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Age, Growth, and Sex Ratio of Golden Grey Mullet, *Liza aurata* (Risso, 1810) in Homa Lagoon (İzmir Bay, Aegean Sea)

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Abstract: In this study, age, growth, and sex ratio of 342 golden grey mullets, which were caught in fish traps during fishing season were determined. The samples were between 7.5 and 39.5 cm in length and were between < 1 and 4 years old. The length-weight relationship for this population was calculated as $W = 0.01*L^{2.93}$, $L_\infty = 43.2$ cm, $K = 0.33$ yr^{-1}, and $t_o = -0.30$ yr. The male:female ratio of the population was 1:1.87 and first maturity was at the age of one year for both sexes.

Key Words: Grey mullet (*Liza aurata*), Homa Lagoon, age, growth, sex ratio

Homa Dalyanı'nda (İzmir Körfezi, Ege Denizi) Altınbaş Kefal'in *Liza aurata* (Risso, 1810) Yaş, Büyüme ve Eşey Oranı

Özet: Çalışmada, dalyanın üretim sezonu içinde kuzuluklardan avlanmış 342 bireyden faydalanılarak türün; yaş, büyüme ve eşey oranları saptanmıştır. Örneklerin, 7.5–39.5 cm total boya sahip 0–IV'üncü yaştaki bireylerden oluştuğu belirlenmiştir. Populasyon için boy–ağırlık ilişkisi $W=0.01*L^{2.93}$, $L_\infty=43.2$ cm, $K=0.33$ yıl^{-1} ve $t_o=-0.30$ yıl olarak, erkek:dişi oranı 1:1.87 ve ilk eşeysel olgunluk yaşı her iki eşey için birinci yaş olarak saptanmıştır.

Anahtar Sözcükler: Altınbaş Kefal (*Liza aurata*), Homa Dalyanı, Yaş, Büyüme, Eşey oranı

Introduction

Homa Lagoon is one of the 10 most productive lagoons in the Aegean Sea and it is the third largest, with an 1,800 ha fishing area. The Lagoon's gates are closed between June and December and fishing occurs in this period. Annual fishing production is about 25 tons and commercially valuable fish species such as grey mullets (*Mugil cephalus*, *Liza ramada*, *Liza saliens*, and *Liza aurata*), gilt-head sea bream (*Sparus aurata*), eel (*Anguilla anguilla*), European sea bass (*Dicentrarchus labrax*), and common sole (*Solea solea*) are caught. In the lagoon, fishing methods include fish traps, strawed trammel nets for grey mullet, and trammel nets; but the bulk of the fishing is performed using fish traps (Elbek et al., 2003).

Golden grey mullet, usually lives inshore, enters lagoons and estuaries, and rarely moves into freshwater. Additionally, it is widely distributed in the Mediterranean Sea and Black Sea, Atlantic coasts from the Azores and Madeira northward to the British Isles, and the southern coasts of Norway and Sweden. However, it is not found in the Baltic Sea (Ben-Tuiva et al., 1986).

L. aurata is one of the target fish species of commercial fishing along Aegean coasts. The process of an intensive study for breeding of this species was reported by Tang (1975) and Chervinski (1975a, 1975b, 1976). Occurrence and distribution of golden grey mullet fry in the rivers of Israel has been reported (Bograd, 1961). The distribution of golden grey mullet along the western and eastern coasts of the Adriatic Sea was reported (Villani, 1988; Morovic, 1960; Katavic, 1980; Kraljevic and Jug–Dujakovic, 1988). Cambrony (1984) published the same information about juvenile golden grey mullet in lagoons of Roussillon (French Mediterranean coast). The data related to the age and

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growth of this species of the Marsala Lagoon were presented (Andaloro, 1983), and growth parameters from several brackish water lagoons were studied in Languedoc and Roussillon. Kraljevic and Dulcic (1996) analysed age, growth, length-weight relationship, and mortality of *L. aurata* in Mirna Bay (eastern Adriatic). Hotos et al. (2000) reported reproduction biology of golden grey mullet in the lagoon of Klisova (Messolonghi, western Greece).

The aim of the present study was to describe data on age, growth, and sex ratio of golden grey mullet from Homa Lagoon, located in İzmir Bay (lat 38°31'10''N, long 26°49'50''E) (Figure 1). This area is approximately 1,824 ha.

Materials and Methods

The study population included 342 fish collected from fish traps in the lagoon. Fish were measured in the natural body position for total length (TL) to the nearest mm and weighed (W, wet weight) to the nearest g, and sex determination was performed by macroscopic observation. Age was determined by reading scale rings under a stereoscopic zoom microscope at 100x magnification. Ages were assigned on the basis of formed annular counts. From each specimen, scales were removed from the second row of scales just under the front edge of the first dorsal fin on each side of the body, and the scales were cleaned in 5% sodium peroxide.

The commonly used length-weight relationship was applied (Ricker, 1975): , where W is the weight (g), L is the total length (cm), and a and b are constants. We used the von Bertalanffy growth equation to estimate L_∞, K, and t_0 growth parameters ($Lt = L_\infty * (1-e^{-K(t-t_0)})$). The software program SPSS 8.0 was used to estimate the length-weight relationship and growth parameters. The difference in total length-weight relationship between sexes was tested by ANCOVA, and the hypothesis of isometric growth (Ricker, 1975) by t-Test. Growth performance was analyzed by the index (Phi Prime Test) (Munro and Pauly, 1983; Pauly and Munro, 1984), $\Phi' = \ln(k) + 2\ln(L_\infty)$.

Results

Length-Weight Relationship

The total length of fishes ranged from 7.5 to 39.5 cm and weight ranged from 6 to 500 g (Figure 2). Length-weight regression was calculated separately for males, females, immature, and all fishes (Table 1). The calculated length-weight equation was $W = 0.01*L^{2.93}$

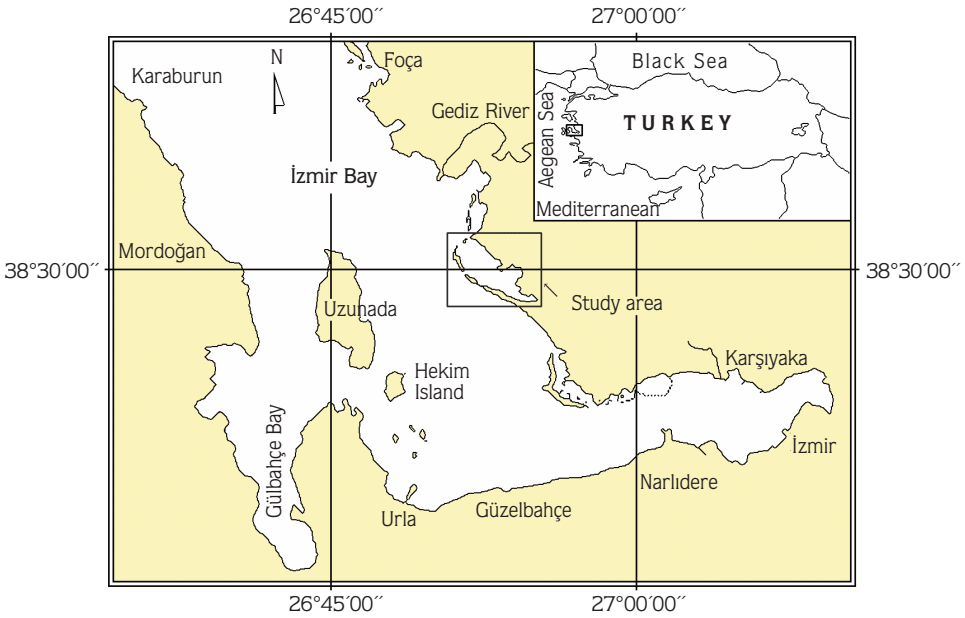

Figure 1. Study area.

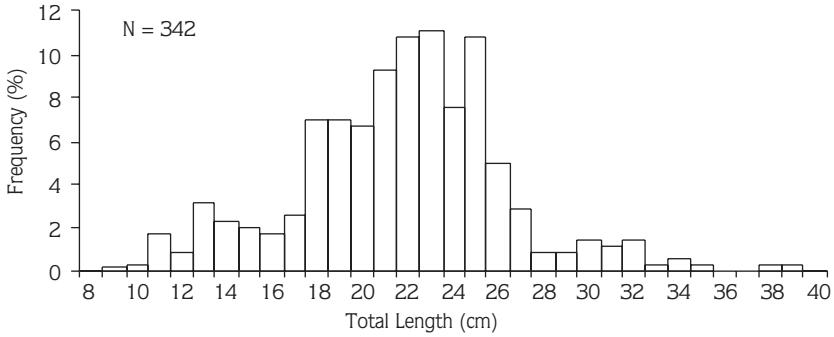

Figure 2. Length-frequency distribution for golden grey mullet in Homa Lagoon.

Table 1. Parameters of the regression ($W = a*L^b$) between total length (LT, cm) and total weight (W, g) for golden grey mullet (males, females, and immature) (S_x: Standard Error of b).

Sex	a	b	Sx	n	r
Males	0.1278	2.7856	0.0412	99	0.8920
Females	0.1152	2.9426	0.0356	186	0.9297
Immatures	0.0197	2.7875	0.0318	57	0.8957
Sexes combined	0.0111	2.9299	0.0586	342	0.9614

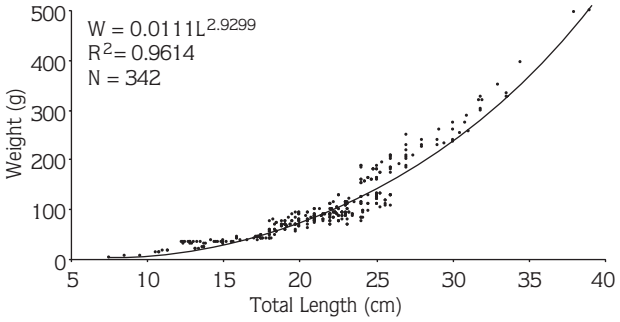

Figure 3. Length-weight relationship for the golden grey mullet from Homa Lagoon.

(R^2 = 0.96) (Figure 3). The slopes (b values) of the length-weight relationship, which differed significantly between sexes (ANCOVA, $P < 0.05$), indicated a negative allometric growth for males (b = 2.79) and females (b = 2.94). While a significant difference was found in the b values of males, such a difference wasn't determined in the females or the sexes combined (2.93) (SPSS 8.0, t-test, $P > 0.05$).

Age and Growth

The results of total length and weight recorded for each age are given in Table 2. The mean lengths of fish assigned to each age group were used to fit the von Bertalanffy growth model (Figure 4). Growth parameters in length for the von Bertalanffy equation were estimated as: L_∞ = 43.2 cm (S_x = 13.54), K = 0.33 yr^{-1} (S_x = 0.042) and t_o = –0.30 yr (S_x = 0.126), yielding $LT = 43.29(1-e^{-0.33(t-(-0.30))})$ R^2 = 0.7244.

Sex Ratio

Of all the fish examined, 57 were immature, 99 were male, and 186 were female. The sex ratio was 1:1.87 in favour of females. First maturity occurred at one year of age for both sexes. Number of fish related to the sex for each age group, mean length, weight, and standard error are given in Table 3.

Discussion

The aim of the present study was to describe data on age, growth, and sex ratio of golden grey mullet from Homa Lagoon. The exponents of the length-weight relationship (males: b = 2.79; females: b = 2.94; immature: b = 2.79; sex combined: b = 2.93) of golden

Table 2. Total length at each age and weight at each age of golden grey mullet from Homa Lagoon.

Age	n	LT (min)	LT (max)	W ($\bar{X} \pm S\bar{x}$)	LT ($\bar{X} \pm S\bar{x}$)
< 1	57	7.5	18.7	32.89 ± 4.35	12.19 ± 4.05
1	211	16.6	26.4	90.20 ± 6.20	21.06 ± 3.45
2	59	22.1	30.8	184.44 ± 24.0	26.99 ± 5.51
3	13	29.8	35.2	317.30 ± 88.0	32.66 ± 9.06
4	2	39.4	39.5	497.5 ± 2.5	39.45 ± 0.05

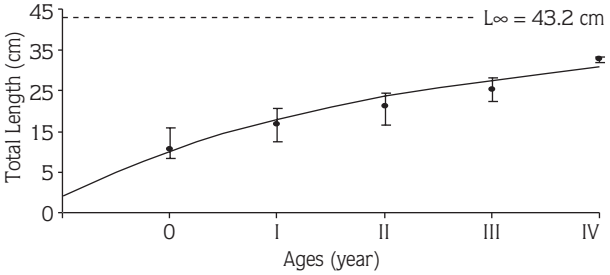

Figure 4. von Bertalanffy growth curve of golden grey mullet.

grey mullet were estimated in Homa Lagoon and showed isometric growth. The value of b in this study is the same as in the Dulcic and Kraljevic (1996) study.

von Bertalanffy growth parameters in length of golden grey mullet revealed a high variability (R^2 = 0.7244) and L_∞ value was estimated as 43.2 cm. This value is similar to golden grey mullet from Mirna Bay (north Adriatic) (Kraljevic and Dulcic, 1996) and the Gulf of Marseilles (Albertini–Berhaut, 1978). The asymptotic length was L_∞ = 43.2 cm in Homa Lagoon, which is less than reported in other researchers' investigations. Overall growth performance Φ' was 11.0. This value is higher than the 10.6 (Albertini–Berhaut, 1978), 10.5 (Andaloro, 1983), 10.9 (Arruda et al, 1991), and 10.4 (Kaaljevic and Dulcic, 1996) previously reported (Table 4). These variations 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 golden grey mullet represent epigenetic responses to the different environmental conditions (temperature, food, geographic location), and nutrient levels also probably different vary by study area (Table 4).

In this study, the estimated asymptotic length for golden grey mullet was 43.2 cm. This value is slightly lower than the asymptotic length value of 45.0 cm reported by Albertini-Berhaut (1978), but slightly higher than the asymptotic length value of 41.8 cm reported by Kraljevic and Dulcic (1996). The growth coefficient values showed that golden grey mullet in Marsala Lagoon (K = 0.63 yr^{-1}) approached asymptotic length faster than in any other area. Although the K value is the same as Krka estuary (middle Adriatic) (K = 0.30 yr^{-1}) reported by Modrusan et al. (1988), it is different from that of Ria de Averio, (K = 0.11 yr^{-1}) (Arruda, 1991), Mirna Bay (North Adriatic (K = 0.21 yr^{-1}) (Kraljevic and Dulcic, 1996), and the Gulf of Marseilles (K = 0.20 yr^{-1}) (Albertini–Berhaut, 1978).

The mean lengths for each age at Homa Lagoon were: < 1 year = 12.19 ± 4.05 cm; 1 year = 21.06 ± 3.45 cm; 2 years = 26.99±5.51 cm; 3 years = 32.66 ± 9.06 cm; 4 years = 39.45 cm. Drake et al. (1984) presented individual age categories of golden grey mullet from the lagoons of Spain: < 1 year = 13.5–23.5; 1 year = 19.5–32.5; 2 years = 25.5–40.4; 3 years = 32.5–43.5 cm; however, Modrusan et al. (1988) reported mean length for age from Krka Estuary (Eastern Adriatic) as age 2 years = 23.0; 3 years = 27.5; 5 years = 34.5 cm, Andaloro (1983) reported 1 year = 10.6; 2 years = 17.4; 3 years = 19.8; 4 years = 21.7; 5 years = 22.6; 6 years = 24.0 cm from Marsala Lagoon, and Arruda et al. (1991) reported < 1 year = 3.7; 1 year = 10.5; 2 years = 16.5; 3 years = 21.9; 4 years = 26.8 cm from Ria de Aveiro (Portugal), but the results of Drake et al. (1984) and other authors are different from these results.

The sex ratio was 1:1.87 in favour of females. First maturation occurred at the age of one year for both sexes. Although maturation in golden grey mullet occurs

Table 3. Individual distribution related to the sex of age groups and ratios, mean total length ($\overline{TL}$) and weight ($\overline{W}$), and standard error (S_x).

Age	Immature			Males			Females		
	N	$\overline{TL} \pm S_x$	$\overline{W} \pm Sx$	N	$\overline{TL} \pm S_x$	$\overline{W} \pm Sx$	N	$\overline{TL} \pm S_x$	$\overline{W} \pm Sx$
0	57	12.19 ± 4.05	32.89 ± 4.35	-	-	-	-	-	-
I	-			71	19.35 ± 2.05	63.25 ± 5.28	140	21.98 ± 3.36	102.94 ± 6.14
II	-			24	24.67 ± 4.17	169.84 ± 7.51	35	28.54 ± 4.47	194.77 ± 7.88
III	-			4	31.05 ± 5.42	281.44 ± 14.42	9	33.49 ± 8.57	355.03 ± 15.02
IV	-			-	-	-	2	39.45 ± 0.05	497.5 ± 2.50
Total	57 (17%)			99 (29%)			186 (54%)		

Table 4. von Bertalanffy growth parameters and Munro's Φ' values of golden grey mullet from various parts of the Adriatic Sea, Mediterranean Sea, Black Sea, Atlantic Ocean, and Aegean Sea.

Author	Area	Age range	L_∞ (cm)	K yr^{-1}	t_0 yr	Φ'
Nikolskii* (1954)	Black Sea		51.6	0.229	-0.214	11.017
Nikolskii* (1954)	Hazar Sea		60.0	0.177	-1.56	11.062
Alexandrova* (1964)	Black Sea		54.1	0.311	0.116	11.42
Albertini– Berhaut (1978)	Gulf of Marseilles	0 – 1	45.0	0.20	-0.49	10.609
Andaloro (1983)	Marsala Lagoon	1-6	24.3	0.63	-0.11	10.524
Modrusan et al. (1988)	Krka Estuary (middle Adriatic)	2-3 and 4	51.0	0.30	-0.40	11.265
Arruda et al. (1991)	Ria de Aveiro (Portugal)	0-4	68.5	0.11	-0.51	10.852
Dulcic–Kralcevic (1996)	Mirna Bay (north Adriatic)	3-8 and 11	39.8	0.21	-1.14	10.403
Present study	Homa Lagoon (Izmir Bay)	0-4	43.2	0.33	-0.30	11.028

* From Quignard and Farrugio (1981).

at the age of one year, its true age at the time of year ring formation can range between 18 and 26 months due to its peculiar first-year ring formation process (Cambrony, 1983). In contrast, for other European areas, higher ages of first maturation were recorded; i.e., for the Black Sea, third-fourth year for males and fourth-fifth year for females (Tomazo, 1940; Nikolskii, 1961; Berg, 1965; Brusle, 1981). For Brittany, first maturation was reported to be the third year (Thong, 1969), and for the lagoon of Berre (SE France), at the end of the third year for males and fourth year for females (Ezzat, 1965). According to Brusle (1981), these differences are due to varying mean seawater temperatures. Hotos et al. (2000) reported first maturation for golden grey mullet as one year of age for both sexes. This age of first maturity value was the same as our results.

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