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## Growth, Mortality and Yield of Chub (*Leuciscus cephalus* L., 1758) Population in Almus Dam Lake, Turkey

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**Abstract:** The aim of this study was to establish the growth, mortality and yield of Chub (*Leuciscus cephalus* L., 1758) in Almus Dam Lake. A total of 305 specimens were collected from January 2003 to December 2003. The total length ranged from 14.0 to 34.0 cm and total weight from 41.00 to 668.00 g. Sex ratio (1: 1.4) was biased towards females ( $p < 0.05$ ). A positive allometric growth was determined ( $p < 0.05$ ) in both male and female fish. The length-weight relationship for all individuals was described by the following parameters:  $a = 0.0043$ ,  $b = 3.359$  with the  $r^2 = 0.94$ . This population comprised of seven age groups as from 0 to VI years. The von Bertalanffy growth parameters for the entire population were:  $L_{\infty} = 39.11$  cm,  $K = 0.162$  1/year and  $t_0 = -3.05$  year with the  $r^2 = 0.76$ . For all fish, instantaneous rates of mortality were  $Z = 0.93$  1/year,  $M = 0.40$  1/year and  $F = 0.53$  1/year; the exploitation rate was  $E = 0.56$  1/year. The Bevarton and Holt model of yield-per-recruit indicates that the stock of *L. cephalus* in the Almus Dam Lake is over fished ( $F_{0.1} = 0.5$  1/year).

**Key words:** *Leuciscus cephalus*, growth, mortality, yield

### INTRODUCTION

Chub, *Leuciscus cephalus* (L., 1758) is the most common and distributed widely throughout European waters, the Black Sea River, the Caspian Sea River, the Sea of Azov River and Caucasian Region<sup>[1,2]</sup>.

Because of its importance in the inland waters, both commercial and ecological, a series of papers has addressed the biology and ecology of chub inhabiting European and Turkish waters<sup>[3-20]</sup>. However, there is no study deal with the chub population in the fisheries management aspect in Turkish waters. Monitoring of fish stocks should be made periodically to sustain able exploitation and to protect biodiversity. The aim of this study was to investigate age, growth, mortality rates yield of Chub population inhabiting in Almus Dam Lake.

### MATERIALS AND METHODS

The study was performed in Almus Dam Lake, which is located in North-eastern of Turkey. Chubs were captured ( $n=305$ ) by using of gill nets of various mesh sizes (30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90, 95 and 100 mm) between January and December 2003. Environmental conditions were recorded during the survey (Table 1).

Table 1: Environmental conditions at the sampling sites

Characteristics	Minimum	Maximum	Mean±SD
Temperature (°C)	3.0	25.5	17.4±6.47
Dissolved oxygen (mg mL <sup>-1</sup> )	7.4	10.5	8.9±0.72
Lake depth (m)	7.0	43.0	16.0
pH	6.9	8.4	8.0±0.32
EC (mhos cm <sup>-1</sup> )	1600.0	21000.0	14252.0±8500
Hardness (FS°)	225.0	390.0	297.0±123

Total length (L) and wet weight (W) of the captured fish were recorded with 1 cm and 0.01 g sensitivity, respectively. Scales were used for age determination<sup>[21]</sup>.

Sex was determined by examination of the gonad tissue, either by eye in bigger fish or with the aid of a microscope in smaller fish. All weights and lengths were fitted to length-weight equations,  $W = aL^b$ , using the Statistica software.

The von Bertalanffy Growth Function (VBGF) was fitted to the age-length relationship by means of Marquardt's algorithm, using the Statistica software. The growth performance index ( $\Phi$ ) was estimated in order to compare growth parameter values obtained in the present paper with those report for *L. cephalus* species<sup>[22]</sup>. The instantaneous rate of total mortality (Z) was calculated from the length-converted catch curve using the program FISAT<sup>[23]</sup>. Instantaneous rate of natural mortality (M) was estimated using the Pauly<sup>[24]</sup> equation;

$$\ln M = -0.0152 - 0.279 \times \ln[L_{\infty}] + 0.654 \times \ln[k] + 0.463 \times \ln[T]$$

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 (L) and corresponding proportion of fish caught (P) to estimate length at first capture (Lc), using Sigma Plot software;

$$P = ax \exp \{-0.5x((L-Lc)/b)^2\}$$

The relative Yield Per Recruit (Y/R) was calculated by the method of Bevarton and Holt<sup>[25]</sup> using with the Yield Version 1.0<sup>[26]</sup>.

### RESULTS

A total of 305 specimens of *Leuciscus cephalus* were caught. Age-length key for the Chub from the Almus Dam Lake is given in Table 2. Of the fish examined, 127 (41.36%) were males and 178 (58.36%) females. The overall ratio of males to females was 1: 1.4 and  $\chi^2$  analysis showed this to be significant ( $\chi^2 = 8.52 > \chi^2_{1, 0.05} = 3.84$ ). The age of fish ranged from 0 to VI.

Fish ranged in size from 14.0-34.0 cm (TL) and weighted between 36.60-668.00 g. Males ranged between 14.0-31.0 cm and 35.60-408.40 g. Females ranged from 14.7 to 34.0 cm and from 41.00 to 668.00 g.

Length-weight relationships ( $W = aL^b$ ) were calculated for males, females and all individuals as;  $W = 0.053L^{3.27}$  (CL of b = 3.11-3.43),  $W = 0.005L^{3.27}$  (CL of b = 3.16-3.38) and  $W = 0.004L^{3.35}$  (CL of b = 3.26-3.45), respectively.

A positive allometric growth was detected in population (based on the confidant limit of b parameter, (p<0.05). The value b of males and females was no significant differences (p>0.05).

The von Bertalanffy growth parameters for Chub population were calculated as;  $L_{\infty} = 39.11$  cm,  $K = 0.162$  1/year and  $t_0 = -3.05$  year ( $r^2 = 0.76$ ) (Table 3 and Fig. 1).

According to the Kolmogorov-Smirnov test, there were no statistical differences between observed (23.46±2.94) and predicted (23.46±2.57) mean lengths (p>0.05). The growth performance index ( $\Phi$ ) was found to be 2.394 (Table 3).

The instantaneous rate of total mortality (Z), natural mortality (M) and fishing mortality were 0.93 1/year, 0.40 1/year and 0.53 1/year, respectively (Fig. 2). The exploitation ratio was 0.56 1/year. Length at first capture ( $L_c$  for all individuals was 22.75 cm (Se of  $L_c = 0.08$ , a = 20.16, b = 1.79 and  $r^2 = 0.96$ ).

Table 2: Age-length key for the Chub from the Almus Dam Lake

TL (cm)	Age groups						Σ
	0	I	II	III	IV	V	
14	2						2
15		1					1
16	2	3					5
17		5					5
18		4					4
19		4	5				9
20		4	7				11
21		1	40				41
22			41	14	1		56
23			16	42	2		60
24				42	3	2	48
25				22	1	1	25
26				9	2	1	13
27					4	1	5
28				2	3	2	7
29					1	1	2
30					1	4	5
31						1	1
32							3
33							2
Σ	4	22	109	131	18	13	305
%	1.3	7.2	35.7	42.9	5.9	4.5	100
$L_{mean}$	15.3±1.10	18.6±1.60	22.0±0.94	24.4±1.21	26.6±2.24	28.7±2.35	30.2±4.06
$W_{mean}$	44.9±8.5	77.2±21.7	137.5±19.5	203.2±36.6	255.4±70.1	361.3±144.8	427.7±192.8
$N_{\text{♀}}$	2	6	49	97	10	8	178
$N_{\text{♂}}$	2	16	60	34	8	5	127
♂:♀	1:1.00	1:0.3	1:0.8	1:2.8	1:1.2	1:1.6	1:3.0
♂:♀							1:1.4

♀:Female ♂:Male

Table 3: Parameters of von Bertalanffy growth curve for *L. cephalus* and sp. in different areas.  $L_{\infty}$ , the asymptotic length; K, the growth rate;  $t_0$ , the theoretical age at length zero and  $\Phi$ , the growth performance index

Sex of fish	Length	$L_{\infty}$ (cm)	K(1/yaer)	$t_0$ (year)	$\Phi$	Area	Species/ssp.	Reference
Male+Female	FL	40.58	0.254	-1.143	2.73	Almus Dam Lake	<i>L. cephalus</i>	[27]
Female	FL	40.46	0.210	-1.358	2.53	Akşehir (Turkey)	<i>L. cephalus</i>	[9]
Male	FL	32.32	0.396	-0.607	2.61	Akşehir (Turkey)	<i>L. cephalus</i>	[9]
Female	FL	36.66	0.111	-1.390	2.17	Aras River (Turkey)	<i>L. cephalus orientalis</i>	[14]
Male	FL	32.47	0.121	-1.630	2.10	Aras River (Turkey)	<i>L. cephalus orientalis</i>	[14]
Female	FL	41.41	0.116	-1.320	2.29	Karasu River (Turkey)	<i>L. cephalus orientalis</i>	[16]
Male	FL	35.87	0.124	-1.166	2.20	Karasu River (Turkey)	<i>L. cephalus orientalis</i>	[16]
Female	FL	40.18	0.121	-1.575	2.29	Topçam Dam Lake (Turkey)	<i>L. cephalus</i>	[18]
Male	FL	27.08	0.302	-0.455	2.34	Topçam Dam Lake (Turkey)	<i>L. cephalus</i>	[18]
Male+Female	TL	31.8	0.28	---	2.45	Croatia	<i>L. cephalus</i>	[31]
Female	FL	37.8	0.412	-1.000	2.76	Karakaya Dam Lake (Turkey)	<i>L. cephalus</i>	[20]
Male	FL	35.45	0.606	-0.188	2.88	Karakaya Dam Lake (Turkey)	<i>L. cephalus</i>	[20]
Male+Female	TL	39.11	0.162	-3.05	2.39	Almus Dam Lake (Turkey)	<i>L. cephalus</i>	Present Study

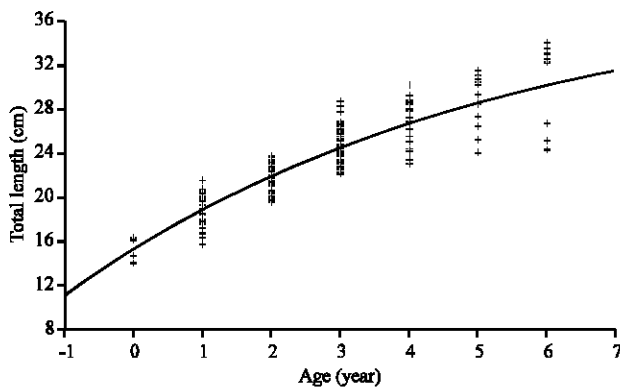


Fig. 1: von Bertalanffy growth curve fitted by length-at-age for the Chub

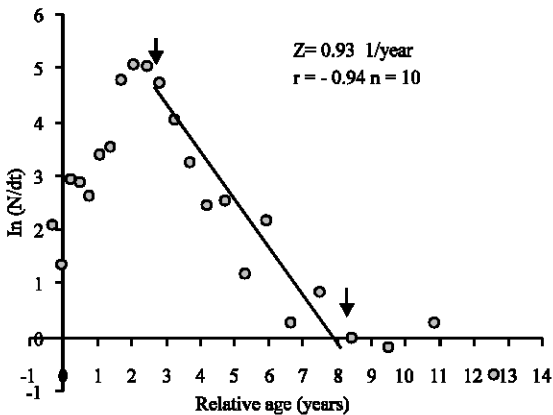


Fig. 2: Length-converted catch curve for the *L. cephalus*. Arrows indicate points used for the regression

Yield-per-recruit analysis was carried out using the population parameters ( $L_{\infty}$ ,  $Z$ ,  $K$ ,  $L_0$ ,  $M$  and  $F$ ) and the optimum level of  $F$  ( $F_{0.1}$ ) was found to be  $0.51 \text{ year}^{-1}$  (Fig. 3).

### DISCUSSION

The age of fish varied between 0 and VI. Third age group was the dominant in the population and sex ratio

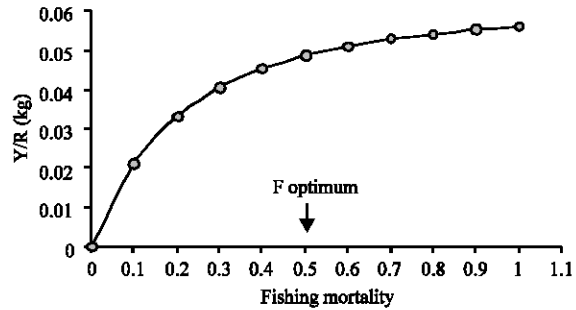


Fig. 3: Yield per recruit graph for the Chub. Arrow indicates the  $F_{0.1}$  point (0.5)

was biased towards females significantly ( $p < 0.05$ ). At the same dam lake Cengizler<sup>[27]</sup> and Karatas<sup>[28]</sup> determined as the age of fish between I-V and I-VII, respectively. Erkakan and Akgül<sup>[29]</sup> found that in the Kızılırmak Basin age dispersion were I-V, in Topçam Lake age dispersion was I-VII and male to female ratio was 1: 2.68<sup>[18]</sup> in Müceldi Stream age dispersion was I-VI and sex ratio was 1: 1.22 and the age group II and III were dominant in the population<sup>[8]</sup>. In Saryer Dam Lake age dispersion was I-X, the sex ratio was 1:1.02 and IV and V age groups were found to be dominant<sup>[10]</sup>. In Karasu River, age distribution for females and males were I-XII, I-VII, respectively and sex ratio was 1:0.98 and the age group II and III were dominant in the population<sup>[16]</sup>. In Karakaya Dam Lake, age distribution for females and males were I-VI, I-V, respectively and sex ratio was 1:1.40, the age group II and III were dominant in the population<sup>[20]</sup>.

Different stocks may have different age composition. Sex ratio differs from one population to another, even in the same species and in the same stock at the different ages. Also, the rate of male in the early life stage is higher than females, but in the later stage an inverse situation is observed<sup>[30]</sup>.

The values of  $b$  in length-weight relationships of *L. cephalus* show that growth is positive allometric for both sex. These results similar to those found for the populations of Myrtia stream (3.23), Rihios stream (3.44)

and Strymon estuary (3.85)<sup>[31]</sup>, but was different from the population of Karasu River ( $\bar{K} = 2.98$ ,  $\bar{L} = 2.95$ )<sup>[16]</sup>, Karakaya Dam Lake ( $\bar{K} = 3.02$ ,  $\bar{L} = 2.48$ )<sup>[20]</sup> and Topçam Dam Lake ( $\bar{K} = 3.19$ ,  $\bar{L} = 2.85$ ). The variation in the exponent could be attributed to different stages in ontogenetic development, as well as to differences in age, maturity, sex and species. Geographic location and associated environmental conditions, such as seasonality, stomach fullness, disease and parasite loads, can also affect the value of  $b$ <sup>[32-33]</sup>.

The value of growth performance index estimated for *L. cephalus* is similar those estimated in the different locations. The Beverton and Holt model of yield-per-recruit indicates that the stock of *L. cephalus* in the Almus Dam Lake is over fished. To decrease fishing pressure to the optimum level (0.5) on this stock, some regulations should be set. One of the regulation or combined of them can be applied such as minimum mesh size, legal minimum lengths and closures and the protection of breeding stock in the closed season.

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