 for males. These differences can be explained by major environmental factors, food supply and stomach fullness (Ricker, 1975).

Asymptotic length was calculated for females, males and all individuals as 93.114 cm, 86.494 cm and 92.675 cm, respectively. The difference in asymptotic length of sexes can be because of growth differences between females and males. Shafi and Jasim (1982) ($L\infty$ = 91.00 cm) and Al-Dabical and Al-Daham (1995) ($L\infty$ = 104.118 cm) reported similar results. The longest values of $L\infty$ were reported in the Atatürk Reservoir ($L\infty$ = 158.36 cm for females and 218.47 cm for males) (Oymak *et al*., 2011). This difference can be explained by water temperature and quantity and quality of food.

There was no such information on the growth performance index (Φ′) previously. The growth performance index was 3.12 for females and 3.11 for males and all individuals.

The mean condition factor was calculated as 0.865 for females, 0.821 for males and 0.839 for all individuals. These results show similarities with Özdemir *et al.* (1985) (CF = 0.590- 0.830) in Keban Reservoir, Ali *et al*. (1986) (CF = 0.73) in Al-Tharthar Reservoir and Epler *et al*. (2001) (CF = 0.87) in Habbaniyah and Tharthar Lakes. However, Shafi and Jasim (1982) reported a higher mean somatic condition value as 1. Oymak *et al*. (2011) reported the mean somatic condition factor as 1.069 for females and 1.062 for males. On the other hand, Al-Saleh *et al*. (2012) reported the condition factor 0.71 for females and 0.70 for males. The differences of somatic condition factors among different stocks may be explained by water temperature and quantity and quality of food.

The fecundity of *A. vorax* was previously reported at different localities. Shafi and Jasim (1982) and Epler *et al*.(2001) reported that the mean fecundity of *A. vorax* was 74509 and 92000 respectively. Oymak *et al*.(2011) stated the fecundity between 5247 and 237162. Al-Saleh *et al*.(2012) reported the fecundity between 41250 and 239765. The differences in fecundity at different localities can be due to environmental factors, egg size, quantity and quality of food, gonad weight and length and weight of fish (Bagenal,1978). Also, the mean egg diameter was measured as 1.021 mm during the survey. However, Shafi and Jasim (1982) reported a similar value for egg diameter (1.071 mm) with our study; Oymak *et al*. (2011) stated a higher egg diameter value (between 1.70 and 2.00) than our result. The egg diameter can be changeable not only in different fish species and fish size, but also for the same species which lives at different localities (Bircan and Polat, 1995).

Any previous data on the mortality rate of *A. vorax* could not be found in the literature. In this study, Survival rate was found as S=0.63 $year^{-1}$, annual mortality rate was estimated as A=0.37 $year^{-1}$. Instantaneous mortality rate was calculated as Z=0.46 $year^{-1}$, natural mortality rate M=0.20 $year^{-1}$ and fishing mortality rate F=0,26 $year^{-1}$. This population was characterized by about optimum explaitation rate (E=0.56). When E = 0.5, it is considered that the stock is optimally fished (Gulland, 1971). Pauly (1984) stated a lower optimum value for E (F= 0.4 M). It was understood that the stock of *A. vorax* is being overexploited and the fishing pressure should be reduced to achieve a sustainable fishery in Karakaya Reservoir.

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