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Research Article

Some biological aspects of four marine fish species in Iraqi marine waters, northwest Arabian Gulf

Ali H. Al-Hassani
Department of Fisheries and Marine Resources, College of Agriculture, University of Basrah, Iraq
Abdul-Razak M. Mohamed*
Department of Fisheries and Marine Resources, College of Agriculture, University of Basrah, Iraq

*Corresponding Author. E-mail: abdul19532001@yahoo.com

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Abstract
The study described some biological characteristics of four commercially important fish species in Iraqi marine waters including *Planiliza klunzengeri*, *P. subviridis*, *Acanthopagrus arabicus* and *Otolithes ruber* from February 2020 to January 2021. The length and weight of individual fish caught were measured. The length-weight relationships were $W= 0.027L^{2.715}$ for *P. klunzengeri,* $W= 0.034L^{2.670}$ for *P. subviridis,* $W= 0.030L^{2.867}$ for *A. arabicus* and $W= 0.023L^{2.755}$ for *O. ruber,* and all species indicated negative allometric growth. The lower values of the relative condition factor (K_n) were found at the mid-lengths of *P. klunzingeri* and *P. subviridis*, and the large individuals for *A. arabicus* and *O. ruber*. Scales were used for age determination and measurements, and the back-calculated lengths-at-ages were calculated using the body proportional formula. Asymptotic total lengths ($L\infty$) estimated were 29.6, 32.8, 44.9 and 70.6 cm for *P. klunzengeri*, *P. subviridis, A. arabicus* and *O. ruber*, respectively. These results could assist in fisheries management for the sustainable exploitation of these commercially important species in Iraqi marine waters.

Keywords: Age and growth, Arabian yellowfin seabream, Mullets, Northwest Arabian Gulf, Tiger tooth croaker

INTRODUCTION

The Klunzinger's mullet, *Planiliza klunzingeri* (Day, 1888) and the greenback mullet, *Planiliza subviridis* (Valenciennes, 1836) belong to the Mugilidae family, which comprises 46 available genera, 26 valid genera, 304 available species and 80 valid species in the world (Fricke *et al.,* 2022). Mohamed and Jawad (2021) showed that there were seven species belonging to the Mugilidae living in the Iraqi waters, namely Abu mullet *Planiliza abu* (Heckel, 1843), Klunzinger's mullet *P. klunzingeri* (Day, 1888), Greenback mullet *P. subviridis* (Valenciennes, 1836), Largescale mullet *P. macrolepis* (Smith, 1846), Keeled mullet *P. carinata* (Valenciennes, 1836), Silver mullet *Osteomugil speigleri* (Bleeker, 1858) and Longarm mullet *O. cunnesius* (Valenciennes, 1836). They are widely distributed in the Iraqi marine waters and enter the rivers and marshes of southern Iraq for feeding and are locally known as “Beyah”. They are considered a commercially important species in these waters. The total landing of mullet species in the artisanal fisheries in the Iraqi marine waters including the study species, was about 1439 tons, composed about 12.7% of the total Iraqi marine landings and predominated the landings during 2019 (Mohamed and Abood, 2020a).

Arabian yellowfin seabream, *Acanthopagrus arabicus* Iwatsuki, 2013 belongs to the Sparidae family and is widely distributed in the northwestern Indian Ocean: Arabian Gulf and Oman east to Pakistan and India (Iwatsuki, 2013; Esmaeili *et al.* 2014; Parenti, 2019). The individuals of *A. arabicus* inhabit the Iraqi marine waters, and their juveniles enter the rivers and marshes of southern Iraq for feeding and are locally known as “Shank”.

The tiger tooth croaker (*Otolithes ruber*), locally known as “Newaiby” belongs to the Sciaenidae family, one of the most common fish families in the Iraqi artisanal marine fisheries in the northwest of the Arabian Gulf. The sciaenid species in the Iraqi waters are tigertooth croaker, *O. ruber*, sin croaker, *Johnieops sina* (synonym of *Johnius dussumieri*), silvery croaker, *Johnius belangerii* and blotched croaker, *J. maculates*, which formed about 5.02% (568 tons) of the total Iraqi marine landings during 2019 (Mohamed and Abood, 2020a).

Although many studies have been conducted on the growth of *P. klunzengeri, P. subviridis, A. arabicus* and *O. ruber* in different regions of the world using FiSAT II software (Gayanilo *et al.,* 2005) such as Hakimelahi *et al*. (2012); Mohd Rosli (2012); Mohamed *et al*. (2013); Rahman *et al*. (2016); Santhoshkumar *et al.* (2017); Farkhondeh *et al*. (2018); Mustafa *et al*. (2019); Baloch *et al*. (2020); Mohamed and Abood (2020b); Mzingirwa *et al*. (2020); few studies on the growth of some of these species were conducted using fish scales or otoliths, such as Wiheyaratne and Costa (1987) in a tropical lagoon in Sri Lanka; Al-Daham and Wahab (1991) in the Shatt Al-Basrah Canal, Iraq; Mohamed *et al*.. (1998) in the northwest Arabian Gulf; Brash and Fennessy (2005) in the KwaZulu-Natal, South Africa; Eskandari *et al*. (2012) in the northwestern part of the Arabian Gulf and Rahnama *et al*. (2017) in Oman Sea, Iran.

Due to the importance of these four species as essential commercial species in the Iraqi marine fisheries, some biological aspects of these species were described including the length-frequency distribution, length-weight relationship, age, growth rate and growth model of *P. klunzengeri*, *P. subviridis*, *A. arabicus* and *O. ruber* in the Iraqi marine waters, northwest Arabian Gulf was studied to provide the basis for proper management of these commercially important species in this region.

MATERIALS AND METHODS

The materials for this study were obtained from Iraqi marine waters, northwest Arabian Gulf (Fig. 1) from February 2020 to January 2021. The region is dominated by the large river delta of the rivers Euphrates, Tigris and Karun, merging into the Shatt Al-Arab represents the central outflow in the Arabian Gulf (Pohl *et al*., 2014). Despite the restriction of the Iraqi coastline of 105 km, continental shelf of 1034 km^2 and territorial sea of 716 km^2 (Earth Trends, 2003), but considered the most productive area in the Gulf due to running off the Shatt Al-Arab River (Al-Yamani, 2021).

Monthly random samples of *P. klunzengeri*, *P. subviridis, A. arabicus* and *O. ruber* were collected from the Shaheen steel-hulled dhow (21 m length, 7 m wide and 2m draft with a horsepower of 150 horses), and from the catches of local artisanal fishermen at the leading fish landing site of Al-Fao port, 100 km south of Basrah city. Fig. 1 illustrates the main fishing grounds for Iraqi marine fisheries, including the Shatt Al-Arab estuary, Khor Abdulla and Khor Al-Amaya (Mohamed *et al*., 2005). The fishermen employed different fishing gears such as drift gillnets, trawl nets, traps (gargoor), stake nets (hadra) and hook and line (Mohamed and Jawad, 2021). Subsamples of fish were immediately iced and transported to the laboratory for measuring the total length (L) of each fish to the nearest 0.1 cm using a flexible measuring tape and the total body weight (W) was recorded to the nearest 0.1 g using an electronic balance.

The length-weight relationship for each species was described by the power equation: $W= aL^b$ (Le Cren, 1951), where a and b are the intercept and the slope, respectively. The type of growth for each species was assessed by testing the slope (b) from the value 3 using the Student's t-test. The t-test was used to determine if the b value was significantly different from 3 (isometric growth). The relative condition factor (K_n) for each species was calculated using the equation K_n= W'/W (Le Cren, 1951), where W'= the observed weight and W= the calculated weight.

Four to six scales were collected from the left side of each fish to determine the age between the lateral line and the dorsal fin base. Scales were cleaned in water then dried and mounted dry between two microscopic glass slides (Schneider, *et al.,* 2000). Scale reading was carried out at a magnification of 10X using a modified slide projector (model Pradovit P150). Thereafter, the scale radius and radius of annuli were measured with a ruler and only complete annuli were counted according to the method recommended by Bagenal and Tesch (1978).

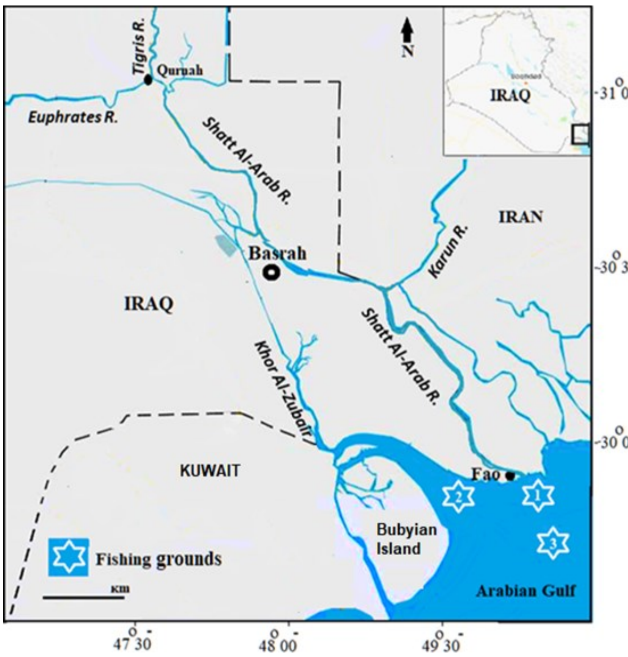

Fig. 1. *Fishing grounds in Iraqi marine waters, northwest Arabian Gulf*

The relationship between fish length (L) and the radius of scale (S) was described by the equation: L= a + b S (Bagenal and Tesch, 1978), where "a" is the intercept (correction factor) and "b" is the slope of the regression line. The back-calculated lengths-at-ages were estimated using the back-calculation method as recommended by Bagenal and Tesch (1978): 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 the scale radius and L is the length at the time of capture. Age validation was confirmed using modal class progression analysis, as available in the ELEFAN I module implemented in the FiSAT II (FAO- ICLARM Stock Assessment Tools) software (Gayanilo *et al.* 2005) as was applied by Al-Hassani and Mohamed (2021) and Mohamed and Al-Hassani (2021a, b, c).

The growth was modelled using the von Bertalanffy growth equation (VBGE) following the Beverton and Holt method using the back-calculated mean lengths for each age of the species (Ricker, 1975): $L_t= L\infty[1-e^{-k(t+t0)}]$, where L_t is the total fish length at age t, L∞ is the asymptotic total length, K is the growth coefficient, and t_0 is the hypothetical age when fish would have been at 0 cm total length. All analyses were performed using Microsoft Excel (ver. 10) and SPSS software (ver. 16.0).

RESULTS

Length-frequency distributions

The overall length-frequency distributions of *P. klunzingeri, P. subviridis, A. arabicus* and *O. ruber* from the Iraqi marine waters are illustrated in Fig. 2. The length-frequency distribution of 3319 individuals from *P. klunzingeri* was involved with lengths ranging from 11.0 to 27.0 cm. The most frequent length was 17 cm composing about 11.0% of the total catch, and the majority of fish sampled were within a restricted size range of 14.0-19.0, with 63.1% of the sample. A total of 3350 length-frequency distribution data of *P. subviridis* was gathered during the study period and the fish lengths ranged from 12.0 to 30.0 cm, and the major peak was at the length of 18.0 cm, forming 10.8% of the total caught. The population is dominated by middle-sized fish 16.0-22.0 cm, constituting 61.6% of the total catch. The sample of *A. arabicus* is composed of 3484 individuals with lengths ranging from 13.0 to 41.0 cm. The most frequent length group percentages were 7.26, 6.31 and 5.86%, corresponding to length groups 24, 28 and 19 cm. The dominant individuals ranged from 19 to 29 cm and formed 62.7% of the total catch. The length frequency of 3835 individuals from *O. ruber* was assembled in length groups with 3 cm intervals, ranging in total length from 17 to 60 cm. Amongst these, over 62.5% of the catch ranged in length between 20 to 34 cm. More importantly, the length group of 26 cm composed about 5.4% of the total catch.

Length-weight relationships

The descriptive statistics of the length-weight relationship (combined sexes) including sample sizes (N), length and weight range, regression parameters a and b, and the coefficient of determination (r^2) for *P. klunzingeri*, *P. subviridis*, *A. arabicus* and *O. ruber* (combined sexes)from the Iraqi marine waters demonstrated in Table 1.

The sample size for determining the length-weight relationships ranged from 500 (*P. klunzengeri*), 324 (*P.*

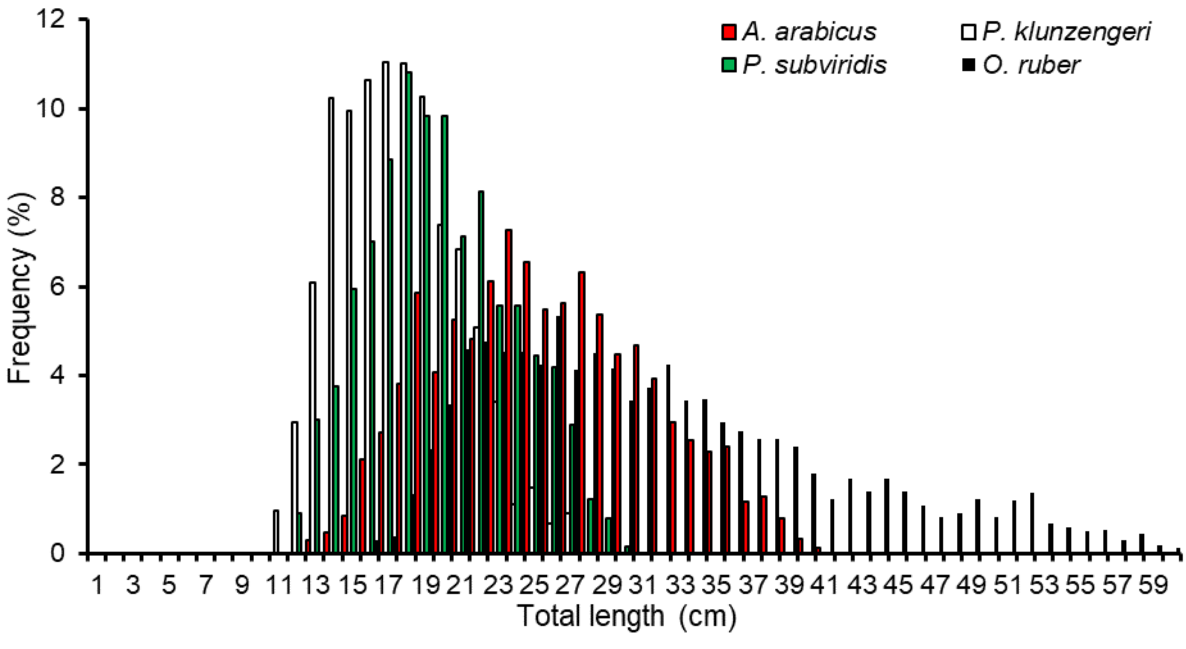

Fig. 2. *Overall length-frequency distributions of studied fish species*

subviridis), 319 (*A. arabicus*) and 264 (*O. ruber*) individuals. The growth coefficient (b) varied from 2.670 for *P. subviridis* to 2.867 for *A. arabicus.* The t-test revealed that the regression slopes (b) in the length-weight relationships for all species were significantly different from value 3 (t= 20.09, p<0.05 for *P. klunzengeri,* t= 15.5 for *P. subviridis,* t= 9.2 for *A. arabicus* and t= 16.86 for *O. ruber*) indicated negative allometric growth for all species.

Relative condition factor

Variations in the mean relative condition factor (K_n) of the four species for different length groups (combined sexes) are presented in Figs. 3 and 4. It was clear from Fig. 3 that the lower values in the K_n were observed at mid-lengths for *P. klunzingeri* and *P. subviridis*, while the higher values of K_n were for small and large individuals for both species. The K_n for *P. klunzingeri* is the lowest value (0.93) in the 23 cm length group and shows the highest value (1.15) in the 13 cm length group, and for *P. subviridis* from 0.99 in the 24 cm length group to 1.26 in the 13 cm length group.

On the other hand, it was clear from Fig. 4 that irregularity is found in the values of K_n for *A. arabicus* and *O. ruber* and did not show noticeable trends. However, there was a somewhat decline in the fish condition factor in fish with larger sizes for both species. The lowest value of K_n for *A. arabicus* was 0.92 in the length group 40 cm and the highest one was 1.13 in the length of 20 cm, and for *O. ruber* varied from 0.84 in the length group 56 cm to 1.15 at 18 cm. The mean relative condition factor was 1.09 (±0.07), 1.03 (±0.09), 1.01 (±0.05) and 1.03 (±0.08) for *P. klunzingeri*, *P. subviridis*, *A. arabicus* and *O. ruber*, respectively.

Age and growth

The ages of the collected specimens from scales showed there were five ages (1-5) for *P. klunzengeri,* six ages (1-6) for *P. subviridis,* six ages (1-6) for *A. arabicus* and eight ages (1-8) for *O. ruber.*

The scatter diagrams denote the straight-line relationships between fish length (L) and scale radius (S) for the four species (Fig. 5). The computed equations of the total length-scale

radius relationships of the species can be expressed as follows:

L= 1.421 - 1.182S; n= 72; r^2= 0.962 for *P. klunzengeri,*
L= 1.376 - 0.832S; n= 82; r^2= 0.955 for *P. subviridis,*
L= 1.744 + 5.560S; n= 96; r^2= 0.981 for *A. arabicus,*
L= 2.833 + 3.143S; n= 153; r^2= 0.955 for *O. ruber.*

The scales are firstly deposited on the fish body, when they have 1.42 cm length for *P. klunzengeri,*1.38 cm length for *P. subviridis,* 1.74 cm length for *A. arabicus* and 2.83 cm length for *O. ruber.* The linear agreement of the relationships was supported by high coefficient correlations (r^2) for all species, which confirm the close association of the length of each species with the growth of their scales.

The lengths calculated corresponding to the various ages of *P. klunzingeri* were 10.6, 16.5, 19.4, 23.6 and 25.1 cm for the first five years of life, respectively,

The average back-calculated lengths at different years of life for *P. klunzingeri* and *P. subviridis,* and *A. arabicus* and *O. ruber* were done in Tables 2 and 3, respectively. The lengths calculated corresponding to the various ages of *P. klunzingeri* were 10.6, 16.5, 19.4, 23.6 and 25.1 cm for the first five years of life, and of *P. subviridis* were 10.5, 16.3, 18.9, 22.6, 24.4 and 27.1 cm for the first six years of life, while of *A. arabicus* were 16.2, 24.3, 28.2, 30.8, 35.7 and 38.4 cm for the first six years of life, and of *O. ruber* were 17.4, 29.2, 34.7, 40.4, 44.7, 48.5, 53.6 and 58.1 cm for the first eight years of life. The highest annual increment in length was found during the first year of life of the four species, followed by a period of slow growth rates in the rest of their life. The average back-calculated lengths at different years of life for *P. klunzingeri* and *P. subviridis,* and *A. arabicus* and *O. ruber* were done in Tables 2 and 3, respectively. The lengths calculated corresponding to the various ages of *P. klunzingeri* were 10.6, 16.5, 19.4, 23.6 and 25.1 cm

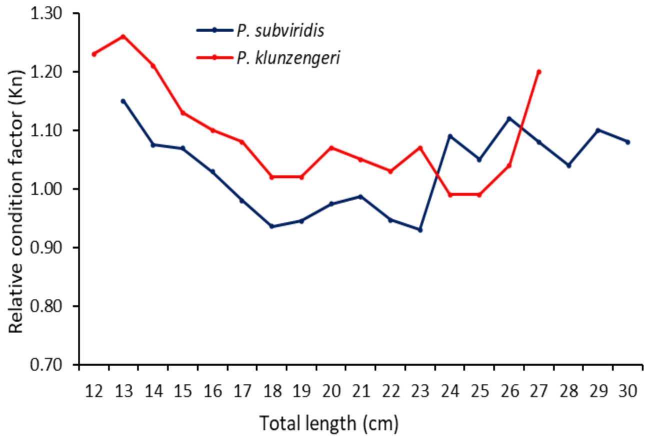

Fig. 3. *Variations of mean relative condition factor (K_n) of P. klunzengeri and P. subviridis*

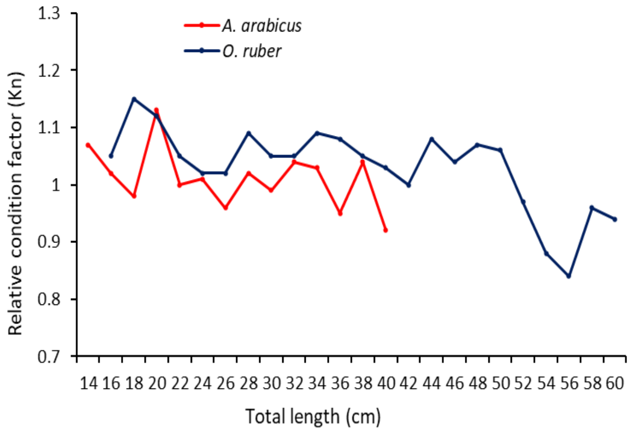

Fig. 4. *Variations of mean relative condition factor (Kn) of A. arabicus and O. ruber*

Table 1. Measurements and parameters of weight-length relationships of the four species

Species	N	Length range (cm)	Weight range (g)	Length-weight relationship		
				a	b	r^2
P. klunzengeri	500	13-30	32-308	0.027	2.715	0.990
P. subviridis	324	13-30	36-352	0.034	2.670	0.980
A. arabicus	319	14-41	53-1161	0.030	2.867	0.992
O. ruber	264	17-60	67-1714	0.023	2.755	0.993

Table 2. Back-calculated lengths (cm) at the end of the different years of the life of *P. klunzengeri* and *P. subviridis*

Age	No of fish	Length (cm)		Calculated lengths (cm) at age					
		Observed	VBGE	1	2	3	4	5	6
P. klunzengeri									
1	14	12.8	10.3	9.8					
2	15	16.0	16.2	10.4	16.3				
3	16	19.9	20.3	10.7	16.6	18.8			
4	14	23.4	23.2	11.1	16.8	19.6	23.5		
5	11	26.1	25.1	11.4	16.3	19.9	23.8	25.1	
Mean length (cm)				10.6	16.5	19.4	23.6	25.1	
Annual increment (cm)				10.6	5.9	2.9	4.2	1.5	
% growth increment				42.2	23.4	11.5	16.7	6.1	
P. subviridis									
1	17	13.4	10.4	10.1					
2	14	15.6	15.6	10.4	16.1				
3	14	19.2	19.5	10.3	16.3	18.6			
4	12	22.3	22.6	10.7	16.5	18.8	22.1		
5	13	25.7	25.0	11	16.7	19.1	22.8	24.2	
6	9	28.5	26.8	11.4	17.5	19.5	23	24.8	27.1
Mean length (cm)				10.5	16.3	18.9	22.6	24.4	27.1
Annual increment (cm)				10.9	5.8	2.6	3.8	1.8	2.7
% growth increment				39.7	21.1	4.9	13.7	6.6	9.6

for the first five years of life, and of *P. subviridis* were 10.5, 16.3, 18.9, 22.6, 24.4 and 27.1 cm for the first six years of life, while of *A. arabicus* were 16.2, 24.3, 28.2, 30.8, 35.7 and 38.4 cm for the first six years of life, and of *O. ruber* were 17.4, 29.2, 34.7, 40.4, 44.7, 48.5, 53.6 and 58.1 cm for the first eight years of life. The highest annual increment in length was found during the first year of life of the four species, followed by a period of slow growth rates in the rest of their life.

The lengths determined by back-calculation of the four species were used to determine the length growth models, according to the von Bertalanffy growth equation (VBGE). These models are as follows:

L_t= 29.6(1-$e^{-0.366(t+0.177)}$) for *P. klunzengeri,*

L_t= 32.8(1-$e^{-0.262(t+0.458)}$) for *P. subviridis,*

L_t= 44.9(1-$e^{-0.286(t+0.515)}$) for *A. arabicus,*

L_t= 70.6(1-$e^{-0.179(t+0.74)}$) for *O. ruber.*

The length-at-ages of *P. klunzengeri*, *P. subviridis, A. arabicus* and *O. ruber* derived from the von Bertalanffy growth equation (VBGE) are given in Tables 2 and 3, and Fig. 6. The comparison of observed, back-calculated and VBGE lengths at different years of life (Tables 2 and 3) showed good agreement, and there were no significant differences between them for the four species (ANOVA: F=019, 0036, 0134 and 0013; P= 0.981, 0965, 0876 and 0987, respectively). Asymptotic total lengths (L∞) estimated were 29.6, 32.8, 44.9 and 70.6 cm for *P. klunzengeri*, *P. subviridis, A. arabicus* and *O. ruber*, respectively.

DISCUSSION

The analysis of the length composition of *P. klunzengeri* in this study revealed that the individuals ranged from 11.0 to 27.0 cm, which the higher limit was larger than those obtained for this species by other authors in the Arabian Gulf (Dadzie et al., 2005; Hakimelahi *et al*., 2010) and in the Shatt Al-Arab River (Mohamed and Abood, 2020b). While, the length range of individuals of *P. subviridis* (12.0 to 30.0 cm) was found to be similar to those documented by Al-Daham and Wahab (1991) from Shatt Al-Basrah Canal and

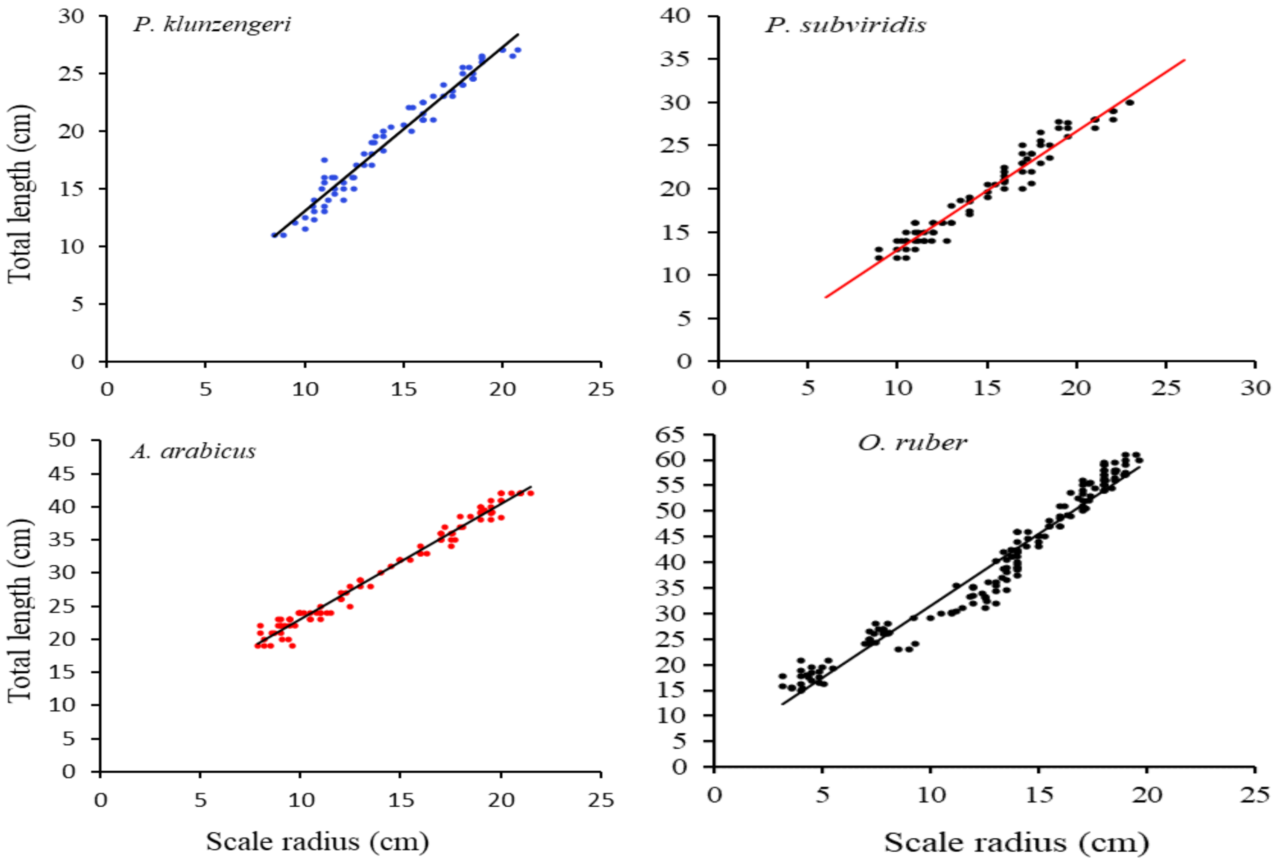

Fig. 5. *Relationships between fish length and scale radius of the four species*

Table 3. Back-calculated lengths (cm) at the end of the different years of the life of *A. arabicus* and *O. ruber*

Age	No of fish	Length (cm) Observed	VBGE	1	2	3	4	5	6	7	8
				Calculated lengths (cm) at age							
A. arabicus											
1	18	20.7	15.8	15.1							
2	18	23.6	23.0	16.2	23.8						
3	15	28.2	28.5	16.4	23.8	27.7					
4	14	34.2	32.6	16.6	23.9	27.5	29.4				
5	14	38.2	35.6	16.4	24.8	28.4	31.0	35.5			
6	13	41.3	37.9	17.0	25.4	29.3	31.6	35.9	38.4		
Mean length (cm)				16.2	24.3	28.2	30.8	35.7	38.4		
Annual increment (cm)				16.2	8.2	3.9	2.6	4.9	2.7		
% growth increment				42.1	21.2	10.2	6.8	12.8	7.0		
O. ruber											
1	22	17.6	18.9	16.5							
2	25	26.8	27.4	16.1	26.4						
3	21	34.4	34.5	16.9	27.5	33.7					
4	20	40.6	40.4	17.4	28.8	33.9	39.9				
5	20	44.9	45.3	17.9	29.6	34.4	39.1	43.6			
6	20	53.1	49.5	17.3	29.8	35.0	39.5	44.3	47.1		
7	12	56.6	52.9	17.9	30.6	35.5	40.5	44.1	48.6	53.2	
8	14	59.1	55.8	19.0	31.9	35.9	43.0	46.6	49.9	54.1	58.1
Mean length (cm)				17.4	29.2	34.7	40.4	44.7	48.5	53.6	58.1
Annual increment (cm)				17.3	11.9	5.5	5.6	4.3	3.9	5.1	4.4
% growth increment				29.8	20.5	9.5	9.7	7.4	6.7	8.8	7.6

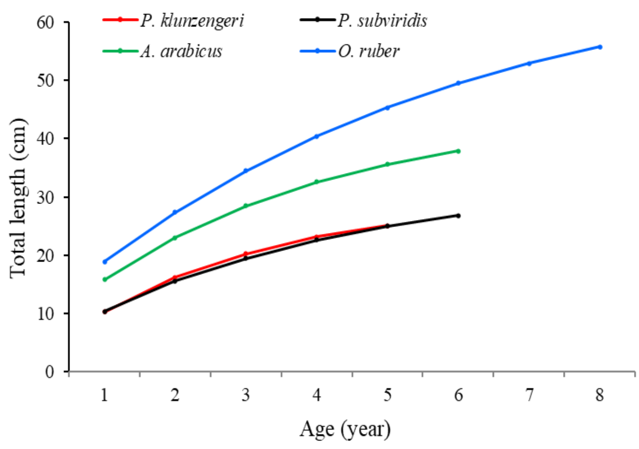

Fig. 6. *Length-at-ages of the four species derived from VBGE*

Mohamed *et al*. (2013) from East Hammar marsh, but was higher than those stated by Samad and Abbas (1999) from Sandspit backwaters along Karachi coast, Pakistan; Zolkhiflee (2016) from Pinang River Estuary, Malaysia, and Mohamed and Abood (2020b) from the Shatt Al-Arab River. Also, the size of the individuals of *A. arabicus* (13.0 to 41.0 cm) was found to be similar to those documented for the species by Resen *et al.* (2008) from Iraqi marine waters but was higher than those stated by Riaz *et al.* (2017) from the Karachi coast, Pakistan. However, Mohamed *et al.* (2010) reported higher lengths for *A. arabicus* from Iraqi marine waters. Moreover, the size range of *O. ruber* in the present study (17-60 cm) was within the values documented for the species in the other local studies (Ali *et al.*, 2002; Resen *et al.*, 2010), whereas higher than those reported by other authors in other regions (Schultz, 1992; Al-Matar, 1993; Brash and Fennessy, 2005; Khodadadi *et al.,* 2010; Eskandari *et al*., 2012; Raeisi *et al*., 2012; Santhoshkumar *et al.,* 2014; Farkhondeh *et al*., 2018; Baloch *et al*., 2020; Mzingirwa *et al.*,2020). The differential in fish sizes for the same species in the various waters could be related to several factors, like variation in the ecological condition, food availability, population density, fishing pressure and using different fishing gears (Nikolsky, 1963; Weatherley and Gill, 1987; Riedel *et al*., 2007; Cuadrado *et al*. 2019).

Riedel *et al.* (2007) stated if the value of regression coefficient (b) for the length-weight relationship is 3.0 indicates that the growth type is isometric, or higher than 3.0 refers to positive allometric growth, or when lower than 3.0 means negative allometric growth. Accordingly, the growth of the four studied species displayed negatively allometric growths, i.e. the fish becomes lighter for its corresponding length. Hakimelahi *et al.* (2010) showed the same growth for *P. klunzengeri* in the Iranian waters of the Arabian Gulf and Oman Sea. A similar growth type was also recorded for *P. subviridis* by Shadi *et al*. (2011) in Iranian waters, north of the Arabian Gulf; Mohd Rosli (2012) in Merbok estuary, Malaysia; Rahman *et al.* (2016) in the Parangipettai Waters, India; Baloch *et al.* (2015) in Damb Harbour, Pakistan and Zolkhiflee (2016) in the Pinang River, Malaysia. In contrast, Zolkhiflee (2016) reported an isometric pattern (b= 3.028) for females' *P. subviridis* in the Pinang River, Malaysia. Moreover, Mathews and Samuel (1991) in Kuwait waters, Arabian Gulf, Riaz *et al.* (2017) in the Karachi coast, Pakistan and Vahabnezhad *et al.* (2017) in Iranian waters, Arabian Gulf noted a negative allometric growth for *A. arabicus* in these waters. Some studies exhibited a negatively allometric growth for *O. ruber* (Mohamed *et al*., 1998; Resen *et al*., 2010; Eskandari *et al*., 2012), while other studies demonstrated isometric growth (Raeisi *et al*., 2012; Santhoshkumar *et al.,* 2014; Farkhondeh *et al*., 2018; Baloch *et al*., 2020). The growth coefficient of fish differs not only in different species but also the same within species depending on habitat, sex, maturity stage, food availability, stomach fullness, health condition, season, stress and sampling methodology (Bagenal and Tesch, 1978; Froese, 2006; Cuadrad *et al*., 2019).

The condition factor (K) of a fish reflects ecological and biological circumstances and fluctuations by interaction among feeding conditions, parasitic infections and physiological factors (Le Cren, 1951). In general, Fulton's condition factor (K) is frequently used to relate weight as the cube of length (Bagenal and Tesch, 1978), and the relative condition factor (K_n) which derived from the length-weight relationship and is recommended when fish growth is allometric (Ricker, 1975). Le Cren (1951) stated that the relative condition factor (K_n) represents the degree of the well-being of the fish in their habitat, when the K_n value is equal to or greater than one, it means the fish have attained a better condition, whereas its value less than one indicates that fish is not in a good condition. According to this principle, the K_n results for *P. klunzengeri*, *P. subviridis, A. arabicus* and *O. ruber* in this study were in good condition, with the means K_n values of 1.09, 1.03, 1.01 and 1.03, respectively. The condition factor of fish has been reported to be influenced by several factors such as species, reproductive cycle, food availability and other environmental and physiological factors (Wootton 2011; Datta *et al*., 2013; De Giosa *et al*., 2014; Keyombe *et al*. 2017).

The age and growth of some involved species in this study were studied by a few researchers in different natural water bodies in the world, especially on *P. subviridis* (Wiheyaratne and Costa, 1987; Al-Daham and Wahab, 1991; Mohamed *et al*., 1998) and on *O. ruber* (Brash and Fennessy, 2005; Eskandari *et al*., 2012; Rahnama *et al*., 2017) using their scales or otoliths. The relationship between fish length and scale radius for the four studied species displayed strong linear correlations and was very close to unity, which confirms the close association of the length with the growth of their scales. This means that the scales of the fish under investigation can be used successfully for age estimation (Ricker, 1992).

The ages of the collected specimens from scales in the present study showed six ages for *P. subviridis* and eight ages for *O. ruber*. A similar number of ages was also recorded for *P. subviridis* by Wiheyaratne and Costa (1987) in a tropical lagoon in Sri Lanka; Al-Daham and Wahab (1991) in the Shatt Al-Basrah Canal, Iraq and Mohamed *et al*.. (1998) in the northwest Arabian Gulf. Brash and Fennessy (2005) reported eight ages for *O. ruber* in the KwaZulu-Natal, South Africa, while Eskandari *et al*. (2012) noted sex ages in the northwestern part of the Arabian Gulf, and Rahnama *et al*. (2017) recorded five ages for the species in Oman Sea, Iran.

Jennings *et al.* (2005) stated that the von Bertalanffy growth equation describes well the growth of most fish species, and its parameters have been utilized considerably in life-history studies. The length-at-ages of *P. klunzengeri*, *P. subviridis, A. arabicus* and *O. ruber* derived from the von Bertalanffy growth equation (VBGE) are compared with the observed and back-calculated lengths at different years of life and showed good agreement. Moreover, the asymptotic lengths ($L\infty$) derived from ELEFAN 1 module implemented in the FiSAT II were 29.8, 33.8, 44.6 and 68.5 cm for the four species respectively (Al-Hassani and Mohamed, 2021; Mohamed and Al-Hassani, 2021a, b, c). Katsanevakis (2006) stated that if the von Bertalanffy growth equation was not the best model for application to a data set, its use would result in biased point estimation and false evaluation of accuracy. A comparison was made between the constants of the von Bertalanffy growth equation and the available data of some studied species in other habitats .The constants of the von Bertalanffy's growth of *P. subviridis* from this study compare closely with those of Mohamed *et al*.. (1998) who esti-mated $L\infty$= 30.8 cm, K= 0.23 and t_o= 0.63 for the species in the northwest Arabian Gulf, Iraq. The asymptotic total length ($L\infty$) of *O. ruber* in this study was 70.6 cm and found to be higher than 41.9 cm found in KwaZulu-Natal, South Africa (Brash and Fennessy, 2005), 67.6 cm in the northwest Arabian Gulf, Iran (Eskandari *et al*., 2012), and 54.7 cm in Oman Sea, Iran (Rahnama *et al*., 2017). However, the growth coef-ficient (K) was lower than that found in other studies (Brash and Fennessy, 2005; Eskandari *et al*., 2012; Rahnama *et al*., 2017). The t_o value of *O. ruber* found here was within the ranges observed in other populations of *O. ruber* (Brash and Fennessy, 2005; Eskandari *et al*., 2012; Rahnama *et al*., 2017). These differences in the growth of the same species in different waters could be attributed to several factors, such as ecological conditions, habitat, availability of food, metabolic activity, reproductive activity, the genetic constitution of the individual, fishing pressure, non-representative sampling and erroneous methodological applications (Nikolsky, 1963; Sparre and Vinema, 1998; Jiménez, 2006; Wootton, 2011; Panda *et al.* 2018).

Conclusion

In conclusion, the size ranges of *P. klunzengeri, P. subviridis, A. arabicus* and *O. ruber* were comparable with those documented by several authors in different geographic localities. The four species had negative allometric growth patterns, and the values of the condition factor for all species were in good condition. The scales of these four species can be used successfully for age and growth estimation. The comparison of observed, back-calculated and VBGE lengths at different years of life showed good agreement. These results could assist in fisheries management for the sustainable exploitation of these commercially important species in Iraqi marine waters.

Conflict of interest

The authors declare that they have no conflict of interest.

Ethical statement

The work was conducted in accordance with institutional guidelines for animal care.

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