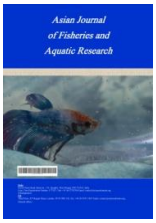

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Age, Growth, Condition Factor and Reproduction of *Planiliza abu* (Mugiliformes: Mugilidae) in the Al-Diwaniya River, Middle of Iraq

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The age, growth, relative condition factor, and reproduction of *Planiliza abu* (Heckel, 1843) from the Al-Diwaniya River, Iraq was described in samples obtained from October 2016 to September 2017, using different fishing gears. Total length and weight were measured, scales were used for age determination, and gonads were excised from the body cavity sexed and weighed. The lengths of the species ranged from 7.0 to 20.0 cm, and the most dominant length group was 13.0 cm. The length-weight relationship was $W=0.0199*L^{2.821}$ revealing a negative allometric growth (b= 2.821). The mean relative condition factor (K_n) was calculated as 1.13 for females and 0.93 for males. Four ages were recognized for the species with mean total lengths of 10.2, 14.5, 39.0, 17.2 and 19.3 cm, respectively. The von Bertalanffy growth parameters based on back-calculated lengths were $L\infty$= 23.4 cm, K=0.38 and to= -0.27. The growth performance index (Ø) of the species is computed as 2.32. The overall sex ratio (male: female) was 1:1.70. The gonad-somatic index (GSI) values of both sexes were highest in April, 8.5 for males and 11.6 for females and the lowest values in August, 0.22 for males and 0.75 for females, indicated that the spawning period was from April to May. Some biological properties such as lengths of individuals, negative allometric growth, ages from 1 to 4 years, values of ultimate growth ($L\infty$) and growth performance index (Ø) and overall sex ratio were among those described for the species in other waters. These results can contribute to providing information for species management in the study river.

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Keywords: Planiliza abu; growth; relative condition factor; reproduction; Al-Diwaniya River.

1. INTRODUCTION

Mugilidae is a widely distributed family. Its member species inhabit coastal temperate and tropical waters. Some species spend part or even their whole life cycle in coastal lagoons, lakes and rivers [1]. This family represented of 304 available species and only 80 valid species [2].

The freshwater mullet (Khishni), *Planiliza abu* (Heckel, 1843) belongs to the Mugilidae family. It was formerly placed in the genus *Liza* and recently became within the genus *Planiliza* [3]. The species is endemic and widely distributed in the Tigris-Euphrates Rver system of Turkey Syria, Iraq, Iran and Pakistan [4-6].

P. abu is widely distributed in different Iraqi waters (streams, rivers, drains, lakes, and reservoirs). Epler *et al*. [7] found it to be the dominant species of fish in lakes Habbaniyah, Tharthar and Razzazah, Iraq, comprising 72% of all fish collected. The species constituted 9.1% of fish assemblage in the Euphrates River at Al-Mussaib Power Station [8], 37.1% in the Al-Hawizeh marsh [9], 35.8% in the East Hammar marsh [10], 61.7% in the Al-Hilla River [11], 62.0% in the Chybayish marsh [12], 5.4% in Euphrates River [13], 14.1% in the Euphrates River near Al-Hindyah Barrier [14], 14.2% in the Al-Diwaniya River, middl of Iraq [15], 8.8% in the Shatt Al-Arab River [16] and 2.0% in the Garmat Ali River [17].

In recent years, several studies on the length-weight relationship, condition factor, age, growth, sex ratio and gonado-somatic index of *P. abu* have been done at different water bodies of Iraq [18-23], Iran [24,6] and Turkey [25-28,4,29], but no information on the biological characteristics of *P. liza* in the Al-Diwaniya River.

Therefore, this study aims to describes the length-frequency distribution, length-weight relationship, relative condition factor, age,growth rate, sex ratio and gonado-somatic index of *P. abu* in the AL-Diwaniya River, middle of Iraq, and compared the findings with results from other *P. abu* populations.

2. MATERIALS AND METHODS

2.1 Fish Sampling

Samples of *P. abu* were collected monthly from two sites in the AL-Diwaniya river, middle of Euphrates River, Iraq (Fig. 1) between October 2016 to September 2017. The river is 123 km long, 25-30m wide and 3-5m depth. During the time of this study, water temperatures varied from 10.2 to 32.8°C, dissolved oxygen 4.5-10.0 mg/L, salinity 0.53-0.81% and pH was between 6.5–8.9 (Mohamed and Al-Jubouri, 2017). The predominant vegetation on both banks of this locality was reed, *Phragmites australis*, and cattail, *Typha domingensis,* whereas hornwort, *Ceratophyllum demersum* was dominant in the deeper areas.

Fish were caught using electro-fishing (electricity generator provides 150-300V) and three types of nets. The seine net (3m long and 2.5m depth with a 20mm mesh size), gill nets (25m long with 20x20, 30x30 and 50x50mm mesh sizes) and cast net (9m diameter with 15x15mm mesh size). Fish were immediately preserved in an icebox for subsequent analysis in the Al-Qasim Green University.

2.2 Methodology

The total length of the fish was measured to the nearest mm by using the measuring board and the body weight measured by using electronic balance (Mettler PE 3600) to the nearest 0.1 g. After the measurement, scales were extracted, cleaned, dried and mounted between two slides for binocular microscopic study [30]. The gonads were excised from the body cavity, then sexed and weighed.

Length and weight fish were analyzed using Length (L)-weight (W) relationship, with the formula $W= aL^b$ [31], where W is the weight in grams; L is the total length in mm; a is the intercept; and b is the regression coefficient. The hypothesis of isometric growth (b= 3) was tested by using Student's *t*-test, with values of $p< 0.05$ [32]. The relative condition factor (K_n) was calculated for both sexes by using the equation $K_n= W/W'$ [31], where W= the observed weight and W'= the calculated weight.

Scales were examined for age determination via a Projectina microscope (Type 4014 BK-2) under 20X magnification. The total scale radius and the distance between the focus and their respective annuli were measured. The relationship between the total length and the scale radius was calculated from the following equation: L= a + bS [33], where L= fish length, S= scale radius, a= the correction factor and b= regression coefficient. Back-calculated fish lengths were

determined by the following formula: $L_n = a + S_n /S (L-a)$, where L_n is the length of the fish at age 'n', a is the correction factor, S_n is the radius of the annulus 'n', S is the scale radius and L is the length at the time of capture [33].

The von Bertalanffy growth curve was fitted to the back calculated mean length at age of the species as $L_t = L\infty(1-e^{-K(t-t_0)})$, where L_t is the fish length at age t, $L\infty$ is the asymptotic fish length, K is the growth coefficient and t_0 is the theoretical age when the fish was at zero length by means of Beverton and Holt method [32]. Growth performance index (Ø) was calculated using the equation Ø=logk+2logL∞ [34].

The sex ratio of the sampled population, expressed as males/females' proportion was analyzed and the deviation from 1:1 null hypothesis was statistically tested using the chi-square analysis (χ^2-test). The spawning period was determined following monthly changes in the gonado-somatic index (GSI). The GSI was calculated as GSI=(Gonad weight/Body weight)*100 [35].

All statistical analyses were performed using the Microsoft Office Excel 2010.

3. RESULTS

3.1 Length-Frequency Distribution

The length-frequency data of 1136 fish were pooled from the sampling sites and subsequently grouped with one cm class intervals (Fig 2). The length of the species ranged from 7.0 to 20.0 cm, and the highest frequency length was 12.0 cm constituting 17.9%. The length groups from 10.0 to 14.0 cm were prevailing the catches and formed 67.1%.

3.2 The Length-Weight Relationship

The length-weight relationship of *P. abu* from the river based on 527 individuals ranging from 13.0 to 20.0 cm in total length is presented in Fig. 3. The determination of the general equation of the length-weight relationship of the species was based on the combination of all the data of lengths and weights, without separation of sexes and season. The relationship between body weight and total length calculated on the entire sample was $W=0.020L^{2.821,}$ $r^2= 0.904$. The Student's t-test result showed that there was a significant difference between the values of (b) of fish (2.821) obtained and the expected value of isometric growth, i.e. 3 (t= 4.49, p< 0.05). Therefore, the growth pattern of *P. abu* of Al-Diwaniya River is said to be negative allometric. Also, the corresponding significant correlation coefficient (r^2) indicated a high degree of positive correlation between the standard lengths and body weights.

3.3 Relative Condition Factor

The monthly variations in the relative condition factor (K_n) for males and females of *P. abu* are illustrated in Fig. 4. The lowest value of K_n for females (0.85) was observed in October and the highest value (1.51) was in February, while for males varied from 0.55 in November to 1.22 in February. The mean values of K_n were calculated as 1.13 for females and 0.93 for males.

Fig. 1. Map of Al-Qadisiyah Province showing the sampling sites in Al-Diwaniya River

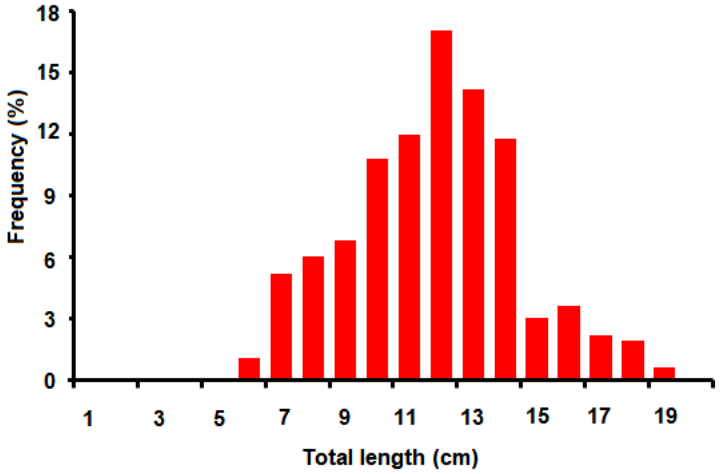

Fig. 2. The overall length frequency of *P. abu*.

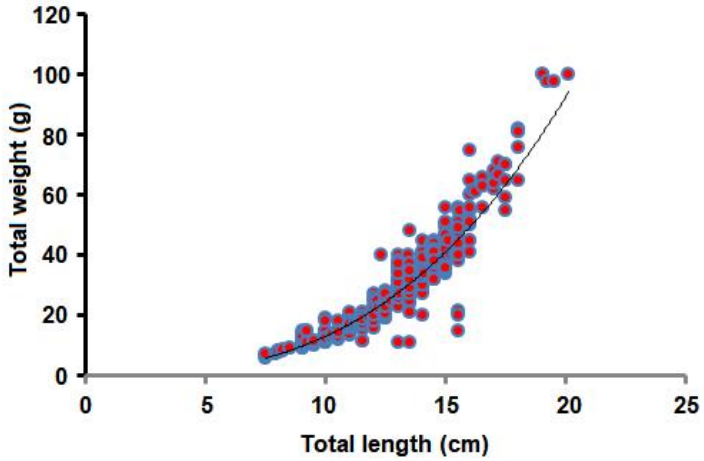

Fig. 3. The length-weight relationship curve for *P. abu*.

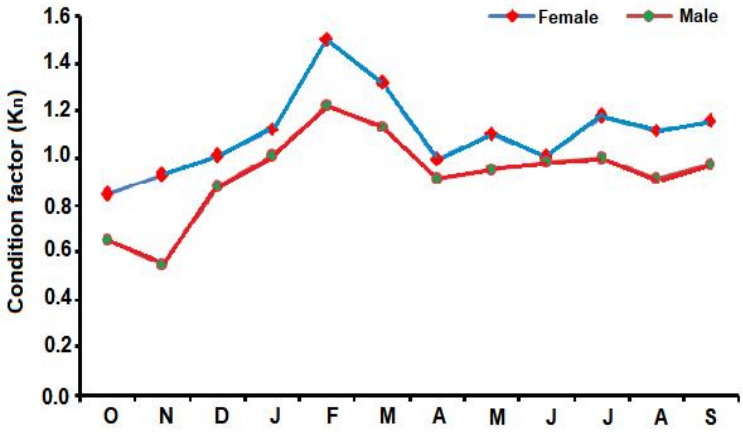

Fig. 4. The relative condition factor of females and males of *P. abu*

3.4 Age and Growth

A total of 131 *P. abu* were examined for age determination. Age of *P. abu* varied from 1 to 4 years and most frequent age was 2 (48.1%), followed by age 1 (31.3%), 3 (13.7%) and 4 (6.9%). The relationship between the fish length (L) and the scale radius (S) was linear, as shown in Fig. 5, and can be represented by the following equation: L= 1.495+0.543S, which reflects the high degree of correlation between these two parameters (r^2= 0.910). The mean size of fish at the time of the formation of scales on the fish body (correction factor) was 1.5 cm.

The mean back-calculated lengths at the end of each year of life are given in Table 1. The mean lengths estimated at ages 1 to 4 years were found to be 10.2, 14.5, 17.2 and 19.3 cm respectively. The highest growth takes place in the first year of life (16.6%), after which the annual increment gradually and progressively decreases with further increase in age.

Using back-calculated lengths at age (Table 1), the von Bertalanffy growth model of the species can be expressed as: L_t= 23.4(1-$e^{-0.386(t+0.271)}$). The growth performance index (Ø) of *P. abu* was calculated as 2.23.

3.5 Sex Ratio and Gonado-Somatic Index (GSI)

The overall ratio of females to males was 1:1.70. A chi-square test of the sex ratio indicated no statistically significant deviations from 1:1 (χ^2=1.071, p<0.05). The monthly variations in the gonado-somatic index (GSI) values for *P. abu* are shown in Fig. 6. The GSI showed higher values for females than for males and both sexes showed a similar trend in GSI value. The GSI values of both sexes were highest in April, 8.5±1.4 for males and 11.6±2.1 for females and to the lowest values in August, 0.22±0.04 for males and 0.75±0.06 for females. The values of GSI for both sexes suggested that the spawning period for the species was from April to May.

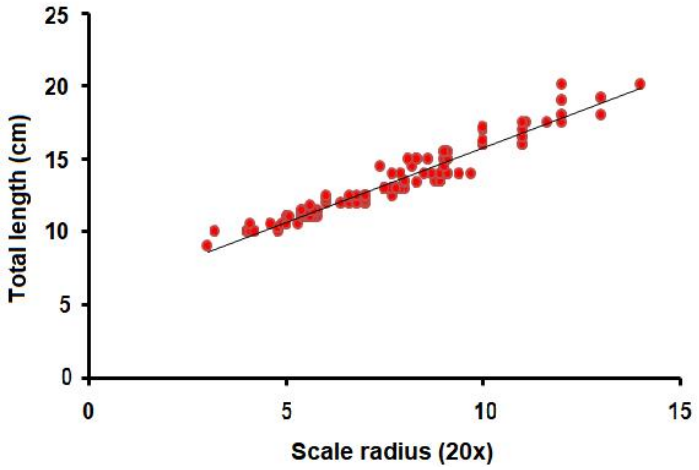

Fig. 5. The relationship between fish length and scale radius of *P. abu.*

Table 1. Mean observed and back-calculated total lengths of *P. abu*

Age	Number of fish	Length at age (cm)				Observed length (cm)
		1	2	3	4	
1	41	10.3				11.4
2	63	10.1	14.6			13.9
3	18	10.2	14.0	17.0		16.6
4	9	10.1	14.1	17.7	19.3	19.0
Mean length (cm)		10.2	14.5	17.2	19.3	
Annual increment (cm)		10.2	4.3	2.8	2.1	
% Growth increment		16.6	7.1	4.5	3.4	

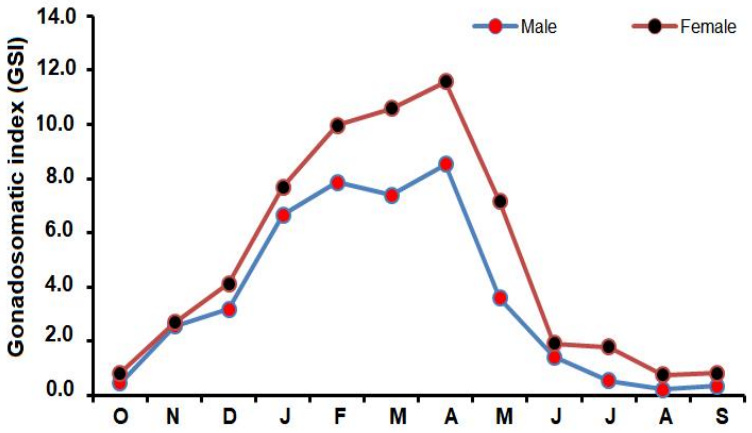

Fig. 6. Monthly variations in the GSI of *P. abu*.

4. DISCUSSION AND CONCLUSION

The lengths of *P. abu* individuals in the present study varied from 7.0 to 20.0 cm and were compared with those obtained for the species by the various authors in different geographic localities. The length range of the species was comparable with those reported by some authors, such as 10.9-20.3 cm in the Tigris River, Turkey [25], 4.0-20.0 and 3.0-19.0 cm in Huwazah and Chybaish marshes, respectively [20], 2.3-19.4 cm in the Orontes River, Turkey [4], 3.7-20.9 cm in Hawr Ad Dalmaj marsh, Iraq [23] and 6.4-19.7 cm in the Shatt Al-Arab River [36].In contrast, other authors recorded higher values of length for this species in other waters, like 12.6-22.8 cm in the Atatürk Dam Lake, Turkey [27], 11.1-22.2 cm in the same lake [28], 2.0-22.0 cm in East Hammar marsh [20],1.4-21.3 cm in East Hammar marsh [21] and 4.0-23.1 cm in Ceyhan River Basin, Turkey [29]. However, Jorfipour *et al*. [6] found that the length range of *P abu* in the Karun River, Iran was 10.0-17.3 cm. These differences may be related to environmental factors, food supply, population density, fishing pressure, and possibly using different fishing gears [37,38].

The study exhibited that the estimated growth coefficient (b) of *P. abu* was 2.821, indicating negative allometric growth, i.e. the fish becomes lighter for its corresponding length [38]. Similar negative allometric growth for *P. abu* population was reported in different locations, like 1.995 to 2.104 in the fish farm at Babylon province, Iraq [18], 2.08 for males and 2.87 for females in the Atatürk Dam Lake, Turkey [28], 2.899, 2.910 and 2.662 in East Hammar, Huwazah and Chybaish marshes, respectively [20], 2.934 in East Hammar marsh [21] and 2.980 in Hawr Ad Dalmaj marsh, Iraq [23]. However, some studies indicated positive allometric growth, such as 3.332 in the Tigris River, Turkey [25] and 3.246 for females in the Orontes River, Turkey [4]. In contrast, other studies indicated isometric growth of *P. abu,* such as 2.938 for males in the Orontes River, Turkey [4], 3.022 in Ceyhan River Basin, Turkey [29] and 3.056 in the Euphrates River, Iraq [39]. The variation in the values of growth coefficient (b) for the species in different habits could be referred to several factors included habitat, season, the size range of fish, stage of maturity, sex, food availability, stomach fullness, disease and parasite loads, stress, and sampling methodology [32,40,41].

Results in this study indicate that the changes of the relative condition factor of *P. abu* showed similar patterns for both sexes based on months. The same finding has been noted for the species in some Turkish waters [25, 28, 4]. The lowest value of K_n for females (0.85) of *P. abu* in the present study was observed in October and the highest value (1.51) was in February, while for males varied from 0.55 in November to 1.22 in February. Unlü *et al.* [25] referred that the highest values of K_n of *P. abu* in the Tigris River, Turkey was in August, while the lowest was in October for females and November for males. Doğu *et al.* [28] found that the lowest values of the condition of *P. abu* in the Atatrk Dam Lake, Turkey were in July (male= 1.07 and female= 0.99), meanwhile their highest values were in August (male= 1.37 and female= 1.30). However, Ay and Özcan [4] stated that the values of K_n of *P. abu* in the Orontes River, Turkey was

calculated as 0.59 in May and 1.11 in March for males, and between 0.56 in May and 1.19 in March for females. The general pattern of relative condition factor of *P. abu* was high from February to March coincided with the growth of the gonads, then declined after that corresponding with the spawning time of the species. Doğu *et al.* [28] showed that the lowest condition values of *P. abu* in Atatürk Dam, Turkey was in July at the reproduction activity of the species was completed before July. The fluctuations in the condition factor of many fish were observed concerning their reproductive cycle, feeding conditions and other environmental and physiological factors [42-45].

The results revealed that the *P. abu* population of the studied river has a narrow age range from 1 to 4 years. Similar age results were reported for the Tigris River, Turkey [25], the Orontes River, Turkey [4] and the East Hammar marsh [22]. On the other hand, specimens up to 6 years old were reported for the Ceyhan River Basin, Turkey by Birecikligil *et al*. [29]. This can be because of fishing pressure and sampling method.

Table 2 shows the comparison of the growth rates of *P. abu* in the present study with those obtained for the species by the various authors in different geographic localities. The growth rates in the present.

study was within the range of the growth of the species reported from other waters and for all ages. However, Birecikligil *et al*. [29] recorded the highest growth (21.2 cm) at age 6 in the Ceyhan River Basin, Turkey. The value of ultimate growth of length (L∞) was closely like the values recorded by Mohamed [20] and Mohamed *et al*. [22] in the East Hammar marsh, but lower than those recorded by Doğu *et al*. [28] and Birecikligil *et al*. [29] in the Atatürk Lake and Ceyhan River, Turkey, respectively, and better than those recorded by other authors (Table 2). The growth performance index (Ø) of *P. abu* in the present study (2.23) was like those reported for the species by Doğu *et al.* [28] in the Atatürk Dam Lake, Turkey and Mohamed [20] in the Chybaish marsh. However, the lowest value of Ø was recorded by Ay and Özcan [4] in the Orontes River, Turkey and the highest value was mentioned by Birecikligil *et al*. [29] in the Ceyhan River Basin, Turkey. The differences between the growth characteristics among populations in different regions involving the same species may be attributed to variation in environmental conditions such as water temperature, diversity, availability of food items, over-exploitation of natural stocks and the genetic constitution of the individuals [46,42].

Table 2. Growth comparison of *P. abu* in different ecosystems

References	Mean total length at each age (cm)						L∞	Ø	Ecosystems
	1	2	3	4	5	6			
Unlü *et al.* [25] ♀	13.3	15.3	16.2	17.6	-	-	19.6	2.34	Tigris River,
♂	12.7	15.3	16.0	17.6					Turkey
Doğu *et al*. [28]	11.4	14.9	17.5	18.9	20.2	-	24.6	2.23	Atatürk Lake, Turkey
Mohamed [20]	7.5	12.5	15.5	18.2	20.1	-	23.2	2.30	East Hammar marsh
Mohamed [20]	7.5	12.5	15.5	17.5	19.3	-	21.1	2.29	Huwazah marsh
Mohamed [20]	6.5	11.5	14.5	16.7	17.8	-	20.0	2.22	Chybaish marsh
Ay and Özcan [4] ♀♂	-	-	-	-	-	-	20.3 19.5	2.18	Orontes River, Turkey
Birecikligil *et al*.[29]	9.7	13.9	15.0	16.1	18.2	21.2	27.9	2.89	Ceyhan River, Turkey
Mohamed *et al*.[22]	10.6	14.7	17.8	19.8		-	23.3	-	East Hammar marsh
Shakir and ♀	8.6	10.8	12.7	14.5	-	-		-	Euphrates
Al-Asadiy [39] ♂	8.9	11.2	13.2	15.0	16.0				river, Iraq
Mohamed and Abood [36]	-	-	-	-	-	-	21.2	2.29	Shatt Al-Arab River
Present study	10.1	14.1	17.7	19.3	-	-	23.4	2.23	AL-Diwaniya River

The overall sex ratio (males: females) of *P. abu* in the present study was 1:1.70, which was biased toward females. This is in the agreement with that reported for the species in other waters, such as 1:1.21 in the Tigris River, Turkey [25], 1:2.7 in the Khuzestan Province, Iran [24], 1:1.04 in the Atatürk Dam Lake, Turkey [27,28], 1:1.29 in the Orontes River, Turkey [4], 1:1.45 in the in East Hammar Marsh, Iraq [22] and 1:1.37 in the Hawr Ad Dalmaj marsh, Iraq [23]. However, Jorfipour *et al*. [6] stated that the sex ratio of *P. abu* in the Karun River, Iran was 1:1. The sex ratio in most species is close to one, but it may vary depends on different factors like differences in mortality rates between sexes, spawning, migration, and differences in growth between sexes, selectivity of fishing gears and differences in sampling and different habitats [37,46,47].

The state of the gonad-somatic index (GSI) for females and males of *P.abu* through the studied period indicates that the spawning period of the species took place from April to May. During this study, water temperatures varied from 10.2°C in March to 32.8°C in August [15]. Al-Shawi and Wahab [19] found that the spawning of *P. abu* in Tuz-Chi tributary, north Iraq occurred from March to May. Chelemal *et al.* [24] pointed that the spawning of the species in the Khuzestan Province, Iran extended from February to June. Şahinöz *et al*. [27] reported that the spawning of *P. abu* took place between April and August in the Atatürk Dam Lake, Turkey. Also, Ay and Özcan [4] found that the period between April and August represented the spawning period of *P. abu* in the Orontes River, Turkey. The spawning period of *P. abu* in the East Hammar marsh extended from January to May [22] and the same period for the species in the Hawr Ad Dalmaj marsh [23]. Jorfipour *et al*. [6] pointed that the species spawning happening in April-May in the Karun River, Iran. The variation in the timing of spawning may be linked to age, size, condition, and other factors such as geographic distribution, climatic conditions, and nutritional status of fish [37,48].

The results showed some biological properties such as lengths of individuals, negative allometric growth, ages from 1 to 4 years, values of ultimate growth (L∞) and growth performance index (Ø) and overall sex ratio were among those described for the species in other waters. These results can contribute to providing information for species management in the study river.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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