Journal of Animal and Veterinary Advances 11 (18): 3452-3456, 2012
ISSN: 1680-5593

Growth and Reproductive Biology of *Gobio gymnostethus* (Ladiges, 1960) in Melendiz Stream, Anatolia, Turkey

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Abstract: The age and size composition, growth rate and reproductive biology of a cyprinid fish *Gobio gymnostethus* which is endemic species were studied in Aksaray-Melendiz Creek. The minimum and maximum fork length for female and male were 39.25-145 and 39.10-132.2 mm, respectively. Age distribution of *Gobio gymnostethus* populations living in Melendiz Creek ranged between 0 to VII. Sexual maturation age of *Gobio gymnostethus* for male and female was I year age and reproduction period of this species were April to July.

Key words: Endemic fish, Turkey, central Anatolia, growth, age, reproduction

INTRODUCTION

Turkey has a very rich biodiversity because of its diverse climate and geography. The complexity of the geographical structure and the separation of rivers by mountains which prevented the distribution of species cause high endemism and genetically diversity in Turkey. Central Anatolia had been favorable for living creatures at the end of the glacial era and an inland lake which was located here was connected with various water systems relevant with this lake at first species spreaded out widely but afterwards the barriers which brought forth Anatolia's present aquatic fauna. The cyprinid fish *Gobio gymnostethus* is an endemic species which lives in Aksaray-Melendiz Creek. The Melendiz Creek is located in Konya Closed basin. This basin has a significant role for speciation and it shelters a good many of endemic species. Existence of endemic species in Anatolia has occurred significantly data in term of paleogeography. Species concern to *Gobio* genus in Turkey originated from Paleoarctic Europe (Banarescu, 1990). To assess the threaten factors that could affect endemic species, Crivelli prepared a form in IUCN Red List. In this form habitat loss/degredation, dam building, water pollution, recreation/tourism, drought, exotic species, limited dispersal, poor recruitment, fisheries, temperature extremes have taken into consideration. According to this assessment, some precautions are suggested to protect of endemic species. In 1960, it was described as a subspecies of *Gobio gobio* by Ladiges (1960). However, Naseka *et al.* (2006) expressed that Turkish subspecies represent distinct species owing to general appearance and some anatomical features. In this study, growth and reproduction characteristics of an endemic species, inhabit in Melendiz Creek was investigated. To date, only systematic studies were carried out regarding this species and no research available for its growth and reproduction biology. But there have been a few studies of *Gobio* genus biology (Mann, 1980; Minano *et al.*, 2003). This study is the first to describe these basic biological characteristics of this species inhabiting to Melendiz Creek and result of this study will provide basic information for other studies on this species.

MATERIALS AND METHODS

A total 544 fish were sampled on a monthly basis between July 2005 and August 2006, except in December 2005, January 2006 and February 2006 when the weather condition was not suitable. Samples were collected with fishnet and by electro fishing in the Melendiz Creek. Fork Length (FL) were measured with an accuracy of 0.1 cm and weighed to nearest 0.1 g in the laboratory. Age was determined from microscopic examination of scales. Fifteen to twenty scales from the left side of the body between the lateral line and dorsal fin were removed. They were firstly cleaned by 4% NaOH and dry mount held between microscope slide as given by Lagler (1966). Individuals were classified in respect of sex in order to determined growth feature. Growth in length and weight were examined and Relative Growth in Length (RGL) and Weight (RWL) were calculated by the following equation (Chugunova, 1963):

$$RGL = \frac{L_t - L_{t-1}}{L_{t-1}} \times 100;$$

$$RWL = \frac{W_t - W_{t-1}}{W_{t-1}} \times 100$$

L_t = The fork lenght (mm) at age t
L_{t-1} = The fork lenght (mm) at age t-1
W_t = The total body weight (g) at age t
W_{t-1} = The total body weight (g) at age t-1

Condition factor (Cf) were calculated using the equation (Lagler, 1966):

$$Cf = \left(\frac{W}{L^3}\right) \times 100$$

Where:
W = Body weight (g)
L = Body lenght (mm)

The age of sexual maturity and the spawning period were estimated from the gonad development (GSI) and monthly variations of the samples. Gonads were removed and weighed to the nearest 0.1 g and the ovaries were preserved in 4% formaldehyde solution. Gonadosomatic Index (GSI) was calculated from the equation:

$$GSI = \frac{\text{Gonad weight} \times 100}{\text{Total bodyweight}}$$

The number of eggs was estimated by the Gravimetric Method using ovaries preserved in 4% formaldehyte (Erdem, 1988). Also, fecundity was calculated by using Gravimetric Method (Crim and Glebe, 1990).

Statistically significant between growth, condition factor and Gonadosomatic Index (GSI) for the males and females within same age groups were tested by using ANOVA and t-test.

RESULTS AND DISCUSSION

Since, there is no literature containing data on this endemic fish species, researchers have compared the results with other species from the genus *Gobio*. In this study, 541 samples sexes determined, 3 samples sexes which are 0 age group were not determined as shown in Table 1, age group ranged from 0 to VII for male and female; the V age group was most abundant, constituted about 29 and 38% to the total number of female and male, respectively. VII age class was not included in the statistical analyses due to the availability of only one sample. According to Bennet (1970), normally the 0 age class should be found in the population in densely amount due to age increase that lead to the decrease of individuals with nature and fishery. Only 3 individuals were collected within the 0 age group in Melendiz stream. According to Minano *et al*. (2003) research on *Gobio gobio*, 0 and I age classes with small amounts were collected due to the effect of washing produced by drastic and unpredictable flow changes. Similarly, the effect of the upland location of small water reservoirs in the Melendiz stream and the drawing and releasing of water from stream for irrigation which caused drastic flow changes, caused drifting small size individuals.

The overall ratio of females to males was 0.9:1 that is different from 1:1 (Table 1). The ratio of sexes can differ at spawning period. The females usually leave the spawning grounds more rapidly which also may be considered as an adaptation facilitating preservation of the females or more rapid recovery of gonads which results in an increased population (Nikolsky, 1980). The mean Fork Length (FL) and relative growth in length among all age group of females and males are shown in Table 2. The minimum and maximum fork length for female and male were 39.3-145 and 39.1-132.2 mm, respectively. The maximum Relative Growth in Length (RGL) observed in IV age group, the minimum Relative Growth in Length (RGL) observed VI age group. Differences in the relative growth in length between males and females in the same age groups were statistically significant only for age group V ($p<0.05$) (Table 2). Genetically factors, water temperature, food quality and availability and environment may have caused these results. On the other hand, deterioration of feeding habits of fish decreases total growth and lead

Table 1: The age distributions with respect to sex of the *G. gymnostethus*

	Female		Male		Female + Male		
Age	N	N (%)	N	N (%)	N	N (%)	Female:Male ratio
I	5	50.0	5	50.0	10	100	1:1
II	17	68.0	8	32.0	25	100	2.1:1
III	32	50.8	31	49.2	63	100	1:1
IV	38	57.5	28	42.5	66	100	1.4:1
V	160	43.7	206	56.3	366	100	0.7:1
VI	5	50.0	5	50.0	10	100	1:1
VII	1	100.0	0	0.0	1	100	1:0
Total	258	47.8	283	52.2	541	100	0.9:1

Table 2: The mean fork length and relative growth in length among all age group of females and males

		Female F.L±SD			Male F.L±SD				Female+Male	
Age	N	(Min.-Max.)	RGL	N	(Min.-Max.)	RGL	Significiant	N	F.L±SD (Min.-Max.)	RGL
0	-	-	-	-	-	-	-	3	32±1.53 (30-35)	0.22
I	4	39.25±0.25 (39-40)	0.12	6	39.10±0.70 (37-41)	0.16	p>0.05	10	39.2±0.22 (37-41)	0.13
II	17	44.00±0.54 (40-48)	0.18	8	45.50±1.19 (42-51)	0.15	p>0.05	25	44.48±0.14 (40-51)	0.17
III	32	52.00±0.61 (46-58)	0.34	31	52.58±0.58 (47-58)	0.29	p>0.05	63	52.30±0.00 (46-58)	0.32
IV	38	69.89±0.80 (59-76)	0.34	28	68.03±0.95 (59-75)	0.46	p>0.05	66	69.10±0.43 (59-76)	0.40
V	160	93.94±1.12 (75-133)	0.47	206	99.44±1.10 (75-136)	0.32	p<0.05 significant	366	97.04±1.33 (75-136)	0.39
VI	5	138.00±3.66 (131-151)	0.04	5	132.20±3.8 (120-143)		-	10	135.50±3.57 (120-151)	0.07
VII	1	145	-	-	-		-	1	145	-

different sizes of individuals in same age class appear (Nikolsky, 1963). The mean weight and Relative Growth in Weight (RWL) among all age group of females and males were shown in Table 3. The minimum and maximum weight for female and male were 0.75-39.1 and 0.8-32.8, respectively. The maximum relative growth in weight observed in IV age group, the minimum relative growth in weight observed VI age group. Differences in the relative growth in weight between males and females in the same age groups were statistically significant only for age group V (Table 3). This may be because of the reason that the specimens were collected during their spawning season where their gonad weight increases. Normally body weight increases with age because of the accumulation of fat due to low body metabolism (Nikolsky, 1980). The length-weight relationships of G. gymnostethus shown in Fig. 1. As seen Fig. 1, the weight increases faster than the length.

According to Mann's (1980) research on the growth and reproductive strategy *Gobio gobio*, females grow slower than males but attain sexual maturity earlier. But concerning this study, both females and males attained sexual maturity at same age. The Condition factor (Cf) is an index reflecting interactions between biotic and abiotic factors in the physiological condition of fish. It shows the population's welfare during various stages of the life cycle (Angelescu *et al*., 1958).

The condition factor also gives information when comparing two populations living in certain feeding, density, climate and other conditions when determining the period of gonadal maturation and when following up the degree of feeding activity of a species to verify whether it is making good use of its feeding source (Weatherley, 1972). Condition factor increases gradually during the reproductive period and normalization occurs immediately afterwards (Lizama *et al*., 2002). In this study, mean minimum and maximum condition factor for male and female were 0.84-1.87 (V age group) and 0.86 (V age group)-1.85 (IV age group), respectively. One-way ANOVA statistic test which enable determine in the same age group between the sexes whether condition factor value significant or not, showed that there is no significant differences (Table 4). Seasonal variations in condition factors were also determined for both sexes (Table 5). Monthly examination of condition factor showed a generally similar pattern in both sexes with two maxima, one in April 2006 (at the beginning of spawning) and another in June 2006 (in the spawning season). This reflects the state of gonadal development.

Age at spawning was studied in 258 females and 283 males. Females and males matured at 1 year old. The minimum size at first sexual maturity (Lm) was 39 mm for females and 37 mm for males. The 541 samples of *G. gymnostethus*'s gonads were examined to determine GSI values between June (2005) and August (2006) in

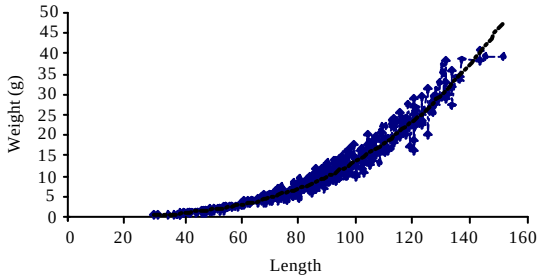

Fig. 1: Length-weight relationship

Table 3: The mean weight and relative growth in weight among all age group of females and males

Age	N	Female W±SD (Min.-Max.)	RWL	N	Male W±SD (Min.-Max.)	RWL	Significiant	N	Female + Male W±SD (Min.-Max.)	RWL
0	-	-	-	-	-	-	-	3	0.47±0.07 (0.40-0.60)	0.7
I	4	0.75±0.02 (0.70-0.90)	0.5	6	0.80±0.04 (0.70-0.90)	0.6	p>0.05 not-significiant	10	0.78±0.03 (0.70-0.90)	0.6
II	17	1.17±0.05 (0.80-1.60)	0.6	8	1.30±0.13 (0.90-2.00)	0.5	p>0.05 not-significiant	25	1.21±0.06 (0.80-2.00)	0.6
III	32	1.84±0.08 (1.00-2.80)	1.6	31	2.02±0.07 (1.20-2.60)	1.1	p>0.05 not-significiant	63	1.93±0.06 (1.00-2.80)	1.3
IV	38	4.61±0.17 (2.60-7.30)	1.7	28	4.29±0.18 (2.50-7.20)	2.3	p>0.05 not-significiant	66	4.48±0.13 (2.50-7.30)	2.0
V	160	12.34±0.53 (3.70-38.10)	1.8	206	14.51±0.51 (4.40-35.70)	1.3	p<0.05 significiant	366	3.57±0.38 (3.70-38.10)	1.5
VI	5	34.66±2.47 (27.10-40.90)	0.1	5	32.80±2.97 (23.20-38.60)	-	-	10	33.75±1.83 (23.20-40.90)	0.1
VII	1	39.1	-	-	-	-	-	1	39.1	-

Table 4: Condition factor (Cf) in terms of age and sexes

	Female		Male			Female + Male	
Age	N	Cf±SD (Min.-Max.)	N	Cf±SD (Min.-Max.)	Significiant test	N	Cf±SD (Min.-Max.)
0	-	-	-	-	-	3.0	1.4±0.05 (1.34-1.48)
I	4.0	1.23±0.03 (1.35-1.18)	6.0	1.32±0.02 (1.28-1.41)	p>0.05 not-significiant	10.0	1.29±0.01 (1.18-1.40)
II	17.0	1.36±0.02 (1.08-1.48)	8.0	1.35±0.05 (1.03-1.51)	p>0.05 not-significiant	25.0	1.35±0.06 (0.97-1.48)
III	32.0	1.28±0.03 (0.88-1.58)	31.0	1.37±0.02 (1.09-1.70)	p>0.05 not-significiant	63.0	1.32±0.01 (0.88-1.69)
IV	38.0	1.33±0.03 (1.03-1.80)	28.0	1.36±0.04 (0.98-1.05)	p>0.05 not-significiant	66.0	1.34±0.01 (0.97-1.85)
V	160.0	1.37±0.01 (0.84-1.87)	206.0	1.36±0.01 (0.86-1.84)	p>0.05 not-significiant	366.0	1.36±0.00 (0.84-1.87)
VI	5.0	1.29±0.06 (1.14-1.45)	5.0	1.40±0.06 (1.28-1.60)	p>0.05 not-significiant	10.0	1.35±0.03 (1.13-1.60)
VII	1.0	1.28±0.00	-	-	-	1.0	1.28±0.00

Table 5: Seasonal variations in condition factor for both sexes

	Female		Male		Female + Male	
Months	N	Cf±SD (Min.-Max.)	N	C±SD (Min.-Max.)	N	Cf±SD (Min.-Max.)
Jul. 2005	19	1.06±0.02 (0.84-1.22)	15	1.09±0.03 (0.86-1.25)	34	1.07±0.02 (0.84-1.25)
Spt. 2005	29	1.23±0.01 (1.11-1.38)	31	1.24±0.02 (1.02-1.40)	60	1.23±0.01 (1.02-1.40)
Oct. 2005	21	1.23±0.03 (0.98-1.48)	27	1.19±0.02 (0.97-1.42)	48	1.21±0.02 (0.97-1.48)
Nov. 2005	58	1.35±0.02 (1.07-1.72)	56	1.37±0.02 (1.03-1.85)	116	1.36±0.01 (1.03-1.85)
Mar. 2006	11	1.12±0.06 (0.88-1.49)	5	1.21±0.02 (1.16-1.26)	16	1.15±0.05 (0.88-1.49)
Apr. 2006	43	1.50±0.03 (0.94-1.80)	36	1.44±0.02 (1.14-1.73)	80	1.47±0.02 (0.94-1.80)
May. 2006	27	1.44±0.03 (1.08-1.80)	23	1.38±0.04 (0.97-1.80)	50	1.41±0.03 (0.97-1.80)
Jun. 2006	26	1.55±0.03 (1.13-1.87)	48	1.53±0.02 (1.10-1.84)	74	1.54±0.02 (1.10-1.87)
Jul. 2006	11	1.54±0.03 (1.41-1.69)	21	1.46±0.02 (1.30-1.67)	32	1.49±0.02 (1.30-1.69)
Agu. 2006	12	1.28±0.03 (0.96-1.41)	22	1.32±0.02 (1.09-1.62)	34	1.31±0.02 (0.96-1.02)

Table 6: Seasonal variations in GSI for both sexes

	Female		Male	
Months	N	GSI±SD (Min.-Max.)	N	GSI±SD (Min.-Max.)
Jul. 2005	19	1.91±0.40 (0.16-6.20)	11	0.67±0.17 (0.14-2.04)
Spt. 2005	29	0.77±0.10 (0.13-2.21)	31	0.22±0.03 (0.05-0.59)
Oct. 2005	21	0.8±0.20 (0.2-5.69)	27	0.17±0.02 (0.05-0.38)
Nov. 2005	58	1.43±0.16 (0.17-4.88)	56	0.49±0.05 (0.07-1.43)
Mar. 2006	11	3.05±0.1 (0.91-6.25)	5	0.53±0.1 (0.21-0.74)
Apr. 2006	43	6.46±1.70 (4.34-16.98)	36	1.06±0.12 (0.13-2.94)
May. 2006	27	10.81±1.3 (0.43-22.29)	23	1.44±0.29 (0.13-5.26)
Jun. 2006	26	6.74±1.20 (0.31-20.66)	48	1.03±0.07 (0.09-2.78)
Jul. 2006	11	6.29±1.08 (2.08-15.49)	21	1.17±0.23 (0.34-5.00)
Agu. 2006	12	1.78±0.24 (0.38-2.68)	22	0.50±0.04 (0.13-0.86)

Table 7: GSI in terms of age and sexes

	Female		Male			Female + Male	
Age	N	GSI±SD (Min.-Max.)	N	GSI±SD (Min.-Max.)	Sinificiant test	N	GSI±SD (Min.-Max.)
I	4	1.30±0.05 (1.25-1.43)	6	1.26±0.07 (1.11-1.43)		10	1.2±0.03 (1.11-1.43)
II	17	0.80±0.04 (0.63-1.25)	8	1.32±0.50 (0.5-5.00)		25	1.02±0.60 (0.5-5.00)
III	32	0.86±0.19 (0.36-4.76)	31	0.79±0.17 (0.38-5.26)	p>0.05 not-significiant	63	0.85±0.04 (0.35-5.26)
IV	38	2.98±0.47 (0.19-11.5)	28	0.45±0.12 (0.14-2.78)	p>0.05 not-significiant	66	1.92±0.60 (0.13-11.4)
V	160	5.54±0.45 (0.13-22.3)	206	0.70±0.04 (0.05-4.97)	p>0.05 significiant	366	2.82±0.17 (0.05-22.2)
VI	5	5.16±2.2 (0.51-11.9)	5	0.53±0.17 (0.17-1.04)	-	10	2.85±0.26 (0.17-11.9)
VII	1	0.13±0.00	-	-	-	1	(0.17-11.9) 0.13±0.00

Melendiz stream. The monthly GSI values of females of *G. gymnostethus* were usually higher than those of males. The highest values of GSI in both sex occurred between April and July with a peak in May for females and males (Table 6). It's found that GSI increases with age. GSI values differences between females and males were statistically significant at V age group (Table 7). This can be due to gonadal development. Gonadal development may be related to some factors such as feeding, temperature and light quantity (Nikolsky, 1963).

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G. gymnostethus population females eggs diameter increased correspond with GSI. The maximum egg diameters were recorded in May 2006, June 2006 and July 2005 with 0.73, 0.74 and 0.76 mm, respectively. To determine fecundity, 70 female gonads eggs were counted. The mean numbers of eggs in ovaries were directly increased with fork length and age. Although, the mean eggs number was found as 952 for IV age group (mean fork length 73 mm), 5310 for VI age group (mean fork length 137 mm). Similarity it's found that eggs number was increased with weight.

CONCLUSION

G. gymnostethus which is an endemic species has a very restricted distribution. Water pollution and inadvisable water policy can cause the extinction of this species. On the other hand, Konya Closed basin has sheltered a good many endemic species. This basin is affected by global warming and some of the water sources had already get dried. For this reason, to take national and international protection law, the biology, ecology, habitat

structure of endemic species should be determined. Also, *G. gymnostethus* and the other endemic species should be urgently taken protection status in Red List before the loss of valuable species.

ACKNOWLEDGEMENTS

The researchers wish to thank Prof. Dr. Fusun Erkakan, Dr. S. Cevher Azeren, Dr. Ali Celal Hos and the technician Ibrahim Aslan for their great helps in the field studies. This research was supported by Tubitak-The Basic Sciences Research Group (TBAG), (Research Grant No.: T07140315).

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