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Some biological parameters of the bergamae barb, *Capoeta bergamae* Karaman, 1969 (Cyprinidae), in Kemer reservoir (Aydin, Turkey)

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Abstract. The age, growth and maturity of *Capoeta bergamae* Karaman, 1969, an endemic and vulnerable fish species from western Anatolia, were studied by monthly samplings throughout January - December 2006. Females represented 44.8% and males 55.2% of the individuals. Age determinations based on scale readings show that the population has four age classes. The von-Bertalanffy growth parameters were $L\infty$:25.0 cm, K=0.344 $year^{-1}$ and t_0=-0.93 year for males respectively $L\infty$:27.2 cm, K=0.308 $year^{-1}$ and t_0=-0.92 for females. Length-weight relationships were estimated as $W=0.020*L^{2.85}$ (R^2=0.94) for males and $W=0.021*L^{2.84}$ (R^2=0.97) for females. The growth characteristics of both sexes were allometric (b=2.85 males; b=2.84 females). According to gonadosomatic index values, the reproduction period began in May and continued til July. Males reached maturity at smaller lengths (FL: 14.0 cm [SD: 0.34], 1.9 years) than females (FL: 15.4 cm [SD: 0.39], 2.2 years).

Key words: *Capoeta bergamae*, growth, sexual maturity size, gonadosomatic index, spawning.

Introduction

The genus *Capoeta* is an inhabitant of the the Turkish freshwater systems is represented by 14 species. The species are the object of commercial and sport fishing (Geldiay & Balik 2007). *Capoeta bergamae* is an endemic cyprinid and has been reported only from western-southwestern Anatolia, from the Kocabas Stream to the Dalaman Stream (Balik 1980, Sari et al. 2006).

The species, locally called 'Bergama siraz baligi', is a benthopelagic fish, and inhabits both lentic and lotic environments with local economic importance in Anatolia. This fish was considered vulnerable by Crivelli (2006) and Smith & Darwall (2006) and endangered by Kucuk (2006). Knowledge on the biology of the Bergamae barb is very limited. Geldiay & Balik (1977) described the distribution and length-weight relationship, Sasi (2002) studied the growth and reproduction biology in Topcam reservoir. The aim of the present study is to investigate age, growth, breeding and sexual maturation properties of the *C. bergamae* in the Kemer reservoir, Aydin, Turkey.

Materials and methods

Kemer reservoir is located near the city of Aydin, in the region of west Anatolia (37° 32' N and 28° 32' E). The reservoir was constructed on the Akcay Stream, one of the important tributaries of

Buyuk Menderes River (Fig 1). It was created behind a 180.50 meter-high wall built in 1954-1958 by the Turkish State Water Supply Administration (DSI) for irrigation, flood control and energy purposes. The reservoir has an oligo-mezotrophic character (Ozyalin 2007). The reservoir surface is 14.75 km^2, overall volume is 544 hm^3 and the depth varies from 11.4 to 52.7 m. The water level fluctuates because of its use for irrigation and lack of precipitation.

125 specimens were captured in total from January 2006 to December 2006 in the Kemer reservoir. Fish samples were caught with a total of 1000 m of gill nets of 18-45 mm mesh sizes and cast nets with 12-22 mm mesh sizes from eight different stations. Due to the vulnerable status of this species, collections were kept at the minimum. After catching, the specimens were preserved in 4% formaldehyde solution. Fork length (FL) to the nearest 1 milimeter and body weight (W) to the nearest 0.01 gram were recorded for all individuals in laboratory. The age of the fish was determined using the microscopic scalimetric method. Ten to 15 scales from the left side of the body between the lateral line and dorsal fin were removed (Tesch 1970). Scales were prepared by applying a series of alcohol dilutives, and read under a binocular microscope, scale reading being done twice, each time by a different person.

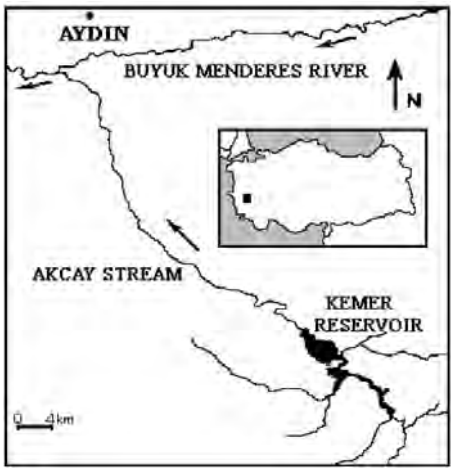

Figure 1. Map of study area.

The overall male:female ratio was tested with χ^2-test. The relation of weight (hereafter W) to fork length (hereafter L) was calculated applying the exponential regression equations, $W = a\ L^b$ (Le Cren 1951). The parameters a and b of the L-W relationships were estimated by the least squares regression method. The significance of the regression was assessed by ANOVA, and different from the predictions for isometric growth (b=3). Species growth was described with the von Bertalanffy equations (Sparre & Venema 1992): $L_t = L_\infty(1-e^{-K(t-t0)})$, where L_t is the fish length at age t, L_∞ represents the asymtotic fish length, e is the base of natural log (2.71828), t is the fish age (year), t_0 is the hypothetical time at which the length of the fish is zero, K is a relative growth coefficient. We applied the widely used growth performance index (Φ) for comparing fish growth: $\Phi=log(K)+2log(L_\infty)$ (Pauly & Munro 1984). The condition factor (CF) was calculated for each specimen using the Formula of Fulton (Le Cren 1951) $CF=100W/L^b$, expressed in grams and centimeter FL. The comparison of the CF between sexes was done for the various age classes using t-test.

Sex and maturity stages were determined by examining the gonad tissue, either by eye, for large fish, or with the aid of a lens for smaller fish. Stages of maturation were classified as follows: I - immature; II - developing; III - ripe; IV - spawning; and V - spent (King 1995). The gonads were removed and weighed to the nearest 0.01 g. The spawning period was determined following monthly changes in the gonadosomatic index (GSI). The GSI was calculated (King 1995) as *GSI=(Gonad weight/Body weight)*100*. At each sampling station, water temperature was measured to determine the relationship between temperature and gonad growth. To estimate the mean length and age of 50% maturity, a logistic function was fitted to the proportion of the mature individuals in size class by using non-linear regression with individuals classed into 10-mm L_T intervals. The following functions were used: $P=[1+e^{(-r(L-Lm))}]^{-1}$ for length, $P=[1+e^{(-r(T-Tm))}]^{-1}$ for age, where P is the maturity proportion in each size class, r is a parameter controlling the shape of the curve, L_m is the size at 50% maturity and T_m is the age at 50% maturity (King 1995). The fecundity of 25 females was estimated gravimetrically. Mature ovaries were subsampled (0.001 g) from anterior, middle and posterior portions of each ovarian lobe. The absolute fecundity (F), which is the number of

mature oocytes spawned by a female in a single spawning, was estimated as: $F=GW*D$, where GW is the weight of the ovary and D is the density of mature oocytes (number of oocytes per gram of ovarian tissue). Eggs from the anterior, middle and posterior parts of ovaries were measured under a stereomicroscope with an ocular micrometer. Samples of 30-40 eggs from each female were collected to measure the egg diameters.

Results

Length frequency distribution

The length-frequency distribution used in the study is shown in Figure 2. The fork length of the 125 *C. bergamae* specimens ranged from 11.0 to 23.5 cm (mean: 15.6, SE: 2.79 cm); specimens between 13.0 and 13.9 cm were abundant for both sexes. The weight of both sexes ranged from 24.60 to 176.70 g (mean: 55.66, SE: 34.38 g).

The average values for the females are slightly higher (FL=16.28 cm, W=64.64 g) than those for males (FL=15.13 cm, W=48.37 g), but the differences were not significant for all cases using the t-test ($p>0.05$).

Length-weight relationship

Length-weight relationships were calculated based on the data gathered from the 125 *C. bergamae* specimens. These were found to be $W=0.020L^{2.85}$ ($r^2=0.94$) for males (Fig. 3), $W=0.021L^{2.84}$ ($r^2=0.97$) for females (Fig. 4) and $W=0.019L^{2.86}$ ($r^2=0.96$) for all individuals. The values of b for males (95%CI: 2.757 - 2.943), females (95%CI: 2.716 - 2.964) and all fish (95%CI: 2.742 - 2.978) were significantly different from 3.0, indicating allometric growth.

Age and growth

56 (44.8%) specimens were female and 69 (55.2%) male fish, ranging in age from one to four years. On account of selectivity of the nets, the 0 age group was not represented in the sample. The male:female ratio

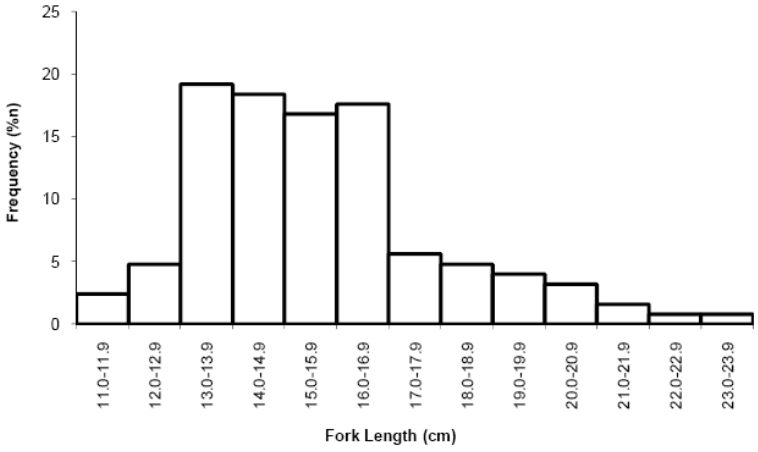

Figure 2. The fork length-frequency distribution of the fish used in the study.

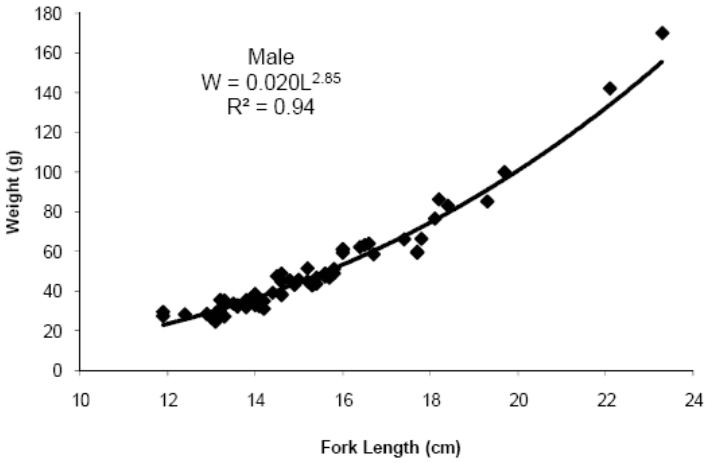

Figure 3. Length-weight relationships in male *C. bergamae* in the Kemer reservoir

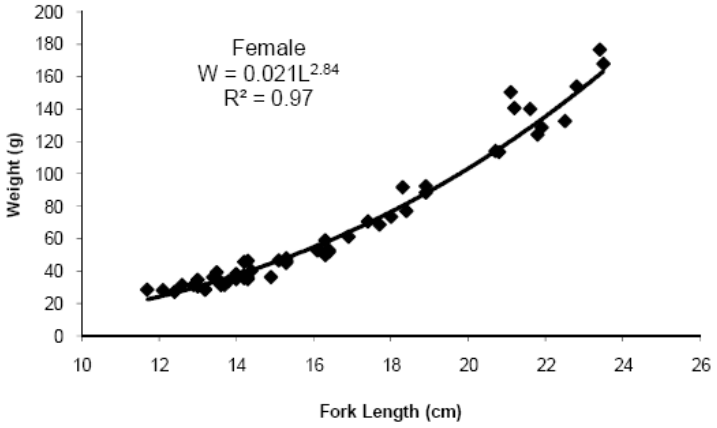

Figure 4. Length-weight relationships in female *C. bergamae* in the Kemer reservoir

was 1:0.81. There were no significant differences between the sexes (χ^2=2.704< $\chi^2_{1,0.05}$=3.84). However, in this study the ratio ranged from 1:0.52 to 1:2.67 (Table 1). Males were dominant in the younger age groups (1-2 age groups), females in the other age groups (Table 1). After determining fish age, we observed that 40.0% of the samples belonged to age group II. Age group IV was represented with only 8.8%.

The von Bertalanffy growth equations were: L_t=25.0[1-$e^{-0.344(t+0.93)}$] and Φ=2.332 for

males, $L_t=27.2[1-e^{-0.308(t+0.92)}]$ and $\Phi=2.358$ for females, while $L_t=27.7[1-e^{-0.277(t+1.10)}]$ and $\Phi=2.327$ for all species.

Condition factor

The condition factor was calculated according to age and sexes. Minimum and maximum values were calculated as 1.290 (age I) and 1.403 (age IV) for males, 1.284 (age I) and 1.434 (age IV) for females. The mean condition factor differed significantly with sex (1.372 for females and 1.357 for males; $p<0.05$) (Table 2).

Sizes and ages at maturity are given by the following equations: for males: $P=\{1 + e^{[-0.829(L-14.0)]}\}^{-1}$, $P=\{1 + e^{[-1.374(T-1.9)]}\}^{-1}$, for females: $P=\{1 + e^{[-0.822(L-15.4)]}\}^{-1}$, $P=\{1 + e^{[-1.489(T-2.2)]}\}^{-1}$, respectively.

Gonad development and spawning period

Gonad development was studied using the GSI values of samples (Fig. 5). Minimum and maximum GSI values were 0.28 for July and 12.14 for May. Yearly average value was computed as 3.95. Spawning occurred between May (21.2 ◦C) and July (26.8 ◦C).

Length and age at first maturity

Table 1. Yearly variation in sex ratio (male: female) of *Capoeta bergamae* in the Kemer reservoir

			Total			
Age	**Male**	**Female**	**N**	**%N**	**Sex ratio**	**Chi-square**
I	15	12	27	21.6	1:0.80	0.667
II	33	17	50	40.0	1:0.52	**10.24***
III	18	19	37	29.6	1:1.06	0.054
IV	3	8	11	8.8	1:2.67	**4.545***
Total	69	56	125	100.0	1:0.81	2.704

Significant at *P=0.05

Table 2. Condition factor and comparison between sexes of *Capoeta bergamae* in the Kemer reservoir

		Male			Female			
Age	**N**	**Mean**	**S.D.**	**N**	**Mean**	**S.D.**	**t**	**P**
I	15	1.290	0.133	12	1.284	0.097	0.564	P<0.05
II	33	1.354	0.116	17	1.363	0.195	0.839	P<0.05
III	18	1.387	0.139	19	1.403	0.116	0.901	P<0.05
IV	3	1.403	0.170	8	1.434	0.158	0.838	P<0.05
Total	69	1.357	0.145	56	1.372	0.161	0.591	P<0.05

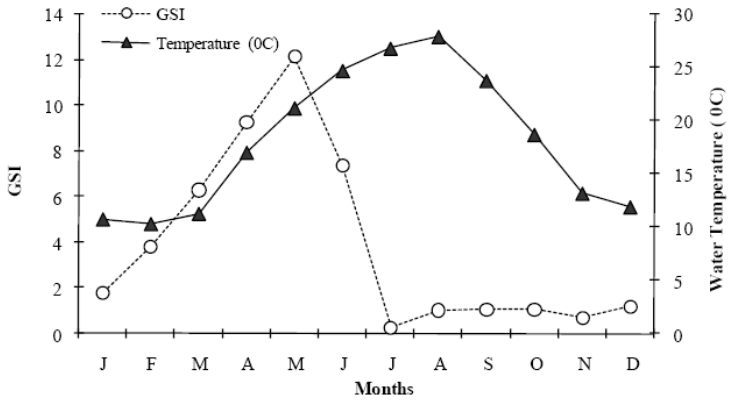

Figure 5. Gonad cycle of *C. bergamae* and water temperatures of the Kemer reservoir

During spring (February–May), an obviously rapid growth of gonads occurred until the next spawning.

Fecundity

Fecundity was studied in 25 females captured just prior to spawning period. Oocyte numbers in the ovaries varied from 2058 to 10633; the average value proved to be 6937. Egg diameters varied between 0.78 and 1.45 μm with a mean of 0.92 μm (SD: 0.23).

Discussion

C. bergamae population in Kemer reservoir consisted of age groups I-IV; 69.60% of the samples for combined sexes belonged to the age groups II and III. The sex ratio did not differ from the ratio of 1.00:1.00, found by Sasi (2002) and Kalkan (2008) (Table 3).

The growth of *C. bergamae* in Kemer reservoir shows negative allometry (females: *b*=2.850, males: *b*= 2.841). "*b*" values were close to the estimations of Geldiay & Balik (1977, except for Cine S.), Turkmen et al. (2002) and Alp et al. (2005) but different from those found by Geldiay & Balik (1977, only Cine S.), Sasi (2002), Elp & Karabatak (2007), Abdoli et al. (2008), Kalkan (2008) (Table 4). The *b* values are often 3.0 and generally between 2.5 and 3.5. As the fish grows, changes in weight are relatively greater than changes in length due to approximately cubic relationships between fish length and weight. The *b* values in fish vary according to species, sex, age, seasons and feeding. In addition, changes in fish shape, physiological conditions, and different amounts of food available, life span or growth increment can all affect the *b* growth exponent (Le Cren 1951, Ricker 1975, Tesch 1970).

The L_∞ values were 25.0 cm, 27.2 cm and 27.7 cm for males, females and sexes combined. The value of L_∞ of females was higher than that of males. Sasi (2002), Turkmen et al. (2002), Alp et al. (2005), Abdoli et al. (2008) and Kalkan (2008) pointed out similar

Table 3. The spawning ages, lengths and seasons for different species of genus Capoeta in different areas (S: stream, T: Temperature, Sa: Spawning age, Sl: Spawning length, Sp: Spawning period)

Author(s)	Species	Study area	M:F ratio	Sex	Age	Sa	Sl	Sp	T
Geldiay & Balik 1977	*C. bergamae*	Cine S.	-	M+F	1-4	3	20.0	May-June	-
		Bakircay S.	-	M+F	1-4	3	20.0	May-June	-
		Dalaman S.	-	M+F	1-4	3	20.0	May-June	-
		Gediz S.	-	M+F	1-4	3	20.0	May-June	-
Yildirim & Aras 2000	*C. tinca*	Oltu River	1:0.79	M	1-10	2	12.0		
				F	1-12	3	15.5	May-July	16.0-18.0 ^{0}C
Sasi 2002	*C. bergamae*	Topcam reservoir	1:1.12	M	2-6	2	15.3		
				F	2-6	3	15.4	March-May	13.5-24.1 ^{0}C
Turkmen et al. 2002	*C. c. umbla*	Karasu River	1:0.76	M	1-10	2	16.9		
				F	1-12	4	21.9	May-June	15.0-22.0 ^{0}C
Elp & Karabatak 2007	*C. capoeta*	Kockopru reservoir	1:1.43	M	2-6	3	24.9		
				F	2-6	4	34.9	May-June	-
Kalkan 2008	*C. trutta*	Karakaya reservoir	1:0.98	M	0-7	2	-		
				F	1-7	3	-	May-June	-
Present study	*C. bergamae*	Kemer reservoir	1:0.81	M	1-4	1.9	14.0		
				F	1-4	2.2	15.4	May-July	21.2-26.8 ^{0}C

Table 4. Parameters of the length-weight relationship and von Bertalanffy growth equation for different species of genus Capoeta in different areas (C.: Capoeta).

Author(s)	Species	Study area	Sex	Age	b	L∞	k	t_0
Geldiay & Balik 1977	*C. bergamae*	Cine S.	M+F	1-4	3.28	-	-	-
		Bakircay S.	M+F	1-4	2.93	-	-	-
		Dalaman S.	M+F	1-4	2.82	-	-	-
		Gediz R.	M+F	1-4	2.80	-	-	-
Sasi 2002	*C. bergamae*	Topcam reservoir	M	2-6	3.18	34.1	0.358	0.34
			F	2-6	3.14	43.5	0.195	-0.19
			M+F	2-6	3.16	40.0	0.238	-0.12
Turkmen et al 2002	*C. c. umbla*	Karasu River	M	1-10	2.94	42.3	0.146	-0.98
			F	1-12	2.99	45.7	0.139	-0.83
			M+F	1-12	2.86	47.5	0.112	-1.02
Alp et al. 2005	*C. c. angorae*	Ceyhan River	M	1-7	2.81	47.3	0.133	-0.76
			F	1-10	2.68	62.3	0.101	-0.60
Elp & Karabatak 2007	*C. capoeta*	Kockopru reservoir	M+F	1-6	2.99	58.2	0.152	0.38
Abdoli et al. 2008	*C.c. capoeta*	Gorganrud R.	M	0-3	3.05	19.0	0.462	-1.00
			F	0-3	3.05	23.0	0.472	-0.74
Kalkan 2008	*C.trutta*	Karakaya reservoir	M	0-7	2.93	76.4	0.060	-2.65
			F	1-7	3.03	89.5	0.057	-2.41
Present study	*C. bergamae*	Kemer reservoir	M	1-4	2.85	25.0	0.344	-0.93
			F	1-4	2.84	27.2	0.308	-0.92
			M+F	1-4	2.86	27.7	0.277	-1.10

situations (Table 4). The reasons for this may be that females grow faster than males, and live longer (Ricker 1975). The theoretical maximal length value (L_∞=27.7 cm) was close to the size of the largest fish examined.

In the present study, the mean monthly gonodosomatic index values were the highest in May (12.14) and decreased in July (0.28). Spawning occurred between May (21.2 ◦C) and July (26.8 ◦C). The spawning period in Kemer reservoir is similar to the findings of previous investigations, except for Sasi (2002) (Table 3). Spawning periods of fish vary with respect to their species; the ecological characteristics of fish are determined by such ecological differences as stagnant or running water, altitude, temperature and quality of food (Nikolsky 1963).

The youngest mature male was 1.9 years old, and this situation was similar to the results reported by Yildirim & Aras (2000), Sasi (2002), Turkmen et al. (2002), Kalkan (2008), but was different from the findings of Geldiay & Balik (1977), Elp & Karabatak (2007) (Table 4). The youngest mature female was 2.2 years old, and this situation was different from other observations (Table 3). The reason for these differences is that first spawning age is determined by the species' requierements and affected by several environmental factors such as temperature, the quantity and quality of food and inhabited water systems (such as lake or river).

The length at first maturity of females was higher than that of males: most of investigators have reported similar patterns (Geldiay & Balik 1977, Yildirim & Aras 2000, Sasi 2002, Turkmen et al. 2002, Elp & Karabatak 2007, Kalkan 2008) (Table 3).

Fecundity ranged from 2058 to 10633 eggs per ripe ovary. Yildirim & Aras (2000) reported that fecundity varied from 1768 to 29120 eggs per female, Sasi (2002) pointed out between 2026 and 14510 eggs per female, Turkmen et al. (2002) reported from 3754 to 35859 eggs per female. Egg diameters varied between 0.78 and 1.45 µm with a mean of 0.92 µm (SD: 0.23). The recorded mean egg diameters of genus *Capoeta* varied between 0.37 and 1.88 mm (Sasi 2002, Turkmen et al. 2002, Elp & Karabatak 2007, Kalkan 2008).

To preserve and enhance the status of *C. bergamae*, we propose that fishing should be prohibited between May and July in the Kemer reservoir. Also, the minimum fishing size should be 15.0 cm FL. Pollution and introduced fish species in rivers or the reservoire itself represent another threat to this threatened endemic species, therefore conservation interventions should also address these issues.

References

Abdoli, A., Rasooli, P., Mostafavi, H. (2008): Length-weight relationships of *Capoeta capoeta capoeta* (Gueldenstaedt, 1772) in the Gorganrud River, South Caspian Basin. Journal of Applied Ichthyology 24: 96-98.

Alp, A., Kara, C., Buyukcapar, H. M., Bulbul, O. (2005): Age, growth and condition of *Capoeta capoeta angorae* Hanko, 1924 from the upper water systems of the River Ceyhan, Turkey. Turkish Journal of Veterinary and Animal Sciences 29: 665-676.

Balik, S. (1980): Güney Anadolu Bölgesi içsularında yaşayan tatlısu balıklarının sistematik ve zoocoğrafik yönden araştırılması (Systematic and zoogeographical investigations upon freshwater fish living in the inland water in South Anatolia Region). Ege University Science Faculty, Izmir. [in Turkish].

Crivelli, A. J. (2006): *Capoeta bergamae*. In: IUCN 2007. 2007 IUCN Red List of Threatened Species.

<www.iucnredlist.org>. Downloaded on 18 April 2008.

Elp, M., Karabatak, M. (2007): A study on *Capoeta capoeta* (Guldenstaedt, 1772) population living in Kockopru Dam Lake, Van-Turkey. Journal of Applied Biological Sciences 1 (2): 57-61.

Geldiay, R., Balik, S. (1977): Batı Anadolu akarsularındaki siraz balığının *Capoeta capoeta bergamae* (Karaman, 1969) biyolojisi üzerine araştırmalar (A study on biology of *Capoeta capoeta bergamae* (Karaman, 1969) living in West Anatolia Streams). Tubıtak, VIth Science Congress, Ankara. [in Turkish].

Geldiay, R., Balik, S. (2007): Türkiye tatlısu balıkları (Freshwater Fish of Turkey). Ege University Fisheries Faculty, Izmir. [in Turkish].

Kalkan, E. (2008): Growth and reproduction properties of *Capoeta trutta* (Heckel, 1843) in Karakaya Dam Lake. Turkish Journal of Zoology 32: 1-10.

King, M. (1995): Fisheries biology, assessment and management. Fishing News Books, England.

Kucuk, F. (2006): Türkiye'deki bazı endemik içsu balıklarının dünya doğayı koruma birliği (IUCN) ölçütlerine göre degerlendirilmesi (Appreciation according to scale IUCN of Turkey endemic freshwater fish). 1st National Fish Introducing and Management Symposium, Antalya. [in Turkish].

Le Cren, E. D. (1951): The Length-weight relationships and seasonal cycle in gonad weight and condition in perch (*Perca fluviatilis*). The Journal of Animal Ecology 20: 210-219.

Nikolsky, G. V. (1963): The ecology of fishes. Academic Press, London.

Ozyalin, S. (2007): Kemer Baraj Gölü (Aydın) fitoplanktonunun incelenmesi (Investigation for phytoplankton of the Kemer Dam Lake, Aydin). Ege Universitesi Fen Bilimleri Enstitusu, Izmir. [in Turkish].

Pauly, D., Munro, J. L. (1984): Once more on the comparison of growth in fish and invertebrates. ICLARM Fishbyte 2: 21.

Ricker, W. E., (1975): Computation and interpretation of biological statistics of fish populations. Bulletin of the Fisheries Research Board of Canada, No. 191, Ottawa, Canada

Sari, H. M., Balik, S., Ustaoglu, M. R., Ilhan, A. (2006): Distribution and ecology of freshwater ichthyofauna of the Biga Peninsula, north-western Anatolia, Turkey. Turkish Journal of Zoology 30: 35-45.

Sasi, H. (2002): Topçam Baraj Gölü'nün (Cine-Aydın) balık türleri ve bazı ekonomik türlerin biyo-ekolojik özelliklerinin araştırılması (The investigation on the fish species and the bioecological characteristics of some economical fish populations in Topcam Dam Lake). Ege Universitesi Fen Bilimleri Enstitusu, Izmir. [in Turkish].

Smith, K. G., Darwall, W. R. T. (2006): The status and distribution of freshwater fish endemic to the Mediterranean basin. IUCN, Gland, Switzerland and Cambridge, UK.

Sparre, P., Venema, S. C. (1992): Introduction to tropical fish stock assessment. Part 1. Manuel. FAO Fisheries Technical Paper, No 306.1, Rev. 1. Rome, FAO, 376 p.

Tesch, F. W. (1970): Age and growth. p.93-123.In: W. E. RICKER (Ed.), Methods for assessment of fish production in fresh waters. IBP Handbook, Blackwell Scientific Publications, Oxford and Edinburg.

Turkmen, M., Erdogan, O., Yildirim, A., Akyurt, I. (2002): Reproduction tactics, age and growth of *Capoeta capoeta umbla* Heckel, 1843 from the Askale region of the Karasu River, Turkey. Fisheries Research 54: 317-328.

Yildirim, A., Aras, M. S. (2000): Some reproduction characteristics of *Capoeta tinca* (Heckel, 1843) living in the Oltu Stream of Coruh Basin. Turkish Journal of Zoology 24: 95-101.

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