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## Growth, Mortality and Yield of Barbel, *Barbus plebejus* (Bonaparte, 1839) in Almus Dam Lake (Tokat, Turkey)

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**Abstract:** Growth, mortality and yield of Barbel, *Barbus plebejus*, in Almus Dam Lake (Turkey) were studied. A total of 201 specimens were collected from January 2003 to December 2003. The total length ranged from 15.2 to 41.5 (TL) cm and total weight ranged from 33.7 to 816.5 g. Sex ratio (1: 1.83) was biased towards females ( $p < 0.05$ ). A negative allometric growth was determined in population ( $p < 0.05$ ). The length-weight relationships for all individuals was described by the following parameters:  $a = 0.036$ ,  $b = 2.60$  with the  $R^2 = 0.83$ . The population comprised of ten age groups (I to X years). The von Bertalanffy growth parameters for the entire population were:  $L_{\infty} = 45.65 \pm 1.72$  cm,  $k = 0.249 \pm 0.023$  1/year and  $t_0 = -0.711 \pm 0.102$  year ( $R^2 = 0.89$ ). The growth performance index was 2.71. The mortality rates for whole population were found to be;  $Z = 0.76$  1/year,  $M = 0.50$  1/year and  $F = 0.26$  1/year; and the exploitation rate was  $E = 0.34$  1/year. The Bevarton and Holt model of yield and biomass per-recruit indicated that the stock of *B. plebejus* in the Almus Dam Lake is not over fished ( $E_{max} = 0.92$ ,  $E_{0.1} = 0.80$  and  $E_{0.5} = 0.38$ ).

**Key words:** *Barbus plebejus*, growth, mortality, yield

### INTRODUCTION

*Barbus plebejus* (Bonaparte, 1839) is widely distributed in the inland waters of Europe (Croatia, Italy, Slovenia and Switzerland) and Asia (Turkey, Iran and Syria)<sup>[1-4]</sup>. This species is considered as a protected fauna species in annex III of the Bern Convention<sup>[5]</sup>. Thus, it is important in the distributed areas both ecological and economic in view. Therefore a series of paper has addressed on the biology and ecology of this species and sub-species in the Turkish waters<sup>[6-9]</sup>.

*Barbus plebejus* is one of the important fish species including *Cyprinus carpio* (L., 1758), *Oncorhynchus mykiss* (Walbaum, 1792), *Capoeta capoeta sieboldi* (Steindachner, 1864), *Capoeta tinca* (Heckel, 1843), *Capoeta capoeta* (Guldenstaedt, 1773), *Chalcaburnus mossulensis* (Heckel, 1843), *Chondrostoma regium* (Heckel, 1843), *Leuciscus cephalus* (L., 1758), *Alburnus orontis* (L., 1758) and *Silurus glanis* (L., 1766) in Almus Dam Lake<sup>[10-12]</sup>. In the past, the growth and reproduction of this species in Almus Dam Lake were investigated by Cengizler<sup>[11]</sup> and Karataş and Akyurt<sup>[13]</sup>. But the current status of this stock is not available. The aim of this study, therefore, was to provide age, growth and mortality rates and also yield of barbel population inhabiting in the Almus Dam Lake.

### MATERIALS AND METHODS

The research was carried out from January 2003 to December 2003 in Almus Dam Lake which is located 3.5 km North-east of Almus town in the province of Tokat on Yeşilirmak River and has a surface area of 3130 ha.

A total of 201 Barbels were captured by gill nets of various mesh sizes between January and December 2003. Total Length (TL) and Fork Length (FL) and wet Weight (W) of the captured fish were recorded with 1 mm and 0.01 g sensitivity, respectively. Scales were used for age determination<sup>[14-15]</sup>. Sex of the fish was determined by examination of the gonad tissue either by eye for larger fish or with the aid of a microscope for smaller fish<sup>[16,17]</sup>. All weights and lengths were fitted to length-weight equations,  $W = aL^b$ , using the Sigmaplot-2001 for Windows software.

The von Bertalanffy growth function (VBGF) was fitted to the age-length relationship using the Sigmaplot-2001 for Windows" software. The growth performance index ( $\Phi$ ) was estimated in order to compare growth parameter values obtained in the present paper with those report for *B. plebejus* sp.<sup>[18]</sup>. The instantaneous rate of total mortality (Z) was calculated from the length-converted catch curve using the program FISAT-II software<sup>[19]</sup>. Instantaneous rate of

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natural Mortality (M) was estimated using the Pauly<sup>[20]</sup> equation;

$$\text{LnM} = -0.0152 - 0.729 \times \text{Ln} [L_{\infty}] + 0.654 \times \text{Ln} [K] + 0.463 \times \text{LnM} [T]$$

where L, K are from the VBGF and T (°C) is the mean annual water surface temperature.

The instantaneous rate of fishing mortality (F) was estimated from the difference between instantaneous rates of total and natural mortality. The exploitation ratio (E) was calculated from the,  $E = F/Z$  where F and Z are the instantaneous rate of fishing and total mortality rate, respectively. A Gaussian function with 3 parameters was fitted to each length class (Li) and corresponding proportion of fish caught (Pi) to estimate length at first capture (Lc), using Sigmaplot-2001 for Windows software,

$P_i = a \times \exp \{-0.5 \times ((L_i - L_c)/b)^2\}$ , where a and b are the parameters of the Gaussian function.

Relative yield-per recruit (Y/R) and relative biomass-per-recruit (B/R) were performed using the Knife-edge selection procedure from FISAT-II software<sup>[19]</sup>;  $Y/R = EU^{mK} [1 - (3U)/(1 + m) + (3U^2)/(1 + 2m) - (U^3)/(1 + 3m)]$

where,  $U = 1 - (L_c/L_{\infty})$  is the fraction of growth to be completed by the fish after entry into the exploitation phase,

$$m = (1 - E)/(M/K) = (K/Z)$$

Relative biomass-per-recruit (B/R) was estimated from the relationship;  $B/R = (Y/R)/F$ .

Also,  $E_{max}$  (the value of exploitation rate E giving the maximum relative yield-per-recruit),  $E_{0.1}$  (the value of E at which marginal increase in Y/R is 10% of its value at

$E = 0$ ) and  $E_{0.5}$  (the value of E at 50% of the unexploited relative biomass-per-recruit) were estimated through the first derivative of the Beverton and Holt<sup>[21]</sup> function.

## RESULTS

A total of 201 specimens were caught and examined. Fish ranged in size from 15.2-41.5 cm (TL) and weighted between 33.7-816.5 g. Males ranged between 19.9-34.5 cm and 80.0-403.6 g. Females ranged from 15.2 to 41.5 cm and from 33.7 to 816.5 g (Table 1).

Of the fish examined, 71 (35.32%) were males and 130 (64.67%) females. The overall ratio of males to females was 1: 1.83 and  $\chi^2$  analysis showed this to be significant ( $\chi^2 = 7.31 > \chi^2_{1, 0.05} = 3.84$ ).

Length-weight relationships ( $W = aL^b$ ) were calculated for males, females and all individuals as;  $W = 0.012L^{2.89}$  (CL of  $b = 2.65 - 3.14$ ),  $W = 0.076L^{2.40}$  (CL of  $b = 2.23 - 2.57$ ) and  $W = 0.036L^{2.60}$  (CL of  $b = 2.45 - 2.76$ ), respectively (Table 2). A negative allometric growth was detected in population ( $p < 0.05$ ), however there was an isometric growth in the females ( $p < 0.05$ ). Also there was a significant difference in the b parameter between males and females ( $p < 0.05$ ).

There were ten-age classes in the population (I to X years). Age of males and females were ranged I-V and II-X years, respectively. According to the age-length key, age group III was dominant with 46.26% in the population. The von Bertalanffy growth parameters ( $\pm SE$ ) for barbel population were estimated as;  $L_{\infty} = 45.65 \pm 1.72$ ,  $k = 0.249 \pm 0.023$  and  $t_0 = -0.711 \pm 0.102$  ( $R^2 = 0.89$ ). The growth performance index ( $\Phi$ ) was found to be 2.71 ( $\Phi_{upper\ limit} = 2.84$  and  $\Phi_{lower\ limit} = 2.56$  with 95% confident

Table 1: Age-length key for the *Barbus plebejus* from the Almus Dam Lake

TL (cm)	Age Groups										Total
	I	II	III	IV	V	VI	VII	VIII	IX	X	
15	1										1
17											
19		1									1
21		23	2								25
23		9	37								46
25		4	29								33
27			19	10							29
29			6	7							13
31				7	14						21
33				1	8	8					17
35					0	5	2				7
37							3	1			4
39									2		2
41										2	2
Σ	1	37	93	25	22	13	5	1	2	2	201
%	0.49	18.4	46.26	12.43	10.94	6.46	2.48	0.49	0.99	0.99	100
$L_{mean}$	15.2	22.4±1.0	25.6±1.8	29.8±1.2	32.3±0.9	34.6±0.6	37.1±0.4	38.3	40.4±0.2	41.4±0.1	27.6±4.6
$W_{mean}$	33.7	118.5±20.7	176.2±35.4	255.7±42.5	324.2±52.5	368.2±45.9	524.8±93.7	541.8	642.7±48.2	775.5±57.9	226.1±119.6
$N_{\sigma}$	1	19.0	47	31	20	13	5	1	2	2	130
$N_{\rho}$		18.0	46	5	2						71
$\sigma:\rho$			1:1.05	1:6.2	1:10	-	-	-	-	-	1:1.83

σ: Male ρ: Female

Table 2: Exponent b in the length-weight relationships from different studies

Sex of fish	b	Area	Species / spp	References
Male	3.02	Almus Dam Lake	<i>B. plebejus</i>	[11]
Female	2.27	Almus Dam Lake	<i>B. plebejus</i>	[11]
Male+Female	2.84	Almus Dam Lake	<i>B. plebejus</i>	[11]
Male	3.12	Almus Dam Lake	<i>B. plebejus</i>	[22]
Female	3.28	Almus Dam Lake	<i>B. plebejus</i>	[22]
Male+Female	2.85	Altinkaya Dam Lake	<i>B. plebejus escherichi</i>	[7]
Male	2.84	Çoruh River	<i>B. plebejus escherichi</i>	[9]
Female	2.91	Çoruh River	<i>B. plebejus escherichi</i>	[9]
Male	2.89	Almus Dam Lake	<i>B. plebejus</i>	Present study
Female	2.4	Almus Dam Lake	<i>B. plebejus</i>	Present study
Male+Female	2.6	Almus Dam Lake	<i>B. plebejus</i>	Present study

Table 3: Parameters of von bertalanffy growth curve for *B. Plebejus* and subspecies in different areas.  $L_{\infty}$  (cm), the asymptotic length; K (1/year), the growth rate;  $t_0$  (year), the theoretical age at length zero and  $\Phi$ , the growth performance index

Sex of fish	Length	$L_{\infty}$	K	$t_0$	$\Phi$	Area	Species / sp.	Authors
Male + Female	FL	44.94	0.226	-1.26	2.65	Almus Dam Lake	<i>B. plebejus</i>	[11]
Male + Female	FL	45.57	0.138	-1.47	2.45	Almus Dam Lake	<i>B. plebejus</i>	[22]
Male + Female	FL	51.06	0.193	-0.6	2.7	Bafra Dam Lake	<i>B. plebejus escherichi</i>	[7]
Male + Female	FL	54.87	0.123	-1.61	2.56	Çildir Lake	<i>B. plebejus</i>	[8]
Female	FL	32.77	0.116	-1.89	2.09	Çoruh River	<i>B. plebejus escherichi</i>	[9]
Male	FL	29.35	0.139	-1.64	2.07	Çoruh River	<i>B. plebejus escherichi</i>	[9]
Male + Female	TL	45.65	0.249	-0.71	2.71	Almus Dam Lake	<i>B. plebejus</i>	Present work

(2.56-2.84)

limit). The value of growth performance index estimated for *B. plebejus* in different studies were presented in Table 3.

The instantaneous rate of total mortality (Z), natural mortality (M) and fishing mortality were estimated as; 0.76 1/year, 0.50 1/year and 0.26 1/year, respectively. The exploitation ratio was 0.34 1/year. Length at first capture ( $L_c$ ) for all individuals was 25.11 cm (Se of  $L_c = 0.68$ ,  $a = 18.10$ ,  $b = 4.19$  and  $R^2 = 0.73$ ).

Yield-per-recruit analysis gave the following summary statistics:  $E_{max} = 0.92$ ,  $E_{0.1} = 0.80$  and  $E_{0.5} = 0.38$  and the Y/R and B/R curve for *B. plebejus* was presented in Fig. 1.

### DISCUSSION

The barbel population comprised of 35.32% male and 64.67% female. Thus, overall sex ratio male to female (1:1.83) was biased significantly towards females. In a previous study in the same area the percent of males and females were found to be 52.30 and 47.70, respectively<sup>[11]</sup>. In the same area, the barbel population was found to be consisting of 35.07% male and 64.85% female<sup>[22]</sup>. These results indicated that female percent in the population have increased gradually. Çalışkan *et al.*<sup>[8]</sup> found that in the Çildir Lake population, females and males were comprised 44.85 and 55.15% of the population, respectively. In the Bafra-Altinkaya Dam Lake the barbell, *Barbus blebejus escherichi* (Steindachner, 1897), which is the sub-species of *Barbus plebejus*, population was comprised of 37.18 and 62.82% males and females, respectively and overall sex ratio male to female was

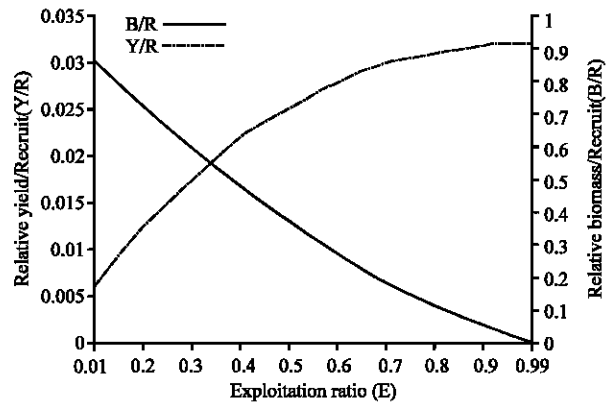


Fig. 1: Relative yield and biomass per recruit for *B. plebejus* in the Almus Dam Lake

found to be 1:1.68<sup>[7]</sup>. For *Barbus blebejus escherichi* (Steindachner, 1897) in the Oltu Stream of Çoruh River, the population was comprised of 67.59% male and 35.14% female<sup>[9]</sup>. The overall sex ratio is close to 1:1 in many species, but it may vary from species to species, even population to population of the same species and may change year to year in the same population<sup>[23]</sup>.

Fish sizes in the barbel population were ranged from 14.30 to 38.59 cm (FL) and mean length was 25.75 cm (FL). In this study we considered the total length. But to compare the results with the previous studies we used a relationships between Total Length (TL) and Fork Length (FL) as;  $FL = 0.2703 + 0.9234 \times TL$  ( $R^2 = 0.99$ ). Karataş<sup>[22]</sup> found that fish size ranged from 12.5 to 35.4 cm (FL) with the 23.6 cm (FL) mean length. In the Çildir Lake, fish size was ranged from 11.0 to 32.0 cm (FL). The differences in

the fish size range among the studies may be due to sampling, nets used, growth, mortality including natural and fishing or other factors.

Although allometric growth is observed in different studies except Karataş<sup>[22]</sup>, the exponent 'b' found for whole population in this study is smaller than that of the others. This result may be evidence of the insufficient utilizing of food resources in the Almus dam lake for the *Barbus plebejus* population.

There were ten ages group (I to X) in the barbel population and third age group was the dominant with the 46.26% in the population. Cengizler<sup>[11]</sup> and Karataş<sup>[22]</sup> found that the age of barbel populations were varied I-V and I-VII and third age group were dominant with 47.28 and 45.69% in both studies, respectively. In Çıldır Lake the *Barbus plebejus* population were consist of five age groups (I-V) and second age group was the dominant with the 47.49% in the population<sup>[8]</sup>.

For comparing propose, the von Bertalanffy growth parameters belong to Karataş<sup>[22]</sup> and Çalışkan *et al.*<sup>[8]</sup> were calculated using the mean length corresponding to each age group by the regression method<sup>[24]</sup> from us (Table 3). There are some differences between growth parameters in different locations or in the same location at the different time. Different environmental conditions and situation of fishes like stomach fullness, time of capture, can also affect the growth parameters in fisheries researches.

The natural mortality rates for 175 fish stocks found that the modal mortality was between 0.2 and 0.3 1/year<sup>[20]</sup>. Value of natural mortality (0.50 1/year) in this study indicated a higher natural mortality. The same species may have different natural mortality rates in different areas, depending on the number and density of predators and competitors whose abundance is influenced by fishing activities<sup>[23]</sup>. The results of relative yield-per-recruit and relative biomass-per-recruit analyses showed that the stock of *B. plebejus* in the Almus Dam Lake is not over-fished.

Although there is no any risk on this stock yet, but monitoring of fish stocks, especially on protected fauna species, should be made periodically to sustainable exploitation and to protect biodiversity.

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