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Age, Growth, Length-Weight Relationship and Reproduction of Chub, *Squalius cephalus* (L., 1758) in Upper Akcay River, Turkey

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ABSTRACT

For the first time, we investigate the aspect of bio-ecological of chub (*Squalius cephalus* L., 1758) in upper Akcay River (Buyuk Menderes Basin) including the age, growth, length-weight relationship and reproduction. The study was conducted in upper Akcay River between June 2012 and May 2013. Monthly data showed that native fish chub were aboundantly with other native fish (*Acanthobrama mirabilis)* in upper Akcay River. The age distribution for both females and males of *S. cephalus* population was between I-VII, and the second age group was found at maximum rate of 30.60%. Their fork lengths and weights ranged between 6.0-22.8 cm and 3.7-134.62 g for females; 6.1-22.1 cm and 2.7-110 g for males, respectively. The growth parameters of the von Bertalanffy equation were found as $Lt=34.71\ [1-e^{-0.116(t+0.867)}]$ for females and $Lt=32.87\ [1-e^{-0.127(t+0.717)}]$ for males. The length-weight relationships were estimated to be $WT= 0.0269\ FL^{2.720}$ (R^2=0.981) for females and $WT= 0.0251\ FL^{2.7535}$ (R^2=0.983) for males. Weight increased negatively allometrical with the fork length for both sex. The average condition factor for females was calculated as 1.37 while 1.32 for males. The sexual maturity age of females and males was determined to be II age group and first sexual maturity. The total length was found as 11.33 cm for female and 10.89 cm for male. According to the trends of GSI values, it was assumed that their season of reproductivity was between March and May.

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Authors' Contributions
HS carried out the study. GGO helped in collection of data and in the laboratory work.

Key words
***Squalius cephalus*, Length – weight relationship, *Acanthobrama mirabilis*, Von Bertalanffy equation, Fork length, GSI values.**

INTRODUCTION

European chub, *Squalius cephalus* (Linnaeus, 1758) is rheophilic (Schiemer and Waidbacher, 1992) that has dominated in ichthyofuana of Turkey. The chub *(Squalius cephalus)* belong to Cyprinidae family, which includes the most common species in Anatolian freshwaters. *Squalius cephalus* (Linneaus, 1758) can also be found in Europe, Black Sea, Caspian Sea basin, Atlantic and Mediterranean basins and Azov Sea. European chub is benthopelagic and potamodromous, to live common in brackish and freshwater. *S. cephalus* is native fish species of Akcay River (Buyuk Menderes Basin) and this fish is consumed locally.

Although this species lives in the same habitat with other native species as *Acanthobrama mirabilis* and *Chondrostoma meandrenses*, which are concerned to be Critically Endengared (CR) species in upper Akcay River. The populations of these species suffers from excessive poaching during reproduction period, habitat loss, increase in number of dams (such as Kemer, Topcam, Cine Dam Lakes), agricultural pesticide use in Buyuk Menderes Basin (Sasi and Berber, 2013; Sasi and Ozay, 2014).

The chub is abundant in small rivers and large streams of barbel zone with riffles and pools. Also, in Turkey, they have high populations in lakes and dams (Slastenenko, 1956; Geldiay and Balık, 1999; Sasi and Balık, 2003). The reason why chub show high distribution geographically is because these fish have high ecological tolerance and its population migrating to rivers for spawning in spring and early summer (Arlinghaus and Wolter, 2003; Kottelat and Freyhof, 2007).

Many studies have been done to determine age, growth, reproductive characteristics of various populations of chub in Turkey (Erk'akan and Akgul, 1986; Unlu and Balci, 1991; Ekmekci, 1996; Altındag, 1997; Karatas and Akyurt, 1997; Unver and Tanyolac, 1999; Yerli et al., 1999; Turkmen et al., 1999; Sasi and Balik, 2003; Sasi, 2004; Kalkan et al., 2005; Koc et al., 2007; Sen and Saygin, 2008; Bektas et al., 2009; Bostancı and Polat, 2009; Innal, 2010) and Europe (Treer et al., 1997, 1999; Georgiev, 2003; Koutrakis and Tsikliras, 2003; Markovic et al., 2003; Raikova-Petrova et al., 2012).

The chub (*Squalius cephalus* L. 1758) is numerically

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dominant with a endemic species *Acathobrama mirabilis* in the upper Akcay River. Kemer Dam Lake has been procreate a barrier for these native species in upper Akcay River and in the future it could be HES (Hydroelectric Station). For determine knowledge about population parameters of the native fish species, especially one which could be protected and contributed by the fishery management. For that reason we conducted this study to investigate age, length-weight relationship, conditions, reproduction of chub population in the upper Akcay River.

MATERIALS AND METHODS

The study was carried out on some growth and reproduction properties of *Squalius cephalus* population in Southwestern Anatolia in Buyuk Menderes basin. Fish species were caught monthly with seine nets and electrofishing between June, 2012 and May, 2013. The study area is shown in Figure 1.

Fig. 1. Map of the study area (Upper Akcay River).

The fishes caught were transported to the laboratory, they were measured using fork length (cm, LF), weight gonad (g, WG) and total weight (g, WT) to the nearest 1.0 mm and 0.01 g, respectively. Then a few scales from each specimen were taken in order to provide further age determination. Scales were collected from left side of the body, below of the first dorsal fin ray and above of the lateral line. Age was determined from microscopic examination of scales after some processes (Lagler, 1956), (The roman numerals indicate a subjective age classes).

The ratio of males and females was given accordingly. Length - weight relations were calculated by applying regression analysis by taking of fork lengths (FL) to total weights (WT) of each fish and the equations were as follows: $WT = q\ FL^b$ (Where *q* and *b* are the parameters to be estimated), (Bagenal, 1978).

Growth parameters *L*, *k* and t_o were found using von Bertalanffy growth equations for all fishes; $L_t = L_\infty (1\text{-}exp^{-K(t\text{-}to)})$. ("$L_t$" is total length at age *t*; "L_∞" are the asymptotic fork length; "*K*" is Brody growth coefficient, which determines how fast the fish approaches L_∞; "*t*" the age (years), and "t_o" the hypothetical age at zero length (Nikolsky, 1969; Bagenal, 1978). Also, the growth performance index (Φ) was determined in this study with equation to use (Munro and Pauly, 1983); $\Phi = Ln(k) + 2\ Ln(L\infty)$; (where *k* and $L\infty$ are the von Bertalanffy growth parameters). This index (Φ) enables the comparetion of growth for different populations in the same species.

Moreover, Fulton's coefficient of condition (C) was calculated, according to equation $C = (WT/FL^3)\ 100$ by using body weights (WT, g) and fork lenghts (FL, cm) (Pauly, 1984). The spawning of chub was estimated from direct observation of the gonads, gonad evolution (GSI) and monthly egg diameters of the samples (Bagenal, 1978). Gonado-somatic index (GSI) was calculated from the equation; $GSI\% = (Wg/Wt)\ 100$; (*Wg* and *Wt* are gonad weight and total weight in grams of fish, respectively).

Fecundity was determined by the gravimetric method (Nikolsky, 1969). The procedure was as follows: sub-samples of 1 or 2 g according to the size of the eggs were taken from front, middle and back parts of the ovaries. The number in the sub-samples was multiplied up to the weight of the ovary. The diameters of various size eggs from different parts of the ovary were measured with an object micrometer between December and May. Sexual maturity was confirmed by noting macroscopically the presence of "yolked eggs" or sperm in the gonads (Nikolsky, 1963). Statistically significant differences between sex and age groups were tested with Student's t test (Ratkowsky, 1986).

RESULTS

Sex and age composition

This study gives information about chub population in the upper Akcay River from Buyuk Menderes Basin. The age and sex distribution of species are shown in Table I. The age of captured specimens of *S. cephalus* is ranged from I to VII years for both sex and the 2nd group was dominant (30.60%) in the population. The sex composition was 54.37% females and 45.63% males (Fig. 2).

Specimens of chub caught 34.15% and 24.05% were shorter than 10.0 cm; 19.40% and 21.31% were between 10.01-20,0 cm; 0.82% and 0.27% were longer than 20,01 cm for females and males, respectively (Fig. 2). The percentage of fish decreased with increasing age. The differences in length between males and females were statistically insignificant (P>0.05).

Growth

S. cephalus species with fork length sizes provide the mean, minimum and maximum values by the use

of Standard Deviation (SD) for each age group and sex (Table II). Male and female individuals of the same age are of no significant differences between the mean fork length values (P>0.05). The mean lengths were larger for females than males. The fork lengths and the total weights of *S. cephalus* ranged from 6.0 to 22.8 cm and from 3.7 to 134.62 g for females; from 6.1 to 22.1 cm and from 2.7 to 110.0 g for males, respectively.

The von Bertalanffy growth equations is determined by using mean fork lengths, for females $Lt= 34.71[1-e^{-0.116(t+0.867)}]$ and for males $Lt= 32.87 [1-e^{-0.127(t+0.717)}]$. The asymptotic length ($L\infty$) of females grew a bit faster than the males, while growth coefficient (K) was lower (Table III). Also, growth performance index (Φ) of all individuals (female, male and all) was found close to each others.

Length - weight relationship

The length-weight equations for chub were $WT= 0.0269\ FL^{2.720}$ for females, $WT= 0.0251\ FL^{2.7535}$ for males and $WT= 0.0262\ FL^{2.7331}$ individually. In these equations, the correlation coefficients found for females ($R^2= 0.9814$) and males ($R^2= 0.9832$) are close to each other. In slope "*b*" females are higher than males.

The slope (*b*) of the lenght-weight relationship were not significantly different (P>0.05); b values for females, males and all were not statistically different from 3 (P>0.05). The results showed that growth was negatively allometrical. The curves of length-weight relationships for female, male and all individuals are presented in Figure 3.

Table I.- Age and Sex composition chub from upper Akcay River.

Age	Females		Males		F+M		Ratio
	N	%n	N	%n	N	%n	1:1
I	23	6.28	21	5.74	44	12.02	1.10:1
II	56	15.30	56	15.30	112	30.60	1:1
III	45	12.30	41	11.20	86	23.50	1.10:1
IV	39	10.65	25	6.83	64	17.48	1.56:1
V	25	6.83	14	3.83	39	10.66	1.79:1
VI	6	1.64	7	1.91	13	3.55	0.86:1
VII	5	1.37	3	0.82	8	2.19	1.67:1
Total	**199**	**54.37**	**167**	**45.63**	**366**	**100.00**	**1.19:1**

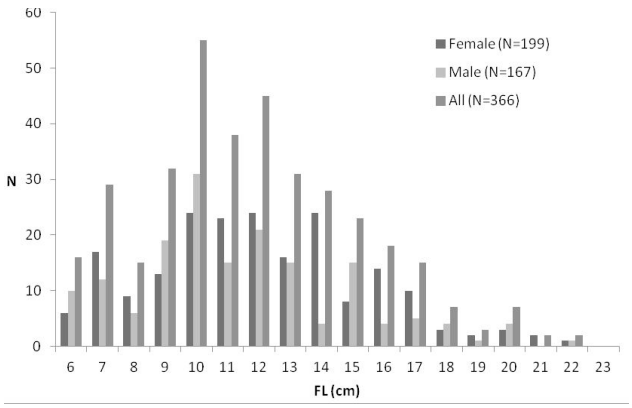

Fig. 2. Length-frequency distribution of chub from upper Akcay River

Table II.- Age-length-keys of Female (F) and Male (M) chub from upper Akcay River.

Age	I		II		III		IV		V		VI		VII		Tot
LF(cm)	F	M	F	M	F	M	F	M	F	M	F	M	F	M	
6-7	22	20	2	2											46
8-9	1	1	20	24											46
10-11			34	30	13	17									94
12-13					32	24	8	11							75
14-15							29	13	3	5					50
16-17							2	1	21	8	1	1			34
18-19									1	1	3	4	1		10
20-21											2	2	3	3	10
22-23													1		1
N	23	21	56	56	45	41	39	25	25	14	6	7	5	3	366
FL	7.1	6.9	10.1	9.9	12.5	12.2	14.5	14.3	16.8	16.6	19.1	18.80	21.2	20.9	
SD	0.6	0.50	0.99	0.75	0.62	0.60	0.64	1.08	0.65	0.79	0.87	0.93	1.19	1.01	
Min	6.0	6.1	7.9	7.9	11.5	10.9	13.5	12.9	15.8	15.5	17.8	17.7	19.9	20.1	
Max	8.1	8.0	11.7	10.9	13.8	13.2	16.1	15,8	18.2	18.0	20.1	20.1	22.8	22.1	

Table III.- Parameters (L∞, K, a and t_0) of the von Bertalanffy growth curve and growth performance indexes (Φ) for female, male and all chub in upper Akcay River.

Sex	N	L∞ (cm)	K (year^{-1})	a	t_0 (year)	Φ
Female	199	34.71	0.116	3.818	-0.867	2.16
Male	167	32.87	0.127	3.907	-0717	2.14
All	366	33.34	0.123	3.868	-0.773	2.15

Condition coefficients

The mean condition coefficient of females (1.37) was higher than that of males (1.32), but the differences between sexes were not statistically significant (P>0.05)

Sex ratio and sexual maturity

A total of 366 individuals were examined, 199 (54,37%) were females and 167 (45.63%) were males. The sex of the remaining all individuals identified macroscopically and microscopically. The overall ratio of females to males was 1.19:1 and this ratio was not different from the theoretical 1:1 sex ratio (P>0.05).

The sexual maturity age of males and females was determined to be II age group and first sexual maturity. The total length was found as 11.33 cm for female and 10.89 cm for male. The mature individual was not determined

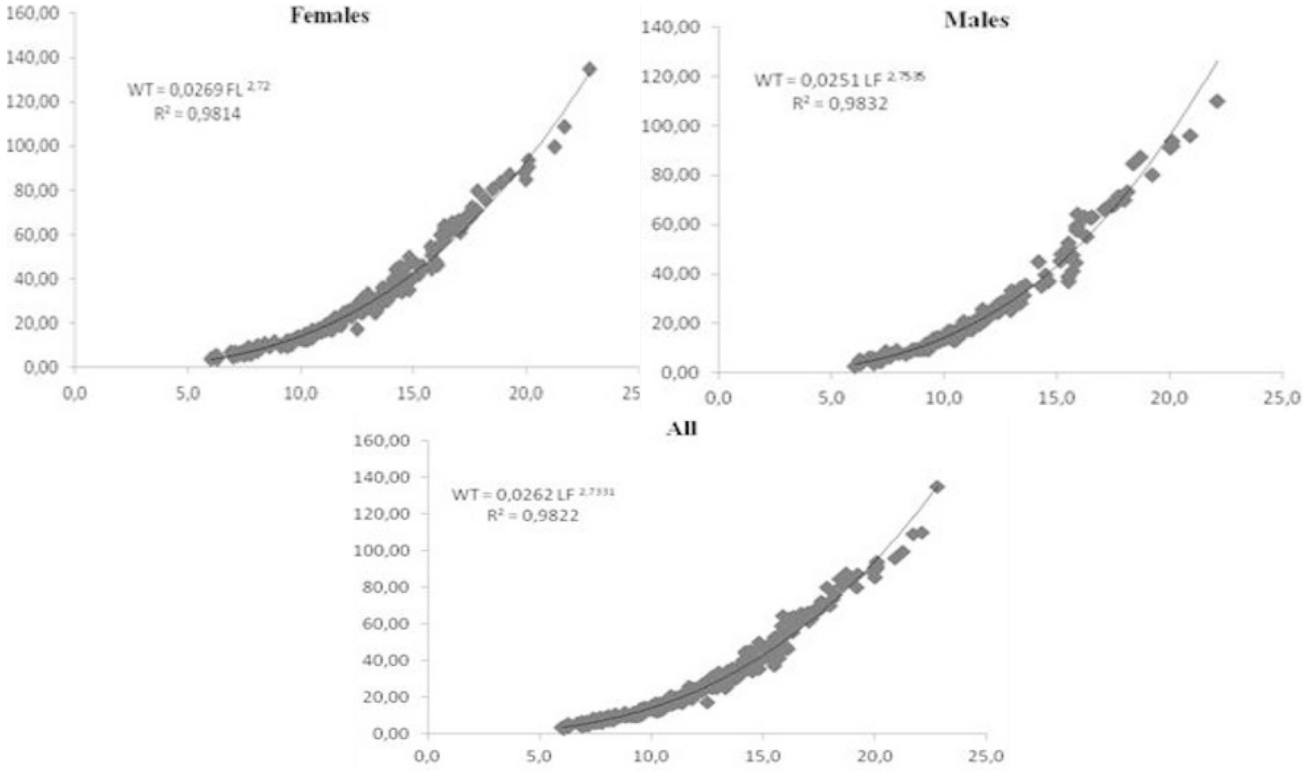

Fig. 3. Length-weight relationships of male, female, and all chub from upper Akcay River.

Table IV.- Mean Total Length (TL, cm), Total Weight (WT, g) and Fecundity (F) of 47 female *S. cephalus* from different age groups (N=Number of fish).

Age	N	TL ± SD	WT ± SD	F ± SD	F /TL	F /WT
II	6	10.80± 0.66	12.90±2.75	6596±4036	610.74	511.32
III	16	13.80± 0.80	27.47 ± 3.99	10427±3386	755.58	379.58
IV	14	15.40± 0.69	39.23 ± 5.40	20036±7756	1301.03	510.73
V	8	17.20± 0.55	58.40± 6.26	36115 ±14310	2099.71	618.41
VI	3	20.80 ±0.76	86.42 ± 3.64	26100±3358	1254.81	302.01

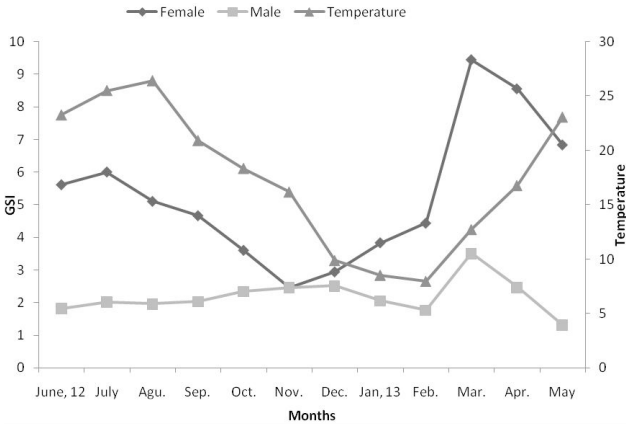

Fig. 4. Monthly variation of the Gonado Somatic Index (GSI) for female and males with water temperature.

for females and males of I age group, while the individuals of II age group were determined mature with 51.78% and 65.50% of females and males, the individuals of III age group were mature with 93.33% and 97.56% of females and males, respectively.

Spawning season

Ovary development began in November. The highest GSI values were determined in March both females (8.50%) and males (3.32%). There was a decrease in the mean GSI values in June, when spawning was almost about to finish (Fig. 4). According to the variations of GSI value, it was founded that the spawning period was between March and May when the water temperature ranged from 12.50 to 23.10 °C.

Fecundity and egg diameter

Fecundity was determined from 47 female fishes caught when eggs developed during spawning period. The number of eggs ranged from 1970 (May) to 59400 (January). Fish had different egg sizes. Fecundity was highest in populations with the smallest eggs. During spawning period, the fecundity of female chub was determined according to their age groups (Table IV).

As shown in Table IV, egg production increased with age. The mean fecundity was determined as 6596, 10427, 20036, 36115 and 26100 in the ages II-VI, respectively. Fecundity was correlated with fish length and weight, and fecundity increased as fish length, weight, gonad weight and age increased (Table IV).

Also, it is observed spawning time in oocytes from ovaries in all seasons. Egg diameters changed within 0,10 mm (December) and 0,110 mm (April). The mean egg

Table V.- The available parameters of length-weight relationship, growth ($L\infty$, K, t_0) and condition factor (CF) of chub from Turkish populations. (a and b: parameters of the length-weight relationship).

Area	Sex	n	Weight range (g)	Length range (cm)	a	b	L∞	K	t_0^{-1}	CF	References
Aras River	♀	558	3.0-302.5	6.3-27.5	0.009	3.14	36.7	0.11	1.39	1.08-1.46	Turkmen *et.al.* (1999)
	♂	533	4.20-81.5	6.7-24.1	0.010	3.11	32.5	0.12	1.63	1.25-1.52	
Topcam	♀	242	19.8-344	10.8-26.2	0.009	3.19	40.2	0.12	1.58	1.41-1.91	Sasi and Balik (2003)
Dam Lake	♂	90	16.2-203	9.7-23.5	0.023	2.85	27.1	0.30	0.46	1.78-1.74	
Isikli	♀	215	44.6-247.0	13.5-23.1	0.014	3.08	28.6	0.17	3.32	1.40-2.00	Balik *et al.* (2004)
Lake	♂	313	41.7-260.1	13.5-23.0	0.016	3.03	31.6	0.03	3.84	1.57-2.14	
Karakaya	♀	49	123.8-721.5	17.0-36.2	-	3.03	37.8	0.41	1,00	1.42	Kalkan *et al.* (2005)
Dam Lake	♂	28	115.4-584.2	17.0-34.4	-	2.49	35.5	0.60	0,19	1.43	
Ikiztepeler	♀	172	18.6-243.6	11.1-24.8	0.023	2.87	28.89	0.22	1.55	0.77-2.40	Koc *et. al.* (2007)
Dam Lake	♂	242	29.3-173.9	12.2-24.1	0.019	2.92	26.71	0.25	1.55	1.30-2.03	
Karasu Stream	♀	205	4.8-1002.5	7.3-40.5	0.008	3.13	60.75	0.09	0.32	1.33	Sen and Saygin
	♂	215	-	-	0.008	3.16	32.93	0.12	1.78	1.29	(2008)
Camlidere	♀	72	151.9-667.6	21.5-35.3	0.013	3.04	38.51	0.33	1,67	1.38-1.99	Bostanci and Polat
Dam Lake	♂	29	124.4-462.6	20.0-31.2	0.014	3.01	34.12	0.37	1,07	1.27-1.91	(2009)
Todurge	♀	379	1.5-320.8	5.3-27.9	0.010	3.09	-	-	-	1.15-1.42	Unver and Erk'akan
Lake	♂	93	3.0-120.5	6.6-20.1	0.012	3.03	-	-	-	1.19-1.43	(2012)
Akcay River	♀	199	3.7-134.6	6.0-22.8	0,026	2.72	34.71	0.12	0,87	1.03-1.99	This study
	♂	167	2.8-109.96	6.1-22.1	0,025	2.75	32.87	0.13	0,72	0.96-1.97	

diameter was highest in April (0.65 mm), while the lowest was in December (0.25 mm). We found that egg diameters became greater in size with fish length, weight and age increase too. The growth curve of egg diameter related to fecundity in various parts of the ovaries is given in Figure 5.

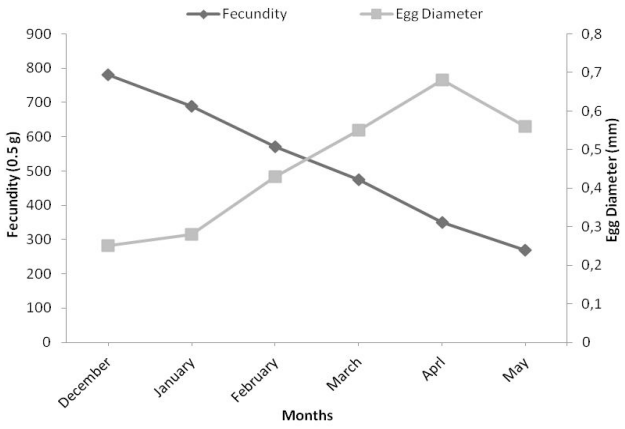

Fig. 5. Monthly Relationships between Fecundity and Egg diameter

The available length-weight relationship, growth parameters ($L\infty, K, t_0$) and condition factor (CF) of chub from some part of Turkish populations is summarized (Table V).

The upper Akcay River water level decreases every year during the late spring and early summer because of irrigational activities. When the rainfalls begin in winter, water level increases. The region climate is warm. During the study period, water temperature varies between 6.87 to 26.40 ºC. Dissolved oxygen was 7.38-11.96 mg/l; pH 6.49-8.56 and conductivity 445-786 µmhos/cm.

DISCUSSION

Our study gives some growh and reproduction parameters of *S. cephalus* for a native fish in upper Akcay River from Buyuk Menderes Basin for the first time. There are some studies about this species from other localities, which give biological traits and distribution. The distribution areas of chub are given for all inland waters of Anatolia (Geldiay and Balik, 1999; Kuru et al., 2014).

The age distribution for both sex of *S. cephalus* population in upper Akcay River that age group II was the dominant, followed, by groups III, IV, I, V, VI and VII. The age distrubition of chub populations in previous studies was: Sariyar Dam Lake, I-X (Ekmekci, 1996), Topcam Dam Lake, I-VII (Sasi and Balık, 2003), Isıklı Lake, I-V (Balik et al., 2004), Sir Dam Lake, I-VI (Kara and Solak, 2004) and Camkoru pond I-X (Innal, 2010). The life span of the chub in the upper Akcay River was similar to the other studies.

In the present study, 54.37% of 199 European chub samples were female individuals and 45.63% of 167 samples were male individuals. The population were mostly young individuals between ages I and III and the most dominant age group in the population was II for both females and males (Table I). This situation was also reported to be the same with Isıkli Lake, Aras River, Karasu River and Camlıdere Dam Lake populations from Turkey (Erdogan et al., 2002; Balik et al., 2004; Bostancı and Polat, 2009) and Iskar River in Bulgaria (Raikova-Petrova et al., 2012). It is reported that most of the studies were dominant in the III age group from Topcam, Karakaya, Almus and Ikizcetepeler Dam Lake populations (Sasi and Balık, 2003; Kalkan et al., 2005; Karatas and Can, 2005; Koc et al., 2007).

The ratio of females to males was determined to be 1.19:1 in upper Akcay River. Female:Male ratio values were reported as 0.82:1 in Muceldi River (Oztas and Solak, 1988), 1:2.15 in Todurge Lake (Unver, 1998) and 1:1.45 in Karasu Stream (Sen and Saygin, 2008). Female:Male can change from expected ratio 1:1 due to the natural and fishing related deaths among sexes, infected by catching during reproduction period and changes in ecological factors (Sarıhan, 1993; Nikolsky, 1963).

The fork lengths for females in all ages were higher than males, but there is no significantly differences between females and males ($P>0.05$). The fork length of the age groups of chub populations in the Topcam and Ikiztepeler Dam Lake, Civril Lake and Akcay River have quite similarity as mentioned in Table V.

The slope (b) values of the length-weight relationship of *S. cephalus* in both sexes (b=2.72 for females, b=2.75 for males) showed that weight increased with length in negative allometry in upper Akcay River. It is given that "b" values varied from 2.49 in Karakaya Dam Lake (Kalkan et al., 2005) to 3.19 in Topcam Dam Lake (Sasi and Balık, 2003), and it was determined that there was a significant differences ($P<0.05$). The b values of *S. cephalus* from European country populations were found in Lika River 2.67; Bednja River 2.87; Kupa River 3.24 and Dobra River 3.36 from Croatia, (Treer et al., 1999), Strymon Estuary from Greece 3.85 with Total Length, TL (Koutrakis and Tsikliras, 2003); and Vardar River 2.88 from Rep. of Macedonia with Fork Length, FL (Georgiev, 2003); while Upor River from Czech Rep., 3.06 with Standart length, SL (Vlach et al., 2005). Some of the difference could be due to use of different length measurements by researchers.

The estimated von Bertalanffy growth constant are $Lt= 34.71[1\text{-}e^{-0.116(t\ +0,867)}]$ for females and $Lt= 32.87[1\text{-}e^{-0.127(t\ +0,717)}]$ for males in the upper Akcay River. On the other hand, we found that the asymptotic length ($L\infty$) for females

and males not to be signaficantly different (P>0.05). The maximum $L\infty$ values for female and male were 60.75 cm in Karasu Stream and 35.5 cm in Karakaya Dam Lake; the minimum $L\infty$ values for female and male 28.6 cm in Isikli Lake and 26.71 cm in Ikizcetepeler Dam Lake, respectively. Many studies reported on European chub growth in different areas. The parameters of theoretical growth in length of chub were $L\infty$=31.80 cm and K=0.28 yr^{-1} for Croatian population (Treer et al., 1997); $L\infty$=24.50 cm and K=0.21 yr^{-1} for Upor Stream in Czech Republic (Vlach et al., 2005). Also, it was reported that the growth constants of *Squalius squalus* $L\infty$=63.91 cm, K=0.12 yr^{-1}, t_0=0.160 yr; the growth performance index (Φ) was 2.70 for Assino Creek in Italy (Pompei et al., 2011). The growth performance index in upper Akcay River found 2.16 for female and 2.14 for male. The K and Φ values of our study for females and males were similar, and usually can be affected by ecological factors.

The condition factors changed between 1.03-1.99 for females and 0.96-1.97 for males from our study area. The minimum and maximum condition factor from Ikiztepeler Dam Lake in Turkey were given as 0.77 and 2.40, respectively. While mean condition factor values from European ecosystems were given in Lika 0.99, Dobra 1.08, Kupa 1.21 and Bednja River 1.29, respectively from Croatia (Treer et al., 1999), and Upor Stream 1.49 from Czech Republic (Vlach et al., 2005). Condition variations can be due to stages differences in ontogenetic development, and also differences in length, age, sex, gonadal development (Ricker, 1975).

The maturity of males and females was determined from 2 years old and this situation showed some similarity with Aksehir Lake (Altındag, 1997) and Topcam Dam Lake (Sasi, 2004) populations. The maturity from Black Sea Basin and Almus Dam Lake is determined at the age of 3 (Slastenenko, 1956; Karatas and Akyurt, 1997). But age of maturity for some areas was reported at the age of 2 for females and 3 for males in Kızılırmak Basin (Erk'akan and Akgül, 1986), Savur Stream (Unlu and Balci, 1991), and Karasu River (Erdogan et al., 2002).

The spawning ages for females and males were reported from Sariyar Dam Lake to be between III-V and III-IV (Ekmekci, 1996), while from Aras River (Turkmen et al., 1999) and Todurge Lake (Unver, 1998) were reported to be females III-IV and males II-III ages, with different location from Northern part of Turkey.

Accordig to Gonadosomatic Index (GSI) the values of *S. cephalus* population in upper Akcay River revealed that the spawning period of the species was between March and May. Other researchers indicated the period to be between May and September in Kizilirmak River (Erk'akan and Akgul, 1986), May and June in Savur River (Unlu and Balci, 1991), May and June in Sariyar Dam Lake and Muceldi Stream (Ekmekci, 1996; Oztas, 1989), March and April in Topcam Dam Lake (Sasi, 2004), March and July in Karakaya Dam Lake (Kalkan et al., 2005). while in Todurge Lake (Unver, 1998), Almus Dam Lake (Karatas and Akyurt, 1997) and in Karasu River (Erdogan et al., 2002) were found in May and July, The spawning time of chub population in upper Akcay River and Topcam Dam Lake (Buyuk Menderes Basin) begins earlier than the other basins because of the warm climate in Southern part of Turkey.

The mean number of eggs of *S. cephalus* in upper Akcay River ranged between 6596 (II age) and 36115 (V age) per female. Fecundity was correlated with fish length, body weight, age and gonad weight, with increase in fecundity the fish length, weight, gonad weight and age increased.

The mean number of eggs of *L. cephalus* were ranged between 2050 and 20140 in Savur Stream (Unlu and Balci, 1991), 4470 and 29780 in Rokytna Stream (Libosvarsky, 1979), 4349 and 51137 in Muceldi Stream (Oztas, 1989), 7056 and 18898 in Almus Dam Lake (Karatas and Akyurt, 1997), 13269 and 59200 in Sariyar Dam Lake (Ekmekci, 1996), 19162 and 106227 in Aksehir Lake (Altindag, 1997), 5012 and 25000 in Karasu River (Erdogan et al. 2002), 9142 and 53100 eggs in Topcam Dam Lake (Sasi, 2004) and 13632 and 72495 eggs in Iskar River (Raikova-Petrova et al., 2012). Fecundity of chub populations is affected by feeding, size, age, environmental conditions and season, as well as geographically and ecologically difference from water bodies (Nikolsky, 1963). It also differs between populations of the same species and does not remain permanent from year to year. From these investigations it is reported fecundity increased as fish length, weight, age and gonad weight increased.

Egg diameter of chub was bigger (1.10 mm) in April and smaller (0.10 mm) in December. Some studies were reported that the egg diameters to be 0.96-1.35 in Rokytna River and 0.65-1.22 in Klikava Dam Lake (Libosvarsky, 1979), 0.58-1.03 in Sariyar Dam Lake (Ekmekci, 1996), 0.86-1.48 mm in Aksehir Lake (Altindag, 1997), 0.88-1.02 mm in Tozanlı Stream (Karatas, 1997), 0.46-1.04 mm in Todurge Lake (Unver, 1998), 0.92-1.45 mm in Aras River (Turkmen et al., 1999), 0.38-0.71 mm in Topcam Dam Lake (Sasi, 2004), 0.70-0.88 mm in Karakaya Dam Lake (Kalkan et al., 2005) and 1.10-1.24 mm in Hafik Lake (Unver and Kekilli, 2012). All studies were mentioned that the egg diameter was correlated with fish length, weight, age and gonad weight. The egg diameter variation in the ovaries is important parameters used to define reproductive potential. Also, egg diameter could be related to the amount of food that females can metabolise

(Nikolsky, 1963).

CONCLUSIONS

Maintenance of species and balance of density population are important in terms of economic fishing of this species in the area. From March to June the prohibition of fishing is advised. In addition, the fish under the age IV and of average total length 15.40 cm for all individuals should not be caught during the fishing period, when all fishes get matured. This can increase both the productivity and population of fish. There have not been any studies undertaken to assess the growth and reproduction of *S. cephalus* in upper Akcay River. Ecological studies can help to understand the relationships between *S. cephalus* and other fishes.

The release of wastewater, sewage and solid waste into upper Akcay River is one big problem, its causes irreparable damage in the River and Kemer Dam. For the remedy of the River it is suggested wastewater should be treatend before discharge and use of small sized seine nets should be restricted and fishing should be scheduled and illegal fishing should be prohibited in upper Akcay River.

The upstream of the river has shown higher abundance in value for native fishes such as *Squalius cephalus*, *Acanthobrama mirabilis, Capoeta bergamae* and suggesting the need of proper conservation and management. These native species have been subjected to a rapid decline in their population were found to be poor in abundance from Buyuk Menderes River, this may be due to the interference of several anthropogenic activities (Sasi and Berber, 2013).

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Conflict of interest statement

We declare that we have no conflict of interest.

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