Population structure, growth and reproduction of leaping grey mullet (*Liza saliens* Risso, 1810) in Beymelek Lagoon, Turkey

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Abstract

Population structure, growth, length-weight relationship and reproduction characteristics of leaping grey mullet (*Liza saliens* (Risso, 1810) were investigated in Beymelek Lagoon from February 2006 to January 2007. During the study, a total of 1248 leaping grey mullet were captured by gill- and trammel nets of various mesh sizes. Male to female ratio for leaping grey mullet population in Beymelek Lagoon was 1:2.71. The ages ranged from 1 to 4 years for males and from 0 to 5 years for females. The growth parameters of the von Bertalanffy equation were: L_∞ = 35.2 cm, K = 0.276 year^{-1} and t_0 = -2.893 year for males, L_∞ = 35.9 cm, K = 0.386 year^{-1} and t_0 = -1.760 year for females and L_∞ = 39.9 cm, K = 0.271 year^{-1} and t_0 = -2.233 year for all individuals. The calculated length-weight equations were W = 0.0061*$L^{3.124}$ for males, W = 0.0060*$L^{3.124}$ for females and W = 0.0099* $L^{2.954}$ for all individuals. The slope (b) values of the length-weight relationship showed that weight of leaping grey mullet in Beymelek Lagoon increased with length in isometric. The mean condition factor for males, females and all specimens were determined as 0.908, 0.900 and 0.897, respectively. According to sex groups, the mean condition factor of males was slightly higher than that of females. The total length at 50% maturity for female leaping grey mullet was determined as 23.3 cm. It was assumed that spawning period for this species was from May to July.

Key words: *Liza saliens*, Population structure, Growth, Reproduction, Beymelek Lagoon

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Introduction

Leaping grey mullet (*Liza saliens* Risso, 1810) is a catadromous species found in various habitats, from shallow brackish and marine waters to lagoons, estuaries and river deltas. It is also widespread in Mediterranean estuaries (Ben Tuvia, 1986).

Leaping grey mullet reproduce at sea, after which fry undertake a trophic migration shoreward to continue their development and enters lagoons, estuarine systems, rivers. It, locally named "kastros", is a mugilid species for commercial fisheries in Beymelek Lagoon. There are many coastal lagoons in Turkey and it is known that leaping grey mullet live in most of them. However, few studies was conducted on biological and population characteristics of leaping grey mullet in Turkish lagoons (Buhan, 1998; Akyol, 1999; Hoşsucu, 2001a, b). There was no study on biologic characteristics and population structure of this species in Beymelek Lagoon. Whereas, biological characteristics and population structure of fish species entering into the lagoons are very important for fisheries management in these habitats.

Estuarine fish are mainly euryhaline that are able to exist in unstable condition such as variable salinities, currents, and food supplies (Koutrakis et al., 2000). Fish populations and their some biological characteristic in these habitats may change season by season and year by year. Our study investigates aspects of the biology of leaping grey mullet in Beymelek Lagoon including age, growth, sexual maturity and spawning period, which may be used to develop a management strategy for the species.

Materials and methods

Beymelek Lagoon is situated in the west coast of Mediterranean in Turkey (30° 04' E, 36° 16' N), has about 255 hectares surface area. Mean temperature and salinity during our study were measured. Fishes were collected monthly at the three different localities of Beymelek Lagoon (Figure 1) from February 2006 to January 2007, using gillnets of mesh sizes (stretched mesh) of 40, 44 and 50 mm and trammel nets of mesh sizes (stretched mesh of inner wall) of 56, 60, 70 and 80 mm. Each of the nets had a length of 100 m. All nets fastened and deployed in circle between 20:00 and 01:00 hours, using small boat in each sampling site.During the study, a total of 1248 leaping grey mullet were collected. Each fish was measured to the nearest millimeter [Total length (L)], and weighted to the nearest gram [Total weight (W)]. Scales were sampled from each specimen for age determination. The sexes of 386 specimens were recorded by macroscopic examination of their gonads. Fish were assigned a maturity stage based on macroscopic examination of gonads. Ovaries of female specimens were removed from fish and weighed (W_G) to 0.01 g. The stages of maturation were classified as follows: stage 1: immature; stage 2: developing; stage 3: ripe; stage 4: spawning; stage 5: spent (King, 1995). In addition, during the sampling the surface water temperature was measured at each sampling sit.

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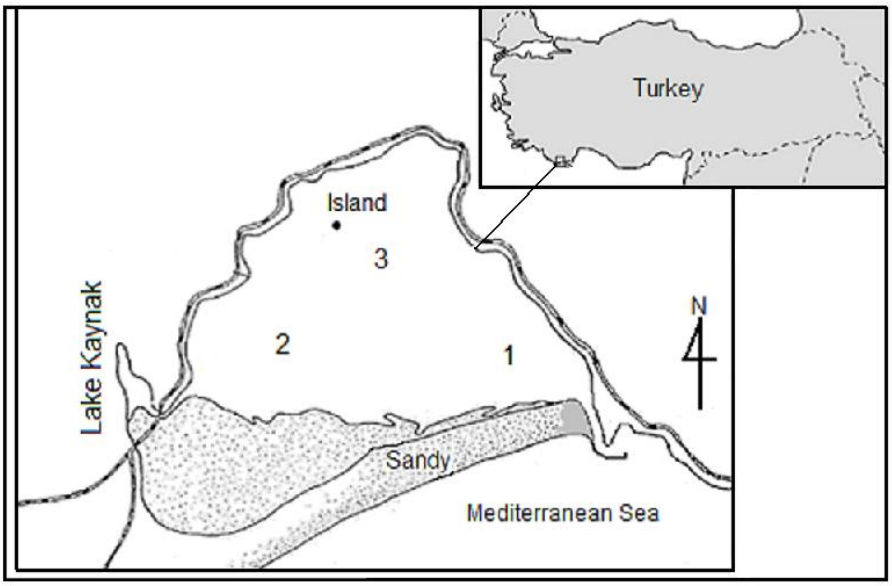

Figure 1: Map of Beymelek Lagoon showing sampling stations.

The age was determined by scale reading (Lagler, 1966). Firstly scales were soaked in 4% KOH solution for 24 hours, then they were rinsed with distilled water and subsequently put in 96% alcohol for 15-20 minutes. Scale reading was made using a binocular microscope under reflected light at 10-25x magnification. Scales of each fish were read three times by the authors, and reading for a given fish scales was accepted only when two readings agreed.

The von Bertalanffy growth parameters were estimated by the least squares method for length observed at each age (Pauly, 1984; Sparre and Venema, 1998; Avşar, 1998): $L_t = L_\infty*(1-e^{-K(t-t0)})$ where L_t = the total length (cm), L_∞ = the asymptotic length, K = the growth coefficient,

t = the age (years), and t_0 = the age at zero length. The von Bertalanffy growth parameters were estimated for males, females and all specimens. To compare the growth parameters obtained in this study with those reported by other authors for the same species, the growth performance index (Φ) was used (Munro and Pauly, 1983): This index has the form: Φ = Ln (K) + 2*Ln (L_∞); where K is the growth coefficient, and L_∞ is the asymptotic length. The relationship between total length and total weight was calculated separately for each sex with $\log_{10}$-transformed data (Le Cren, 1951). The condition factors were determined by using the formula $(W/L^3)*100$ (Ricker, 1975).In order to determine the length at first maturity (the length at which 50% of the fish had become mature) only individuals collected during the spawning period were used. A logistic curve was fitted to the proportion of sexually mature individuals by length and the parameters were estimated using a least square method applied to a non-linear fit (King, 1995). The function used is below:

$P_L=100/[1 + e^{-r(L-Lm)}]$, where P_L is percentage mature at length L, and a and r (b) are regression parameters. The mean length at 50% maturity was calculated by L_m = -a/b.

The reproductive period was determined by analyzing the monthly variation in the

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gonadosomatic index [GSI = (W_G / W)*100] where W_G is weight of gonad in g and W is weight of fish. Correlation between GSI and temperature was tested using the Spearman rank correlation coefficient (r_s) (Zar, 1999).

Results

A total of 1248 leaping grey mullet were investigated, but the sexes of only 386 individuals were determined. Among the sexed specimens, 104 were males, 282 females. Male to female ratio was 1:2.71, and χ^2-test revealed that this ratio was significantly different from the theoretical 1:1 sex ratio (P<0.05). The sexes of the remaining 862 (69.1%) individuals were not identified or could not be identified macroscopically because they were immature and very thin and translucent gonads.The ages ranged from 1 to 4 years for males and from 0 to 5 years for females. Their age-length-keys were given in Table 1. It was shown from Table 1 that most fish were in the age 1 for males and in the age 2 for females. about 96% of the male specimens were in the age 1 and 2 while 77.7% for females in the same ages. The number of fish decreased with increasing age. only 2.9% of 3 aged individuals was males while 16.7% was recorded for females.

Length-weight relationship

The total length and total weight ranged from 20 to 33.3 cm and from 68 to 374 g for males, from 19 to 33.5 cm and from 59 to 398 g for females, and from 16.6 to 35.5 cm and from 40 to 415 g for all individuals. The males were predominant in the smaller lengths and females in the larger lengths (Table 1). Difference between male and female in the length-frequency distribution was statistically significant (Mann-Whitney test; P<0.05). Also, length distribution of all specimens were significantly different (Mann-Whitney test; P<0.05) from sex groups.

Length-weight regression was calculated separately for males, females and all individuals. The calculated length-weight equations were $W = 0.0061*L^{3.124}$ for males, $W = 0.0060*L^{3.124}$ for females and $W = 0.0099*L^{2.954}$ for all specimens (Figure 2). The slopes (b) of the length-weight regressions did not differ significantly between the sexes (t-test; P>0.05). In addition, the b values for both males and females were not statistically different from 3 (t-test; P>0.05). Length-weight regression was calculated separately for males, females and all individuals. The calculated length-weight equations were $W = 0.0061*L^{3.124}$ for males, $W = 0.0060*L^{3.124}$ for females and $W = 0.0099*L^{2.954}$ for all specimens (Figure 2). The slopes (b) of the length-weight regressions did not differ significantly between the sexes (t-test; P>0.05). In addition, the b values for both males and females were not statistically different from 3 (t-test; P>0.05).

Condition factor

The mean condition factor of total population of leaping grey mullet in Beymelek Lagoon was determined as 0.897. According to sex groups, the mean condition factor of males (CF = 0.908) was slightly higher than that of females (CF = 0.900). However, difference between sexes was not statistically significant (t-test; P>0.05). As seen in Figure 3, conditions of both sexes increased gradually with increasing age.

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Table 1: Age-length-keys of males, females and all samples (male, female, immature and others) of leaping grey mullet in Beymelek Lagoon

	Males				Females						All samples					
L (cm)	1	2	3	4	0	1	2	3	4	5	0	1	2	3	4	5
16											1					
17											1					
18											2	1				
19					3						9	12				
20	1				4	1					8	37				
21	7	1			2	4					4	71	2			
22	10	2			1	14	1				2	139	7			
23	21	0				22	2					151	12	2		
24	11	6				29	4					147	24			
25	8	6				17	13					92	47	2		
26	4	9				9	27	1				32	86	1		
27	1	8	1			4	27	0				14	78	3		
28		4	1			1	18	5				6	57	11		
29		1	1				14	4	1			3	41	14	1	
30							8	10				2	22	22		
31						1	2	8				1	10	18	3	
32							1	11	2				3	19	5	
33				1				8	2	1				11	6	1
34														1	2	
35														2		
N	63	37	3	1	10	102	117	47	5	1	27	708	389	106	17	1
$\bar{L}$	23.6	26.1	28.3	33.3	20.4	24.3	27.4	31.2	32.2	33.0	19.9	23.5	27.2	30.6	32.6	33.0
SD	1.6	1.8	0.8	-	1.0	1.7	1.8	1.8	1.6	-	1.4	1.8	2.0	2.2	1.2	-
Min.	20.0	21.8	27.6	33.3	19.0	20.8	22.7	26.7	29.6	-	16.6	18.9	21.8	23.5	29.6	33.0
Max.	27.0	29.4	29.2	33.3	22.2	31.5	32.1	35.5	33.9	-	22.2	31.5	32.3	35.5	34.6	33.0

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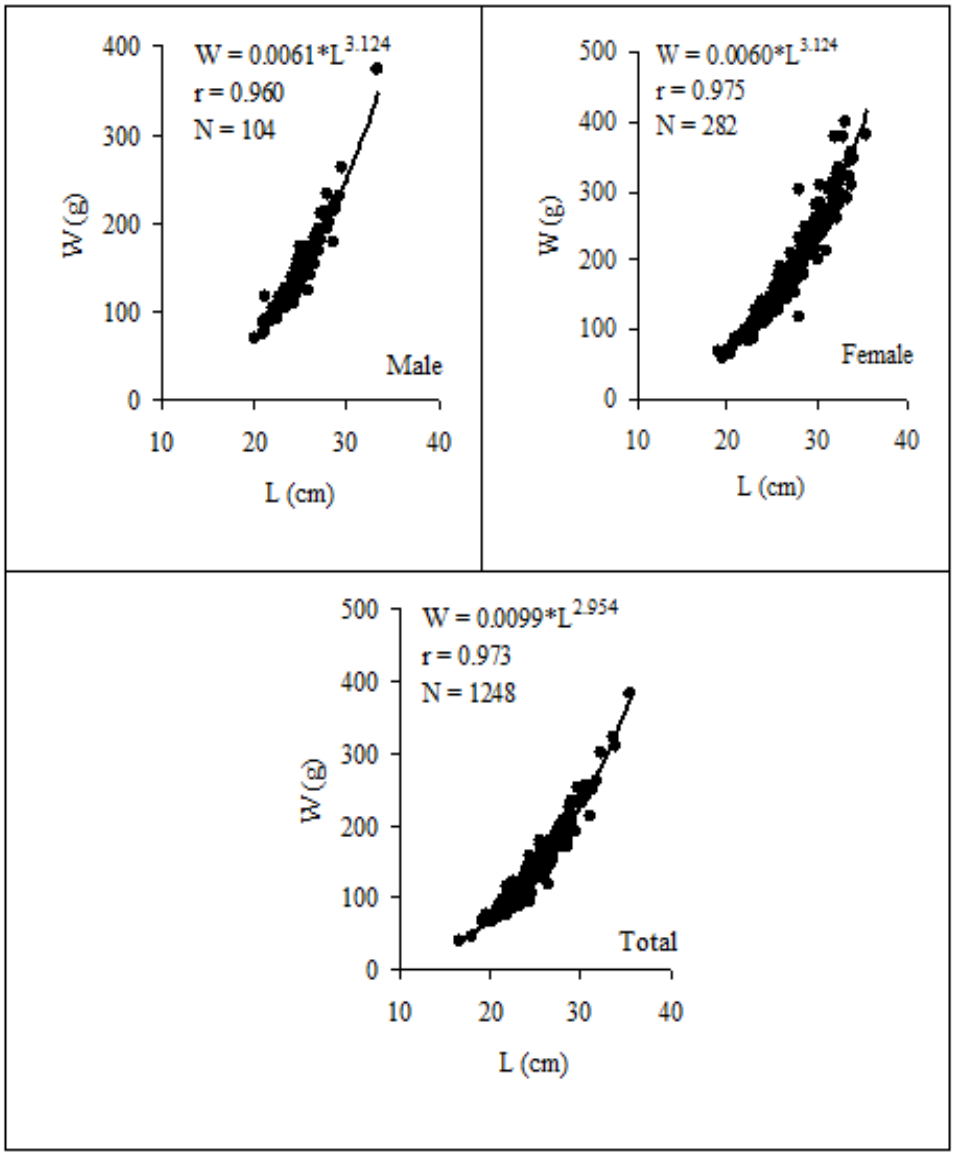

Figure 2: Length-weight relationships for males, females and all specimens of leaping grey mullet in Beymelek Lagoon

The length at first maturity

The length of the smallest female leaping grey mullet was 19 cm and their total length at 50% maturity was determined as 23.3 cm. Thereafter, percentages of mature fish for different lengths were calculated using the formula $P_L = 100/[1+e^{-0.761*(L - 23.3)}]$ and then the maturity ogive was drawn from these values as seen Figure 4

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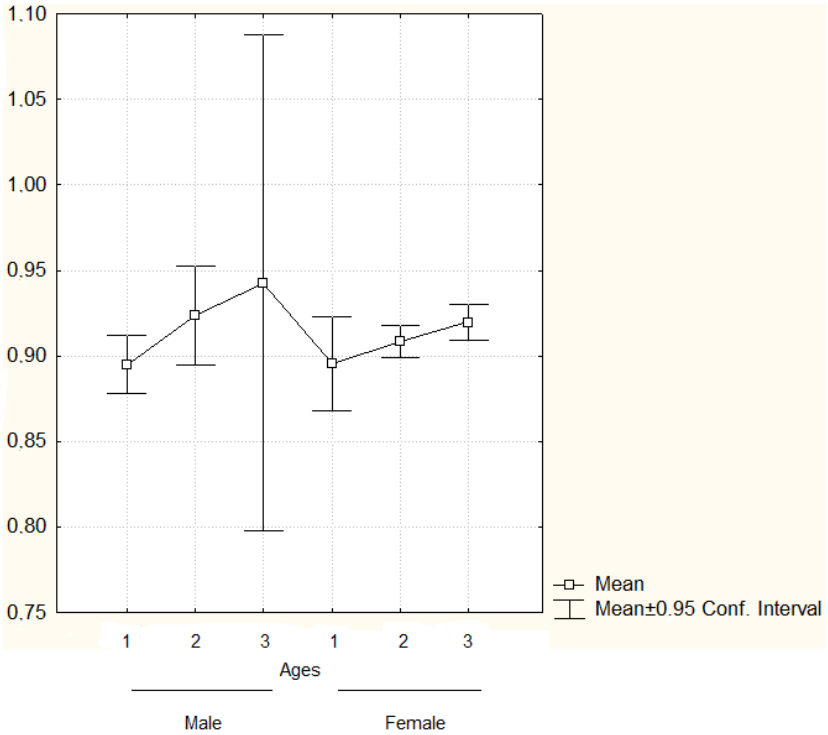

Figure 3: Trend in the mean condition factor according to age and sex of leaping grey mullet in Beymelek Lagoon from February 2006 to January 2007

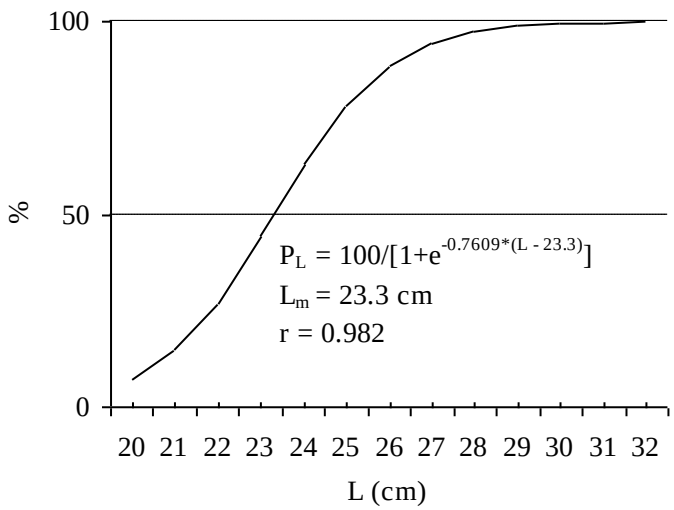

Figure 4: Maturity ogive of female leaping grey mullet in Beymelek Lagoon

Spawning season

The GSI increased gradually until April and reached a maximum value in May (27.1 ºC). As seen in Figure 5, it decreased sharply from May to July. This trend of the GSI values showed that this species spawned from May to July. In addition, a weak positive correlation was found between mean GSI values and surface water temperatures (r_s = 0.276, *n*=11, P=0.386).

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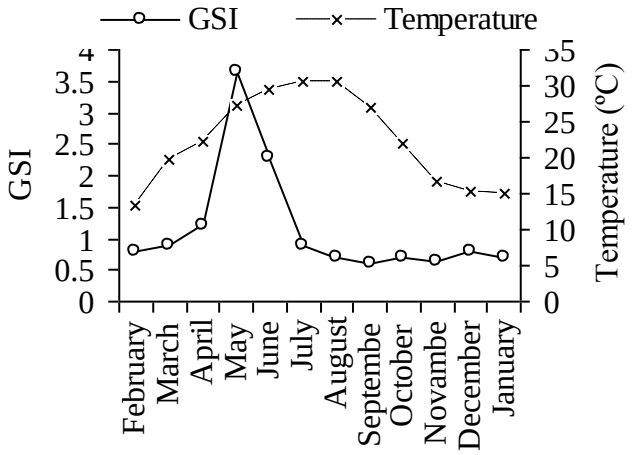

Figure 5: Monthly variation of the GSI values for female leaping grey mullet and water temperature in Beymelek Lagoon

Discussion

Male to female ratio of leaping grey mullet population in Beymelek Lagoon (males to females, 1:2.71) was significantly different from the 1:1 ratio expected for most fish species (Bagenal 1978). The sex ratio was also in favour of females for the same species in Köyceğiz Lagoon [male to female; 1:1.16 (Buhan, 1998)], in Güllük Lagoon [male to female; 1:4.29 (Egemen et al., 1995)] and in Gorgan Bay-Miankaleh Wildlife Refuge (Patimar, 2008). On the other hand, Katselis et al. (2002) reported that the overall ratio of males to females was 1:0.8 for the same species in Messolonghi Etoliko lagoon. Although the sex ratio in most of the species was close to 1, this may vary from species to species, differing from one population to another population of the same species, and may vary year after year within the same population. At early life stages the ratio of males is higher, but at later stages the female ratio is higher (Nikolsky, 1963). Individuals older than three years were rarely represented in the lagoon (oldest fish 5 years). The most abundant age in the catches was 1 years and ninety percent of all specimens were in the 0, 1 and 2 years old. Hoşsucu (2001b), Katselis et al. (2002) and Patimar (2008) reported higher maximum ages than those found in our study. Apparently the age structure is within the range known in other water bodies, although Neophitou (1993) pointed out that the maximum life span of Tench is especially affected by water temperature, fishing effort and a number of ecological conditions.

The slope (b) values of the length-weight relationship showed that growth were isometric for males, females and all specimens. This agreed with the study results of Buhan (1998), Egemen et al. (1999) and Hoşsucu (2001a) from other Turkish lagoons. On the other hand, the slightly higher or similar b values were

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reported by Akyol (1999) in Homa Lagoon (b=3.124), Koutrakis and Tsikliras (2003) in Strymon estuary (b=2.984), Verdiell-Cubedo et al. (2006) in the Mar Menor coastal lagoon (Spain) (b=3.041), Patimar (2008) in Gorgan Bay-Miankaleh Wildlife Refuge (b=2.478 for males and b=2.545 for females) and Katselis et al. (2002) in Messolonghi Etoliko lagoon (b=3.01). Variations can be attributed to many environmental conditions and some biological characteristics of fish populations. In addition, the b values in fish differ according to species, sex, age, seasons and feeding (Ricker, 1975; Bagenal and Tesch, 1978).

The asymptotic length (L_∞ = 39.9 cm) was found similar to values estimated by Buhan (1998), but higher than those estimated by Cardona (1999), Katselis et al. (2002) and Patimar (2008). While the growth coefficient (K =0.271) was similar to values reported by Cardona (1999), Katselis et al. (2002) and Patimar (2008), lower than that of value reported by Buhan (1998). The results of all studies showed that the values L_∞ and K for this species that inhabit various Mediterranean localities fluctuate between 30 and 40 cm and 0.2 and 0.5 year^{-1}, respectively. It is known that lagoons are highly productive systems (Kapetsky, 1984; Labourg et al., 1985). Kjerfve (1994) pointed that lagoons often exhibit very high primary and secondary production rates and are valuable for fisheries. Compared to populations in Köyceğiz Lagoon (Buhan, 1998), Grau Lagoon (Cardona, 1999) and Gorgan Bay-Miankaleh Wildlife Refuge (Patimar, 2008), leaping grey mullet in Beymelek Lagoon (Φ' = 6.067) grow faster than population in Garu Lagoon (Φ'=5.720 male and Φ'=5.702 female) and Gorgan Bay-Miankaleh Wildlife Refuge (Φ'=5.539 male and Φ'=5.545 female), similar to population in Köyceğiz Lagoon (Φ'= 6.199). The variation in growth performance could be caused by different results obtained in age readings by the different researchers; however, it is possible that the variations in population parameters of fish species represent epigenetic responses such as temperature, food; geographic location and nutrient levels also probably varied by study area. In addition, growth of leaping grey mullet is affected by the temperature and food availability.

Because, feeding of this species is connected to primary productivity as these fish feed mainly on algae and diatoms, though they consume zooplankton and zoobenthos as well (Brusle, 1981). Temperatures ranged from 13.4 ºC (February) to 30.5ºC (July and August) in Beymelek Lagoon and were higher than 15 ºC (except for February) during a year. Annual mean water temperature was determined as 22.4 ºC. This value is very high for sea and oceanic areas. Although high temperatures can encourage growth, temperatures above a certain limit will stress fish and may also be associated with low oxygen levels (Emre et al., 2010).The mean condition factor of leaping grey mullet population in Beymelek Lagoon was slightly higher than that of the population in Köyceğiz Lagoon (Buhan, 1998), but lower than that of the population in Gorgan Bay-Miankaleh Wildlife Refuge (Patimar, 2008). Egemen et al. (1999) reported that condition factor of this species in Güllük Lagoon ranged from 0.75 to 0.94. Differences may largely

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be attributed to feeding opportunities. Although condition factors of female individuals in most fish of populations were higher than males, the mean condition factor of males (CF = 0.908) in leaping grey mullet population in Beymelek Lagoon was slightly higher than that of females (CF = 0.900). First sexual maturity length of female leaping grey mullet ($L_{m(50\%)}$ = 23.3 cm) was lower than that of Köyceğiz Lagoon (between 27 and 29 cm) (Buhan, 1998), but higher than that of Grau Lagoon (about 16-17 cm total lengths) (Cardona, 1999). Spawning period for this species (May and June) was similar to Köyceğiz Lagoon (June) (Buhan, 1998), Gorgan Bay-Miankaleh Wildlife Refuge (from May to July) (Patimar, 2008) and İzmir Bay (June) (Akyol, 1999), but earlier than Güllük Lagoon (July) (Egemen et al., 1999; Hoşsucu, 2001b) and Jand Grau Lagoon (August) (Cardona, 1999). This difference may attribute especially to environmental factors. According to Wootton (1990), temperature appears to be the most important factor among those that may influence the reproduction of fishes.

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