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SOME ASPECTS OF THE BIOLOGY OF ABU MULLET *Liza abu* (HECKEL, 1843) IN THE ORONTES RIVER, TURKEY

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ABSTRACT

The age, growth and reproduction are described for 411 individuals of abu mullet from the Orontes River in Turkey between May 2011 and April 2012. The overall male to female ratio was 1:1.29. Fork length of all individuals ranged from 2.2 to 18.5 cm and total weight from 1.85 to 66.40 g. Isometric growth was observed for males (b=2.938) and all individuals (b=2.907); positive allometric growth was observed for females (b=3.246). The von Bertalanffy growth parameters based on data from otoliths were L_{∞} = 19.48 cm, k=0.258 year^{-1} and t_0=-1.738 years for males, L_{∞} = 20.31 cm, k=0.313 year^{-1} and t_0=-1.432 years for females. The growth performance index (Φ) was found to be 1.99 for males, 2.11 for females and 2.18 for all individuals. The mean condition factor (K) was calculated as 0.792±0.027 for males and 0.835±0.030 for females. Length at maturity was 11.49 cm for males and 11.82 cm for females. The fecundity was 14413±1569 with an egg diameter of 0.44±0.07 mm. Spawning period was between April and August. Abu mullet has acclimated well in the Orontes River and is capable of successful reproduction. Its calculated age and size at maturity was smaller and younger than for other populations.

How to Cite

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INTRODUCTION

Abu mullet *Liza abu* (Heckel, 1843) belongs to the family Mugilidae. Mugilidae is a widely distributed family and its member species exist in coastal marine and brackish waters in all tropical and temperate seas (Koutrakis, 2011). Liza genus is common in both marine and freshwater fishes. Abu mullet, present mainly in freshwater (rivers, streams and lakes), sometimes enters lagoons and estuaries. This species is known from freshwater and estuaries of Iraq, Iran, Turkey, Pakistan and the Indus River (Talwar and Jhingran, 1991; Nasır and Naama, 1988; Kaya, 2010). *Liza abu*, called kefal in Turkey, is widely distributed in the Tigris River, Euphrates River, Orontes River and adjacent drainage basins (Ünlü et al., 2000; Yalçın-Özdilek, 2003; Kaya, 2010; Özcan, 2013). Abu mullet was introduced into the Orontes River and tributaries in 2001 by man (Yalçın-Özdilek, 2003). It is a target of a commercial fishery because of high economic importance (Abd et al., 2009).

Despite intensive investigations of the growth, reproduction and ecology of abu mullet in the Tigris and Euphrates Rivers (Al-Nasırı and Sirajul, 1978; Islam and Khalaf, 1982; Islam et al., 1982; Al-Yamour et al., 1988; Ünlü et al., 2000; Şahinöz et al., 2008; Chelemal et al., 2009; Kaya, 2010; Şahinöz et al., 2010) and other places in the Arabian Gulf and marshes (Nasır and Naama, 1988; Naama et al., 1986; Naama and Muhsen, 1986), information on growth, age and reproduction of abu mullet in the Orontes River is still not available.

The aim of this study is to provide information on the biological aspects of abu mullet inhabiting the Orontes River basin.

MATERIALS AND METHODS

The Orontes (Asi in Arabic and Turkish) is the principal river draining to the Levant coastline of the Mediterranean Sea. From its source in the Bekaa Valley of Lebanon, on the flank of the Lebanon mountain range, it flows northwards across western Syria through the cities of Homs and Hama and into Antakya (Antioche), Hatay Province, southern Turkey, before turning sharply south-westward to reach the sea ~30 km downstream of Antakya (Antioche) (Bridgland et al., 2012). The Orontes River is the longest river in the province of Antakya (Antioche, Turkey), 380 km in total length, around 94 km of which is in Turkey. It reserves the Orontes River, Karasu, Afrin, Büyük Karaçay and Küçük Karaçay streams, etc. Two large tributaries, the Afrin and Karasu stream, reach the Orontes River in the Amik valley (Özcan et al., 2012).

In all, 411 specimens of abu mullet were obtained at monthly intervals from the Orontes River and catchment (1 and 3: Orontes River; 2: Karasu stream) between May 2011 and April 2012 by using an electro shocker (SAMUS 725G; 350 V, 17 amp), cast net and from local fishermen (Fig. 1). Collected specimens were transported on ice in a cooler box to the laboratory at the Marine Sciences and Technology Faculty of İskenderun Technology University. The fish were brought in ice to the laboratory within 4-6 hours after collection, where fork length (FL) and body weight (W) were recorded for all individuals to the nearest 1 mm and 0.01 g, respectively. Fish were dissected and gonads were removed, weighed with an accuracy of 0.01 g and examined macroscopically for sex identification.

The age of the fish was determined using otoliths (Tesch, 1970). Sagittal otoliths were extracted from each fish, cleaned and stored in dry conditions inside the microplate.

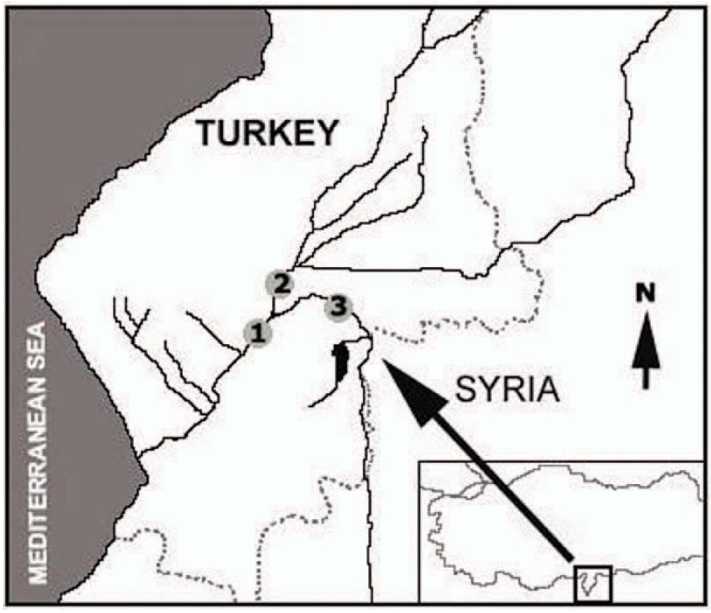

Fig 1. Map showing the sampling area of abu mullet

Otoliths were treated by xylol under a binocular stereoscope with a 25x magnification, using transmitted light, to count the annual rings. Age reading was done twice, each time by a different person. Agreement between age readings was expressed as Index of Average Percentage Error (Beamish and Fournier, 1981), calculated as IAPE = $100*(1/N\ \Sigma(1/R\Sigma(\angle Xij - Xj\angle / Xj)))$, where N is the number of fish aged, R the number of times each fish is aged, Xj the average age for the jth fish, and Xij the ith reading of the jth fish.

The length-weight relationship was determined by the least-squares method on the logarithmically transformed data by means of the equation $W = a\ L^b$, where W is the total weight, L is the fork length, and a and b are parameters to be estimated (Le Cren, 1951). This analysis was performed both on the whole sample and on the sample subdivided by sex. Standard error was calculated for the slope (b): the hypothesis of isometric growth (b=3) was tested through Student's t-test, with values of $p < 0.05$ considered significant (Avşar, 1995).

The sex ratio of the sampled population, expressed as males:females proportion, was analysed on an annual basis and by size interval. Deviations from 1:1 null hypothesis were statistically tested using the chi-square analysis (χ^2-test) (Avşar, 1995).

The von Bertalanffy growth equations were used to describe growth of the species (Sparre and Venema, 1992): $L_t = L_\infty(1-e^{-k(t-to)})$, where L_t is the fish length at age t, L_∞ represent the asymptotic 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. Growth performance index (Φ) was calculated using the equation (Pauly and Munro, 1984): $\Phi = log(k)+2log(L_\infty)$.

Sex and maturity stages were determined by examination of the gonad tissue either by eye for large fish or with the aid of lens for smaller fish. Stages of maturation were classified as follows: I, immature; II, developing; III, ripe; IV, spawning; V, spent (King, 1995).

The spawning period was determined following monthly changes in the gonadosomatic index (GSI). The GSI was calculated as $GSI=(Gonad\ weight/Body\ weight)*100$ (King, 1995). 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_F 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 proportion mature 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). Condition factors were calculated for both sexes by using the equation $K=(W/L^3)x100$, where W is the total weight in g, L is the fork length in cm (Ricker, 1975).

The fecundity of females was estimated gravimetrically.

Mature ovaries were subsampled (0.001 g) from anterior, middle and posterior portions of each ovarian lobe. Samples of 30-40 eggs from each female were collected to measure the egg. 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* (Avşar, 1995), where *GW* is the weight of the ovary and *D* is the density of mature oocytes (number of oocytes per gram of ovarian tissue).

RESULTS

Fork length and body weight

All observed specimens ranged from 2.2 to 18.5 cm in fork length and from 0.11 to 66.40 g in total weight for all individuals. The length of males ranged between 6.7 and 16.3 cm, and their weight ranged between 1.85 and 47.80 g. Fork length ranged from 7.0 to 18.5 cm, and their weight ranged from 2.20 to 66.40 g in females (Table 1). The females of abu mullet were longer and heavier than the males ($p<0.073$ for length and $p<0.056$ for weight).

Length-weight relationship

Length-weight relationship was found to be $W=0.0087L^{2.938}$ for males (Fig. 2), $W=0.0043L^{3.246}$ for females (Fig. 3) and $W=0.0096L^{2.907}$ for all individuals. Isometric growth was observed for males and all individuals (t-test, $t=0.609< t0.05=1.984$ for males, $t:1.146<t0.05:1.965$ for all individuals) and positive allometric growth for females (t-test, $t=2.257 > t0.05=1.984$).

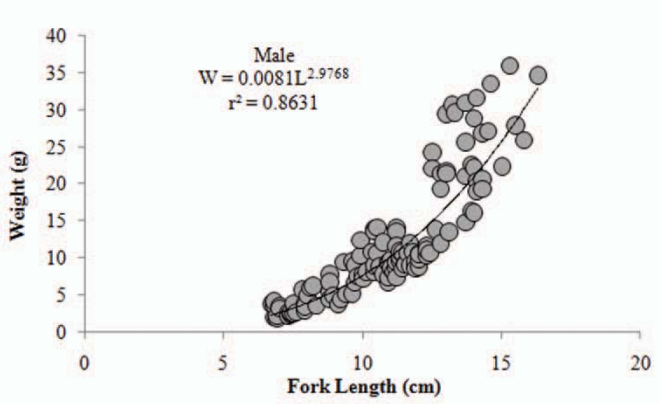

Fig 2. Length-weight relationships in male abu mullet in the Orontes River

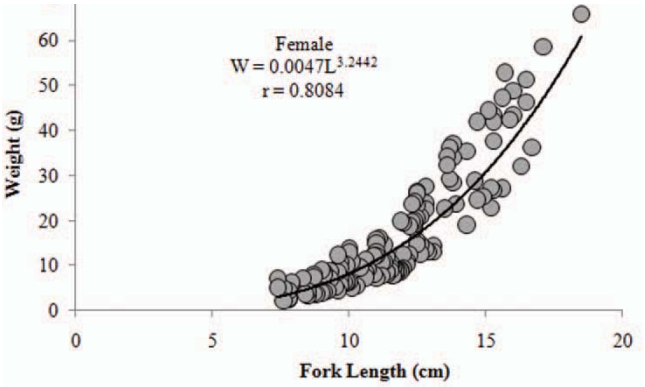

Fig 3. Length-weight relationships in female abu mullet in the Orontes River

Table 1. Fork length frequency of females, males and all specimens of abu mullet

Length groups	Age groups					Total
	0	I	II	III	IV	
2.0-3.9	36					36
4.0-5.9	64	3				67
6.0-7.9	43	21	3			67
8.0-9.9	4	42	7			53
10.0-11.9		35	43	2		80
12.0-13.9		7	37	20		64
14.0-15.9		1	15	17		33
16.0-17.9			3	5	1	9
18.0-19.9				1	1	2
Total	147	109	108	45	2	411
FL_{All}	2.2-8.0	5.8-14.3	7.9-16.3	11.8-18.1	17.1-18.5	2.2-18.5
FL_{Female}	7.0-7.8	7.4-13.9	7.9-16.0	12.4-18.1	17.1-18.5	7.0-18.5
FL_{Male}	6.7-8.0	7.5-14.3	9.7-16.3	11.8-16.3		6.7-16.3
W_{All}	0.11-5.30	1.95-34.15	3.5-53.0	9.35-66.40	38.9-43.65	0.11-66.40
W_{Female}	2.20-5.30	2.85-34.15	3.5-53.0	9.35-66.40	38.9-43.65	2.20-66.40
W_{Male}	1.85	3.20-19.25	7.8-47.8	9.65-39.55		1.85-47.80

Table 2. The age and sex composition of abu mullet from the Orontes River, Turkey

Age	Juvenile		Females		Males		All fish		Sex ratio
	N	%N	N	%N	N	%N	N	%N	M:F
0	142	96.60	4	2.72	1	0.68	147	35.77	1:4.00*
I	15	13.76	47	43.12	47	43.12	109	26.52	1:1.00
II		0.00	64	59.26	44	40.74	108	26.28	1:1.45*
III		0.00	26	57.78	19	42.22	45	10.95	1:1.37*
IV		0.00	2	100.00		0.00	2	0.49	
Total	157		143		111		411		1:1.29*

*Significant difference (p<0.05)

Sex ratio, age and growth

From a total of 411 abu mullet examined, the sex was determined in 254 abu mullet specimens. Overall ratio of males to females was 1:1.29. A chi-square test of the sex ratio indicated statistically significant deviations from 1:1 (p<0.05). A high percentage of individuals smaller than 8.0 cm could not be sexed. In addition, sex ratios varied with age-class (Table 2). Females dominated other age groups, while the sex ratio also seems to be balanced in age group I (Table 2).

The abu mullet population of the Orontes River has a narrow age range from 0 to 4 years. The females were grouped into 5 age groups, while in the males, 4 age groups were found (Table 1). From the examination of otoliths, fish aged 4 years were found. Ages of males ranged between 0 and 3 years, of females between 0 and 4 years. The fact that 88.57% of the abu mullet population was between 0 and II ages indicates that the population had mostly young individuals.

The average percentage of error (IAPE) was found as 8.13% for abu mullet.

The von Bertalanffy growth equations by sex and all individuals were computed as L_∞ = 19.48 cm, k=0.258 year^{-1} and t_0=-1.738 years for males, L_∞ = 20.31 cm, k=0.313 year^{-1} and t_0=-1.432 years for females. The values of L_∞ of the females were higher than those of the males, but there was no significant difference between the growth parameters of males and females (th<t0.05, t_h=1.97). The growth performance index (Φ) was found to be 1.99 for males, 2.11 for females and 2.18 for all individuals, respectively.

Condition factor

The mean condition factor was calculated as 0.792±0.027 for males and 0.835±0.030 for females. Monthly variations in the condition factor were determined (Fig. 4). The changes of mean condition factor showed similar patterns for both sexes based on months. In addition, minimum and maximum condition factors were calculated as 0.594 (May) and 1.105 (March) for males; condition factors of females ranged between 0.562 (May) and 1.192 (March).

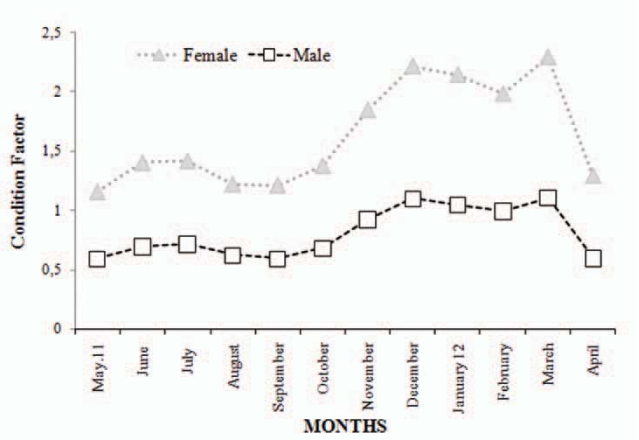

Fig 4. Monthly changes of condition factors

Spawning season

The GSI showed higher values for females than for males (Fig. 5). There was a significant difference between males and females (p<0.05), while both sexes showed a similar trend in GSI value. The GSI values of both sexes were highest in April and reached the lowest value in August. The spawning period was from April to August. Then, between August and October, there was a quiescent period. From November to April, it showed an increasing pattern (Fig. 5).

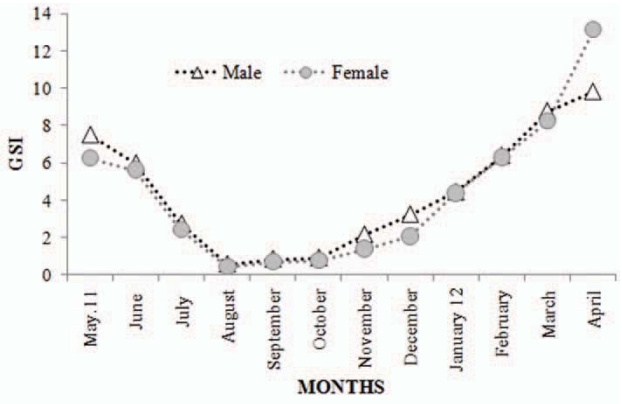

Fig 5. Monthly changes of gonadosomatic index the Orontes River

Length and age at first maturity

The smallest specimen with the signs of maximal sexual activity was a female 10.0 cm long and a male 10.4 cm long. Length at 50% maturity was estimated to be 11.49 cm (SE:0.16) L_M in males and 11.82 cm (SE:0.19) L_M in females. At 14.0 cm all abu mullet population was sexually matured. Age at sexual maturity for females and males was calculated to be 1.18 (SE:0.12) in males and 1.21 years (SE:0.09) in females. The length and age at first maturity (FL_{50}) estimated for abu mullet in the Orontes River did not show significant difference between sexes.

$P=1/(1+\exp^{[-0.8904(L-11.824)]})$ $r^2=0.986$ for females

$P=1/(1+\exp^{[-0.954(L-11.490)]})$ $r^2= 0.989$ for males

Fecundity

During the spawning period, the length, weight and fecundity of 51 females were determined according to age groups. Egg production during the spawning season varied between 12021 and 24850, and it increased with age (Table 3). The mean fecundity of all individuals was estimated as 14413±1569 eggs per female.

The mean egg diameters were calculated for ages (Table 3). The diameter of mature egg in spawning season varied from 0.31 to 0.62 mm, with a mean of 0.44±0.07 mm.

Table 3. Fecundities and egg diameters in the age groups of abu mullet in the Orontes River

	Fish			Fecundity		Egg diameter	
Age	N	FL	W	MF	min-max	ME	min-max
I	9	10.7	15.07	12021	1532-39582	0.36	0.31-0.46
II	28	13.0	22.93	15370	2217-37628	0.41	0.34-0.52
III	12	14.8	30.70	19245	3425-47683	0.44	0.36-0.54
IV	2	16.9	34.20	24850	17522-32178	0.50	0.40-0.62

N: Number of the fish, FL: Fork length, W: Body weight, MF: Mean egg number, ME: Mean egg diameter, Range: Minimum and maximum values

DISCUSSION

Abu mullet was recorded for the first time in the Orontes River basin in 2001. The population of abu mullet in the Orontes River is composed of individuals ranging from 0 to 4 years of age. The oldest male and female were estimated to be 3 and 4 years old, respectively. Al-Nasırı and Sirajul (1978) reported a maximum age of 2 years. Al-Yamour et al. (1988) reports 6-year-old individuals from the Al-Daoodi marshes in Iraq, while the oldest specimen was caught in the Tigris River aged 4 years (Ünlü et al., 2000). Kaya (2010) found the maximum age to be 4 for all individuals in Devegecidi Reservoir. Şahinöz et al. (2010) obtained similar results from Atatürk Reservoir, where the maximum observed life span was 5 for all fish. The age groups found for the Orontes River population were consistent compared to other abu mullet populations described by Ünlü et al. (2000) and Kaya (2010). According to these results, abu mullet can be typified as a short-lived species.

In the present study, females were dominant – 1:1.29 (male: female). A similar situation has been reported by Naama et al. (1986) in Al-Hammar marshes (1:1.30), Al-Yamour et al. (1988) in Al-Daoodi Drain (1:1.30), Ünlü et al. (2000) in the Tigris River (1:1.21) and Chelemal et al. (2009) in Iran (1:2.70). Kaya (2010) found males dominant (1:0.94) in Devegecidi Reservoir, while Şahinöz et al. (2010) found sex ratio balanced (1:1.04) in Atatürk Reservoir.

Al-Yamour et al. (1988) stated that the values of b for abu mullet showed a negative allometry in growth of females and males. Ünlü et al. (2000) noted that abu mullet showed a positive allometry for both sexes. Kaya (2010) reported that the growth of abu mullet in Devegecidi Reservoir showed an isometry for males and positive allometry for females. In the present study, the growth of abu mullet shows isometric in males (*b*=2.9388) and positive allometric growth in females (*b*=3.2464), "*b*" values different from those found by Al-Yamour et al. (1988), Ünlü et al. (2000), while similar to the results found by Kaya (2010). The "*b*"values are often 3.0 and nearly always between 2.0 and 4.0 (Tesch, 1970). These differences are probably associated with the different size structure of abu mullet. In addition, the *b* values in fish vary according to species, age, season, sex, feeding and environmental conditions (Le Cren, 1951; Erkoyuncu, 1995). The L_∞ values were 19.48 (males) and 20.31 cm (females). Ünlü et al. (2000) reported similar situations in his studies, while the L_∞ values were lower than the reported by Kaya (2010) for Devegecidi Reservoir (males: 32.96 and females: 34.55 cm). The growth performance index (Φ) values were lower than the reported by Ünlü et al. (2000), Kaya (2010).

Age-reading errors are possible not only for teleost fishes but also for cartilaginous fishes. Duman and Başusta (2013) claim that an IAPE between 5% and 15%, which is established by at least two independent age readers, is enough for the validation. Our result (IAPE: 8.13 % for abu mullet) is in accordance with Duman and Başusta.

The condition factor values ranged from 0.594 to 1.105 (mean: 0.792±0.027) for males and from 0.562 to 1.192 (mean: 0.835±0.030) for females. Our values are lower than

those given for Al-Daoodi Drain (male: 6.308, female: 3.155) by Al-Yamour et al. (1988), the Dicle River (1.01- 1.10) by Ünlü et al. (2000), Devegecidi Reservoir (0.746-1.910, mean: 1.248 (male), 1.274 (female)) by Kaya (2010).

In Al-Hammar marshes, spawning takes place between November and March (Naama et al., 1986). Al Yamour et al. (1988) reported that the spawning period was between December and May in Al-Daoodi Drain. Ünlü et al. (2000) stated that spawning of abu mullet occurred between March and August in the Tigris River. In Iran, Chelemal et al. (2009) found that spawning started in January and ended in May. Kaya (2010) reported that abu mullet spawned between April and August in Devegecidi Reservoir. In Atatürk Reservoir, abu mullet spawned between April and August (Şahinöz et al., 2010). In this study, spawning occurred between April and August. The spawning period of abu mullet in the Orontes River is similar to the findings of Ünlü et al. (2000), Kaya (2010), Şahinöz et al. (2010), but different from those found by Naama et al. (1986), Al Yamour et al. (1988), Chelemal et al. (2009).

Fecundity varied from 12021 (1-year-old) to 24850 (4-year-old), while mean fecundity was 14413±1969 eggs per female fish. Ünlü et al. (2000) stated that fecundity varied from 12175 to 56400 (mean: 21641±1860), whereas Kaya (2010) reported from 7770 to 84543 (26393±1375). Egg diameter varied from 0.31 to 0.62 mm with a mean: 0.44±0.07 mm. Minimum egg diameter of abu mullet was usually reported to be smaller. However, maximum egg diameter was reported bigger by Kaya (2010) by 0.8 mm and Naama et al. (1986) by 0.70 mm, while Ünlü et al. (2000) reported it smaller by 0.5 mm.

The length at first maturity (FL_{50}) estimated for abu mullet in the Orontes River did not show significant difference between sexes and this situation was similar to that calculated by Ünlü et al. (2000) (124 mm for males, 127 mm for females) in the Tigris River. Naama et al. (1986) in Al-Hammar Marsh, Iraq stated that specimens of abu mullet were mature at 16.0 cm. Ünlü et al. (2000) reported that the smallest mature specimen in the Tigris River was 117 mm (female) and 115 mm (male) in fork length and at the end of their first year of life. Kaya (2010) mentioned that the smallest mature specimen was 12.0 cm for both sexes and maturation age was 2 years for females and 3 years for males in Devegecidi Reservoir. Şahinöz et al. (2010) found that minimum size and age at sexual maturity was 17.20 cm and 4 years, respectively. The calculated age and size at maturity of abu mullet in the Orontes River was smaller and younger than other populations (Naama et al., 1986, Ünlü et al., 2000; Kaya, 2010; Şahinöz et al., 2010). The reason for these differences is that the first spawning age and size is affected by environmental factors such as temperature, feed consumption (quantity and quality) and the water systems in which the fish live (such as lake, reservoir or river).

Once acclimated, an exotic species can create serious problems for fish species which already exist in the habitat. In conclusion, the results clearly indicate that abu mullet has adapted well in the Orontes River basin. There was no evidence to back up this claim prior to this study. Further studies on population status, management and protection are recommended in order to monitor the processes underlying adaptation of the species to its new environment, its succession and distribution.

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Sažetak

NEKI ASPEKTI BIOLOGIJE ABU CIPLA (*Liza abu* HECKEL, 1843) IZ RIJEKE ORONTES, TURSKA

Starost, rast i razmnožavanje abu cipla iz rijeke Orontes u Turskoj su opisani na 411 uzoraka od svibnja 2011. do travnja 2012. godine. Ukupni odnos mužjaka i ženki je bio 1: 1,29. Dužina vilice svih jedinki bila je u rasponu od 2,2 do 18,5 cm, a totalna težina od 1,85 do 66,40 g. Izometrijski rast zabilježen je kod mužjaka (b = 2,938) i kod svih jedinki (b = 2,907); pozitivan alometrijski rast uočen je za ženke (b = 3,246). Parametri rasta von Bertalanffijeve krivulje, dobiveni na temelju podataka iz otolita, iznosili su L_{∞} = 19,48 cm, k = 0,258 godina-1 i t0 = -1,738 godina za mužjake, L_{∞} = 20.31 cm, k = 0,313 godina-1 i t_0 = -1,432 godina za ženke. Indeks performansi rasta (Φ) je utvrđen: 1,99 za mužjake, 2,11 za žene i 2,18 za svaku jedinku. Srednji kondicijski faktor (K) izračunat je kao 0,792 ± 0,027 za mužjake i 0,835 ± 0,030 za ženke. Dužina u zrelosti je 11,49 cm za mužjake i 11,82 cm za ženke. Fekunditet iznosi 14413 ± 1569 s promjerom jaja od 0,44 ± 0,07 mm. Mrijest je bio između travnja i kolovoza. Abu cipal je dobro prilagođen u rijeci Orontes i sposoban je za uspješnu reprodukciju. Njegova izračunata dob i veličina zrelosti bila je manja i mlađa od ostalih populacija.

Ključne riječi: *Liza abu*, dob, rast, reprodukcija, rijeka Orontes

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