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Reproductive Characteristics of Mullet (*Liza abu* H., 1843) (Pisces, Mugilidae) in the Atatürk Dam Lake, Southeastern Turkey

Erdinç Şahinöz[1], Zafer Doğu[1,*], Faruk Aral[2], Ramazan Şevik[3], Hasan Hüseyin Atar[4]
[1] Harran University, Bozova Vocational High School, Department of Fisheries, 63850, Sanliurfa, Turkey.
[2] Nigde University, Bor Vocational High School, Department of Large and Small Animal Breeding, 51700, Nigde, Turkey.
[3] Afyonkocatepe University, Faculty of Engineering, Department of Food Engineering, 03200, Afyonkarahisar, Turkey.
[4] Ankara University, Faculty of Agriculture, Department of Fisheries and Aquaculture, 06110, Dışkapı, Ankara, Turkey.

* Corresponding Author: Tel.: +90.414 7116206 ; Fax: +90.414 7116499;
E-mail: zaferdogu@harran.edu.tr; zafer_dogu@yahoo.com

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Abstract

In this study reproductive biology of *Liza abu* (Pisces Mugilidae) from Atatürk Dam Lake in the Euphrates River Basin was observed. Some reproductive characteristics such as age, egg number, sexual determination, gonadosomatic index (GSI) of *Liza abu* (n=821) are taken into consideration. The relationship between total weight (W_t), and total length (L_t) and fecundity (F) were investigated during the period from January 2004 to December 2005. The ages of investigated fish ranged from 1 to 5. The ratio of the numbers of fish samples with egg (89): total of female (413): total sample of *Liza abu* (810) were determined as 1:4.64:910 respectively. Though the highest gonadosomatic index (GSI) of female was found in April, male's was highest in May. The relationships between the total weight (W_t) and fecundity (number of eggs= F), total length (L_t) and fecundity (F) of *L. abu* were found as $F_w = 25.5+0.00583W_t$ ($R^2= 0.557$) and $F_L= 14.2+0.000373\ L_t$ ($R^2= 0.496$) respectively. Relationship between total weight (W_t) and gonad weight (W_g) in males and females were found as $W_t=38.5+2.55W_g$ ($R^2=0.222$) and $W_t= 36.8+4.55W_g$ ($R^2=0.331$), respectively.

Keywords: Atatürk Dam, fecundity, gonad somatic index, *Liza abu*, reproduction.

Atatürk Baraj Gölü'ndeki Kefal Balığı, *Liza abu* (H, 1843) (Pisces Mugilidae)'nun Üreme Özellikleri

Özet

Bu çalışmada Fırat Nehir Sistemi'ndeki, Atatürk Baraj Gölü'nde bulunan *Liza abu* (Pisces Mugilidae)'nun (n=821); yaş, yumurta sayısı, cinsiyet ve gonadosomatik indeks (GSI) gibi bazı üreme özellikleri dikkate alınarak üreme biyolojisi incelendi. Ocak 2004 ile Aralık 2005 arasındaki dönem boyunca; total ağırlık (W_t), total uzunluk (L_t) ve fekondite (F) verileri arasındaki ilişki araştırılmıştır. İncelenen balıkların yaşları 1 ile 5 arasında değişti. Yumurtalı dişi (89): total dişi (413): total örnek (810) oranları sırasıyla 1: 4,64:9,10 olarak belirlendi. En yüksek gonadosomatik indeks değeri dişilerde Nisan ayında belirlenirken, erkeklerin Mayıs ayı oldu. Total ağırlık (W_t) ve fekondite (F) ile, total uzunluk (L_t) ve fekondite (F) arasındaki ilişki sırasıyla $F_w = 25,5+0,00583W_t$ ($R^2= 0,557$) ve $F_L= 14,2+0,000373\ L_t$ ($R^2= 0,496$) olarak belirlendi. Erkek ve dişilerde total ağırlık (W_t) ve gonad ağırlığı (W_g) arasındaki ilişki sırasıyla $W_t = 38,5+2,55W_g$ ($R^2= 0,222$) ve $W_t= 36,8+4,55W_g$ ($R^2=0,331$) olarak belirlendi.

Anahtar Kelimeler: Atatürk Barajı, fekondite, gonadosomatik indeks, *Liza abu*, üreme.

Introduction

The mullets (Mugilidae) are found world-wide in temperate to tropical coastal waters readily entering estuaries and even resident in freshwaters. *Liza abu* (Heckel, 1843) which is member of Mugilidae exists in freshwater and inhabit Asia: Iraq, Syria, Pakistan (Mahdi, 1967; Coad, 1980), but also has been recorded at Kishni in Iraqi brackish waters and in Arabian Gulf (Nasir and Naama, 1988). Many studies have reported that *Liza abu* lives in Euphrates and Tigris Rivers Basin and their branches (Kuru, 1979; Şevik and Bozkurt, 1997). In addition, this species was recorded in Orontes river systems (Yalçın, 2004). The first important study relating to *Liza abu* was made on Tigris River in Turkey (Ünlü *et al*., 2000). These fish are economically important as food eaten fresh, smoked or canned, as bait, and as cultured fish in ponds (Coad, 2007; Duman, 2001).

Atatürk Dam Lake, situated in the Euphrates River Basin, is the largest dam lake in Turkey, and is used for irrigation and electrical energy production. Its area and volume are about 81,700 ha and 48.7 km^3, respectively. After the construction of Atatürk Dam in 1990, *Liza abu* population could not find an opportunity to migrate to the sea. So, these conditions

might affect some reproductive characteristics of this population.

The aim of this study was to determine some reproductive characteristics such as egg number, sex ratio, gonadal development; gonad somatic index (GSI), total weight (W_t) – fecundity (F), and total length (L_t) – fecundity (F), and the findings may reflect the recent situation of *Liza abu* in Euphrates River System.

Material and methods

Study Area

Atatürk Dam Lake is a large (81,700 ha) reservoir on the Euphrates River in South-eastern Anatolia, Turkey, and is used for irrigation and power generating. The dam was constructed between the years of 1983 and 1992 while water collection was started on 16 June 1986 (DSI, 2009). The Dam Lake is the biggest reservoir in Turkey and has a high fishing potential. There are about 28 species and subspecies belonging to eight families living in the Euphrates River and its Dam lakes (Kuru, 1978–1979; Bozkurt, 1994) (37°21'45" N, 38°31'36" E) (Figure 1).

Samples and Data Analysis

In this study, total 820 *Liza abu* were examined (397 males and 413 females), from the Atatürk Dam Lake. During the sampling period, mean physico-chemical parameters of the lake water were measured as temperature: 08.98-28.86ºC, oxygen: 6.98-9.90 mg/L and pH: 6.75-8.75 by YSI Environmental (YSI 85). Water was taken for chemical analysis at $9:^{00}$ AM, in a layer of 30 cm from the surface.

The samples were obtained monthly by using gill nets of various mesh sizes (15, 17, 20, 28, 30 mm mesh sizes) during the months January 2004 to December 2005 from the Atatürk Dam Lake.

After being caught, samples were immediately brought to the laboratory and the samples were measured as follows: 1) total length (F_t-0.1 mm); 2) total weight (W_t-0.01 g); 3) gonad weight (W_g-0.01 g). Egg samples were taken from gonads which were kept in formaldehyde for the counting. Otolites were used for the forecast of *Liza abu* since rigid tissues give the most reliable results in mugilid fishes (Chilton, 1982). Sex was determined by gonad color: vascular and pink for females and white for males.

The spawning period were estimated from the gonad development (Gonado-Somatic Index; GSI), by direct observation of the gonads and monthly variations in egg diameters of samples (Lagler, 1966). GSI was calculated from the equation,

$$GSI\ \% = (Wg / Wt) \times 100;$$

where Wg and Wt are gonad weight and total weight in grams of fish respectively (Lagler, 1966; Bagenal, 1978).

Fecundity was studied by gravimetric method (Bagenal, 1978). The procedure is follows as; the subsamples of 1 or 2 g according to the size of the eggs were taken from the front, middle and back parts of the ovaries. The number of the sub-samples was multiplied up to the weight of the ovary. The diameters of various eggs size from parts of ovarian were measured with object micrometer.

Sexual maturity was confirmed by noting macroscopically according to the presence of "yolked eggs" or sperm in the gonads (Nikolsky, 1963). On the other hand, fecundity (F) - total length (L_t) and fecundity - body weight (W_t), were calculated with regression analysis. Fecundity (F) was calculated from the equation as following (Nikolsky, 1969; Öztürk, 2001).

$$F = a.L_t^{\ b} \text{ and } F = a.W_t^{\ b}$$

Statistical analyses were carried out by using statistical software (SPSS 11.5.0, Inc. 2002). Sex ratio for the entire sample and for each age group was

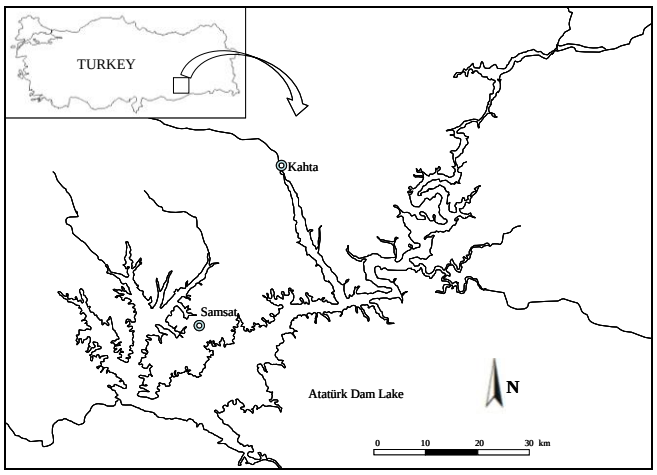


Figure 1. Atatürk Dam Lake.

tested by using a χ^2 test for significant differences from an expected 1:1 ratio. An ά level of 0.05 was used to determine significance.

Histopathological Analysis

In addition, some histopathological features of gonadal tissue were investigated according to Smith and Walker (2004). Seventy two female and thirty six male gonads (only right gonads) excised and allocated to 10% buffered formalin for 24 hours, and then observed in tissue process routine. In the event of staining process 3-5 µm thickness for paraffin-embedded tissues were microtomed (approximately 5-10 µm apart). It was stained Hematoxylin-Eosin, and examined using light microscopy (Figure 2). Three different periods of males and six different periods of females' gonads in *Liza abu* samples were determined. Testes were histologically classified as developing, developed or spent, based on the presence or absence and relative abundance of spermatogonia, spermatocytes, spermatids and mature sperm (Figure 2).

Female gonads were histologically classified in two ways. First, each gonad was staged according to the size, stage of the most advanced oocyte and the presence or absence of migratory nuclei, post-ovulatory follicles and atretic yolked oocytes ('specific inspection'). Second, these latter characteristics were combined with a subjective, overall assessment of the character of each section to account for the relative abundance of oocytes at each developmental stage ('whole-section inspection') (West, 1990; Fowler *et al*., 1999). This additional step proved correctly the distinguishing of early developing, spent and regressing ovaries (Figure 3).

Results

The Sex and Age Composition

A total of 820 samples of *Liza abu* were caught in Atatürk Reservoir during the study period. Investigated fish (397 for males and 413 for females) ranged in 1-5 age and their total lengths varied between 12.60 and 22.80 cm (Table 1). The ratio of male to female in 810 samples was 397:413 = 1:1.04. So, 50.99% of fish found was female and 49.01% male.

Age at Sexual Maturity

In this study, specimens with fully mature were defined as those which were ready to reproduce. The captured fish had sexual maturity at four years of age. The minimum size of fish (L_t) at sexual maturity and weight (W_t) were calculated as 17.20 cm and 70.10 g.

Spawning

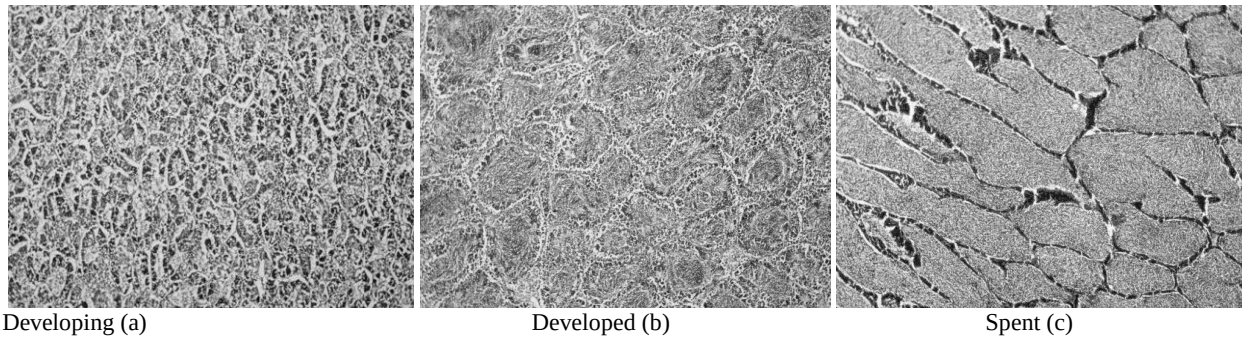
In males, developing stage started in February and continued till the end of the March (Figure 2-a). The developed stage was observed from the beginning of April to the beginning of the August (Figure 2-b). And, the spent stage was determined between August and January (Figure 2-c).

Female gonads were determined histologically as follows; immature/regressing (November-January) (Figure 3-a), immature (January-March) (Figure 3-b), immature/mature developing (March-April) (Figure 3-c), mature (April-June) (Figure 3-d), spent (June-August) (Figure 3-e) and spent-immature (August-November) (Figure 3-f).

The monthly change trend of GSI was given as Figure 4. As shown in Figure 4, mean GSI in males was high (around 8.00) from May to June, decreased from July to January and reached minimum levels in February (1.49). It was high (10.96) for females in April. There was a decrease of the mean GSI from April to August. Mean GSI in females was lower (1.59) in November than the other months.

Fecundity

Average fecundity and weight in 89 female samples with egg were determined as 5,856.15 and 49.61 g, respectively. The number of eggs per 1kg weight was 118,056.77. Total weight (W_t) - number of eggs (F) were calculated as $Fw = 25.5+0.00583W_t$) and $R^2 = 0.557$. Total length (L_t) - number of eggs (F) was also found as $F_L = 14.2+ 0.000373(L_t)$ ($R^2= 0.496$) (Figure 5-6).



Developing (a) Developed (b) Spent (c)

Figure 2. Histological appearance of (a) developing, (b) developed and (c) spent testes (H+Ex200).

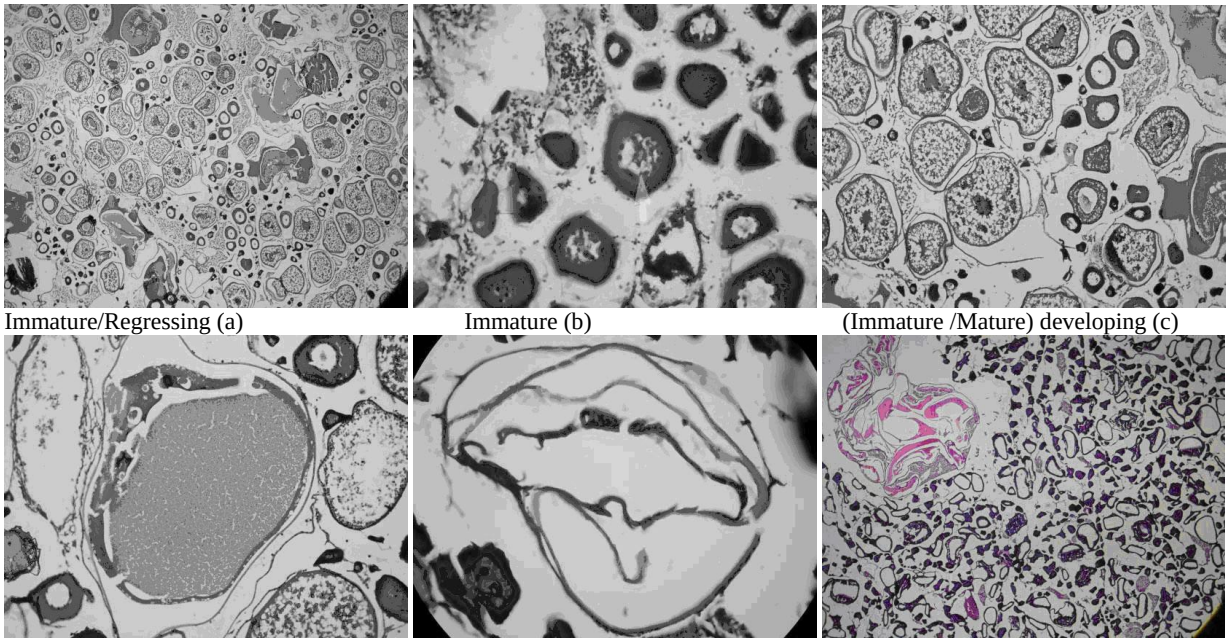


Figure 3. Histological appearance of (a) immature, (b) immature developing/mature developing early), (c) immature developing/mature developing (late), (d) ripe, (e) spent and (f) spent-immature varies in female samples (H+Ex200).

Table 1. Minimum, maximum, mean values and their standard deviations in length, weight and gonads at both sex

Sex	N	n	L_{min}	L_{max}	L_{mean}	W_{min}	W_{max}	W_{mean}	G_{min}	G_{max}	G_{mean}
Male	397	287	12.60	17.90	14.95	21.20	74.50	37.52	2.10	3.10	1.73
Female	413	89	13.70	20.80	15.93	28.90	123.70	49.61	1.30	15.80	2.09
S.D.	-	-	0.78	2.05	0.69	5.45	34.79	8.55	0.57	8.980	0.26

N = total specimen, n = mature specimen, L = total length (cm), W = total weight (g), G = gonad, min = minimum, max = maximum, S.D. = standard deviation.

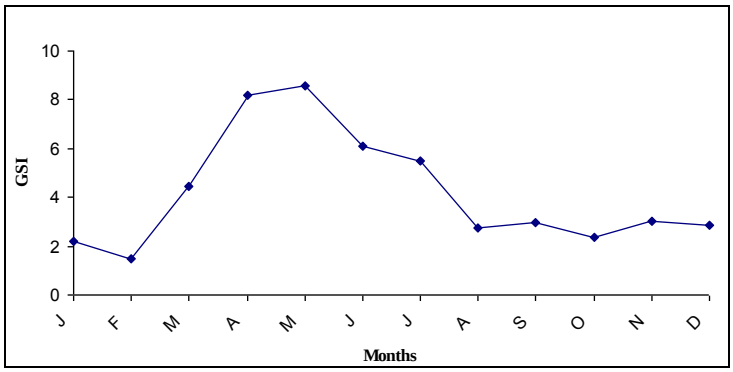


Figure 4. Monthly changes of gonadosomatic Index (Mean±SD) in male *L. abu*. Data for 2004 and 2005 have been combined to show a single annual cycle.
Sample sizes are given in Table 1. GSI: Gonadosomatic Index.

Relationship between total weight (W_t) and gonad weight (W_g) in males and females were found as $W_t = 38.5+2.55W_g$ ($R^2= 0.222$) and $W_t = 36.8+4.55W_g$ ($R^2=0.331$), respectively (Figure 7-8).

Discussion

In the present study, the overall sex ratio of the 810 investigated *Liza abu* samples from Atatürk Dam Lake was 1: 1.04 and ranging between 1 to 5; and percentage of males and females were 49.01 and 50.99, respectively. The similar sex ratio was reported to be 1:1.21 and 1:1.30 for the *Liza abu* by Ünlü *et al*. (2000) and Naama *et al*. (1986), respectively. Mhaisen and Al-Jaffery (1989) reported 6 age groups from Babylon Fish Farm, but Al-Nasiri and Sirajul

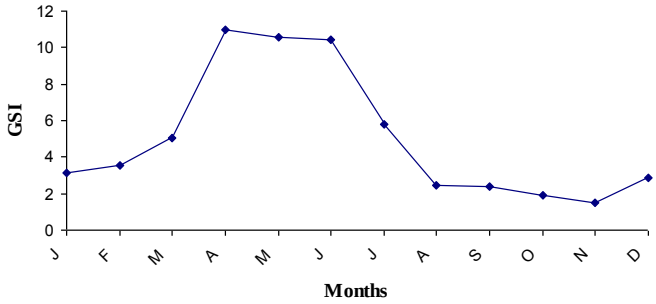


Figure 5. Monthly changes of gonadosomatic Index (Mean±SD) in female in male *L. abu*. Data for 2004 and 2005 have been combined to show a single annual cycle (P<0.05). Sample sizes are given in Table 1. GSI: Gonadosomatic Index.

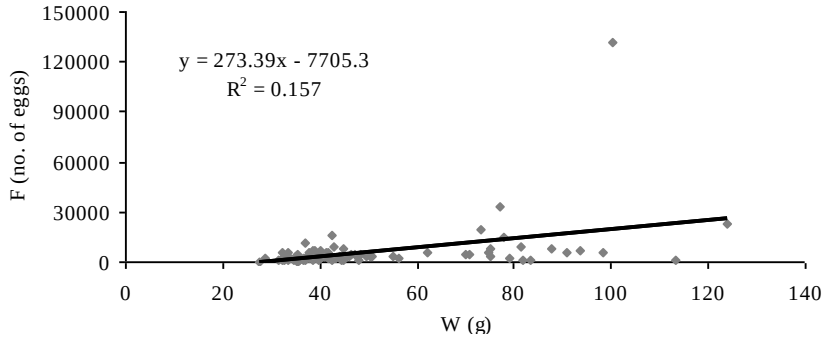


Figure 6. The relationship between total weight and egg number. Sample sizes are given in Table 1. The total Weight (W), the Fecundity (F).

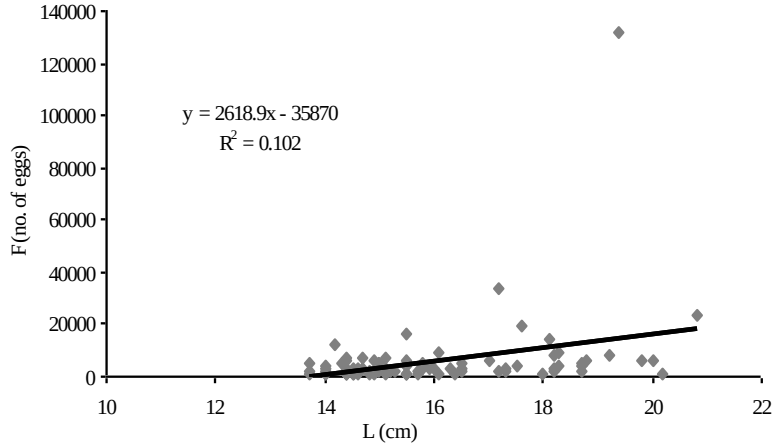


Figure 7. The relationship between total length and egg number. Sample sizes are given in Table 1. The total Length t (W), the Fecundity (F).

Islam (1978) found just age group 0+ to 2+. These different results may be due to fishing methods (Ünlü, 2000).

The captured fish had sexual maturity at four years of age. So, the minimum size of fish (L_t) at this traits and weight (W_t) were calculated as 17.2 cm and 70.1 g. Naama *et al*. (1986) recorded that all the males and females were mature at about 16.0 cm for *Liza abu* in Al-Hammar Marsh, Iraq. However, Ünlü *et al*. (2000) reported that the smallest mature female was 11.7 cm in fork length and 17.0 g in total weight, while male was 14.0 g in their weight and 11.5 cm in fork length in Tigris River. In this study, our findings were similar like the other reported data from Iraq, but were higher to Tigris River (Ünlü *et al*., 2000). The reason for this could be defined as a disparity between ecologic properties of river habitats and Atatürk Dam Lake habitat that was constructed in 1990.

Gonads of males during August-February periods were in the relaxing position. As of February GSI value continuously increased and reached the

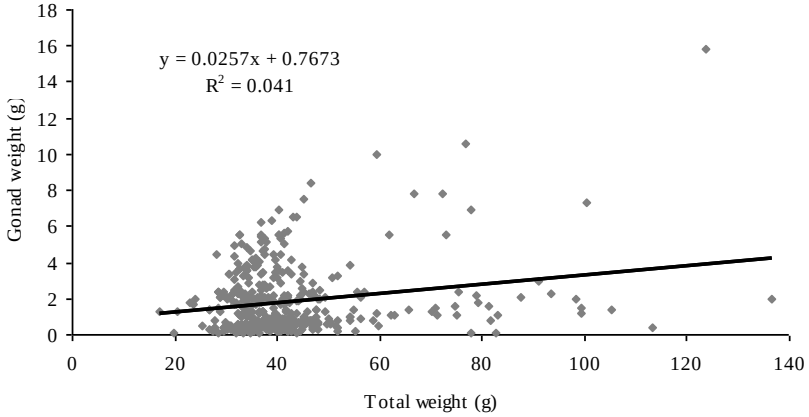


Figure 8. Relationship between total weight and gonad weight in females. Sample sizes are given in Table 1.

highest level in May. The same trend was obtained in females, but the highest level appeared in April (Figure 4). However, gonads in females continued to get free of eggs until August. GSI values in both sexes gradually decreased until August. According to Ünlü *et al*. (2000) *Liza abu* starts for spawning from Tigris River to the sea in January. However, the researchers suggested that *Liza abu* may reproduce in freshwater.

Increasing egg numbers with total weight and length showed a similar trend (Figure 5-6). A high level of relationship exists between the egg number, length (R^2 =0.65) and weight (R^2 =0.68) in *Liza abu* living in Tigris River (Ünlü *et al*., 2000). In the present study, high R^2 values of female and male *Liza abu* were found compatible with the other studies. The high level of correlation coefficients showed the fish adapted the dam lake in terms of reproduction.

Our findings showed that *Liza abu* matured at four years of life in the Atatürk Dam Lake. On the contrary, Naama *et al*. (1986) and Al-Yamour *et al*. (1988) and Ünlü *et al*. (2000) reported that *Liza abu* matured at the end of their first year of life in Iraq's population and in Tigris population, respectively. In addition, the eggs' number of *Liza abu* from Atatürk Dam Lake was similar to Tigris River (Ünlü, 2000).

Based on these results, all maturity stages of *Liza abu* were observed for the population of Atatürk Reservoir. This reflects that Atatürk Dam Lake is the spawning location of this species. Moreover, the samples would be caught all year along, but there was no proof of spawning migration.

In conclusion, when gonad evolution, weight and height were taken into consideration; it was seen that these fish came reproduction period between April and August. So, in spite of the *Liza abu* is known as a migratory species, it successfully adapted the new reservoir environment and can reproduce in the Atatürk Dam Lake.

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