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Age and growth of kutum (*Rutilus frisii kutum*, Kamensky, 1901) in southern Caspian Sea

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Abstract

Age and growth of the Caspian kutum, *Rutilus frisii kutum* were studied in the southern Caspian Sea from early October 2006 to the middle of April 2007. Fork length and weight ranged from 21 to 58 cm and weights from 104 g to 2450 g, respectively. The largest length-groups was observed in December and the lowest in April, which was coincided with feeding and spawning periods, respectively. There was a significant difference from 1 : 1 overall sex ratio. Age determination, based on scale readings, showed that the population was composed of nine age- groups. The Caspian kutum grew isometrically and rapidly during the third year. In both sexes, specimens were maximally 4 years old. In older individuals, condition cycle was related to the gonad development and showed some differences between sexes. Age-at-length data were used to determine von Bertalanffy growth parameters for this population for both sexes indicating that *K* value of males was more than that of females. Growth performance index (*ǿ)* was 2.89 for all individuals. The results showed that *R. f. kutum* is a rapidly-growing species in the southern Caspian Sea.

Keywords: Age, Growth, Caspian kutum, *Rutilus frisii kutum*, Caspian Sea, Iran

Introduction

Bony fishes have been caught in the Iranian coastal waters of the Caspian Sea since 1927. Caspian kutum (*Rutilus frisii kutum*, Kamensky, 1901) is the main fish making over 50% of the catch of bony fish providing more than 60% of the fisherman's income in Southern Caspian Sea (Abdolmaleki and Ghaninejad 2007). *R. f. kutum* also known as "Caspian white fish", is an anadromous fish and native to the Caspian Sea (Shariati 1993). It is a subspecies of *Rutilus frisii* which inhabits in the Black and Azov Sea basins (Belyaeva et al. 1989).

In Iranian waters of the Caspian Sea, *R. f. kutum* migrates into the in March and April for spawning (Adeli Mosabbab and Piri 2005; Afraei Bandpei et al. 2007). This species has a life span of 9-10 years in the southern Caspian Sea with males and females attaining sexual maturity between 2-3 and 3-4 years, respectively (Vossoughi

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and Mostajeer 1994). Kutum have mainly been recorded in the Iranian waters of the Caspian Sea and rarely found in other regions of the Sea, i.e. the North and Volga River (Valipour and Khanipour 2006). A decrease in water levels in the Caspian Sea from the 1950s has led to a drastic decline in the stocks. In recent years, no Black Sea roaches have been caught in Kazakhstan and *R. f. kutum* is red list species in Kazakhstan territory (Alexander 1996).

This species is normally a medium-sized fish, typically reaching 45-70 cm in length, weighing up to 5 kg. It was once common and harvested commercially (Valipour and Khanipour 2006). *R. f. kutum* is a short lived fast growing species. However, a decrease in catch resulted in the establishment of an artificial breeding program for restocking and enhancement of the stock. The Iranian Fisheries Organization (IFO) has been annually releasing up to 200 million fry (average weight 1 g) into the rivers which flow into the southern basin of the Caspian Sea (Razavi Sayad 1995). Since the start of the stock restoration in 1982, the annual total catch of *R. f. kutum* in Iran has increased to 9 600 tons in 2004 (FAO 2003) and 16 000 tons in 2006 (Shilat 2008).

Despite the economical and ecological importance of *R. f. kutum* in the Caspian Sea, there is little information available regarding its age, growth and condition factor in Iranian waters of the Caspian Sea. Such information is especially important because of the ecological changes that are occurring in the Sea at present due to the appearance of *Mnemiopsis leidyi* in 1999 (Shiganova et al. 2001) as well as *R. f. kutum* artificial breeding. The present study aimed to investigate the biology, population structure, age, growth and von Bertalanffy population parameters of *R. f. kutum* in Iranian coastal waters of the Caspian Sea.

Materials and methods

Our study was conducted in the southern Caspian Sea between early October 2006 and middle of April 2007. The trade catches of bony fish is commenced at this time of the year. From May to September, catch of bony fish is forbidden. Fresh samples of *R. f. kutum* were collected using beach seine in Guilan, Mazandaran and Golestan provinces from the southern part of the Iranian waters of the Caspian Sea (Fig.1). The beach seine is 1200 m in length and 10-15 m in height, with a mesh size of 33 mm. Fork length of captured fish was measured to the nearest cm and weighted to the nearest g. Age was determined using scale reading (Ghadirnejad 1996).

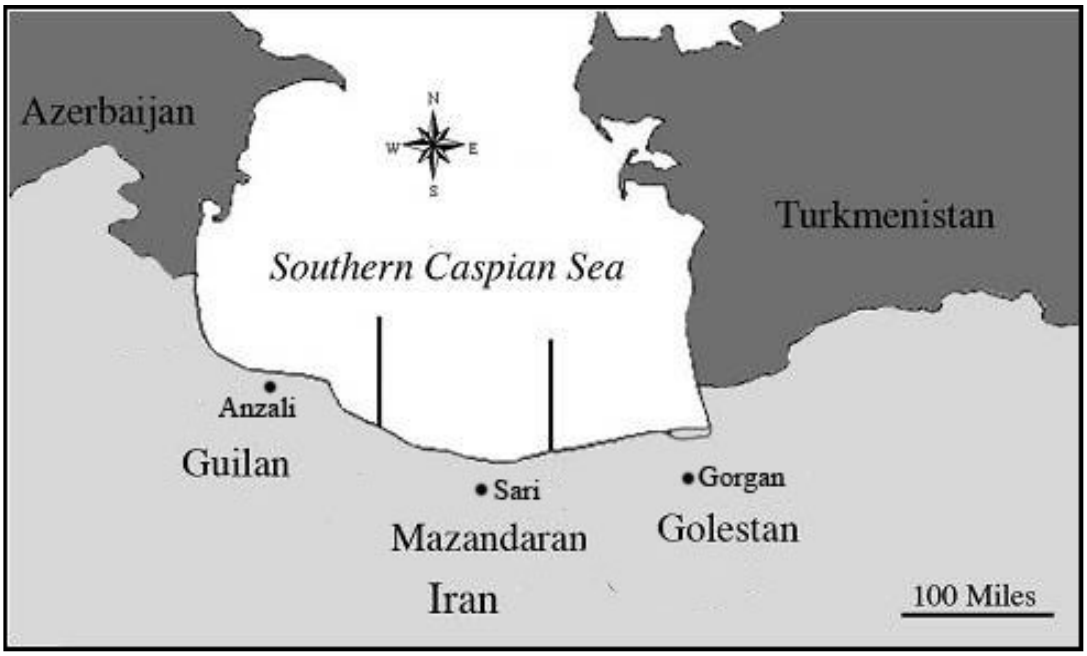

Fig.1. Map of the Iranian waters of the Caspian Sea, showing the fishing area (black spots correspond to sampling provinces center)

Scales were taken from the middle of the body, behind the pectoral fins and above the lateral line. They were then placed in labeled envelopes and returned to the laboratories for reading and analysis. The scales were washed and placed in small covered Petri dishes with tap water. Then, the organic layers of scales were removed by rubbing and washing in tap water (Fazli et al. 2008).
The relationship between weight and length was calculated using the exponential regression:
$W= a \times L^b$

Where W is the total weight (g), L is the fork length (cm); a is the regression constant (intercept) and b is the regression coefficient (slope) (Ricker 1975). The Fulton condition factor (CF) was determined for each fish using the following equation:
$CF= (W/L^3) \times 100$ (Bagenal 1978).

Where W is the total fish weight (g), L is the fork length (cm). Length-at-age data were fitted to the von Bertalanffy growth model (Ricker 1975) using non-linear least-squares regression:
$L_t = L_\infty (1 - e^{-k(t-t_0)})$

where L_t is the length of the fish at age t, L_∞ is the asymptotic length, K is a growth rate per unit of time, and t_0 is the theoretical age at which the fish would have length zero. Overall growth performance index (ǿ) of species can be interpreted by the growth index (Munro and Pauly 1983):
$ǿ = \log (K) + 2 \log (L_\infty)$

Length-at-age data analysis was used to FiSAT software proposes. Chi-squared analysis was used to examine a significant difference from an expected 1: 1 sex ratio for all fish.

Results

Length and weight relationship
1360 specimens of *R. f. kutum* were totally collected and used for this study. 483 of specimens were males and 744 were females. The sex of 133 fish were not known because their gonad were not removed. The sex ratio (males: females) in this study was 0.65:1 which was significantly different from an expected 1:1 ratio ($\chi^2 = 481.1$, df = 1226, $P < 0.05$). The ratio between males and females varied throughout the sampling period with females being the sex from October to February and males were the dominated sex in March. In April, the sex ratio was approximately 1:1 (Fig. 2).

Fork length and weight ranged from 21 to 58 cm and 148 to 2450 g (39.0 ± 6.7 cm, 830.3 ± 429.5 g, n = 744) for females and from 21 to 51 cm and 109 to 1689 g (38.20 ± 4.9 cm, 719.1±261.2 g, n= 483) for males. A significant difference was found in the length and weight relationship between males and females in various months (ANOVA, F = 579.446, $P < 0.05$).

For both sexes of all individuals, the relationship between total length and somatic weight was described as : $W = 0.0066\ FL^{3.02}$ ($r^2 = 0.95$, n = 1360); for females: $W= 0.0061FL^{3.19}$ ($r^2= 0.96$, n= 744); and for males: $W= 0.0067\ FL^{3.16}$ ($r^2 = 92$, n = 483). There was no significant difference between sexes in the slopes (*b*) of length–weight relationship (t-test, t = 3.454, df = 1, P = 0.175).

Length frequency
Fork length frequency of *R. f. kutum* samples varied between 21 and 58 cm. The largest length groups (from 21 to 57 cm) observed in December and the smallest in April (from 27 to 53 cm), which was coincided with feeding during wintering and spawning period, respectively (Fig 3). After a relatively low FL (average 35 cm) in October, an increase in FL was recorded (up to average 38 cm) in November to December. A decrease in FL was observed in January (average 37 cm). In February, the FL started to increase steadily from average 39.1 cm until April (average 40.8 cm).

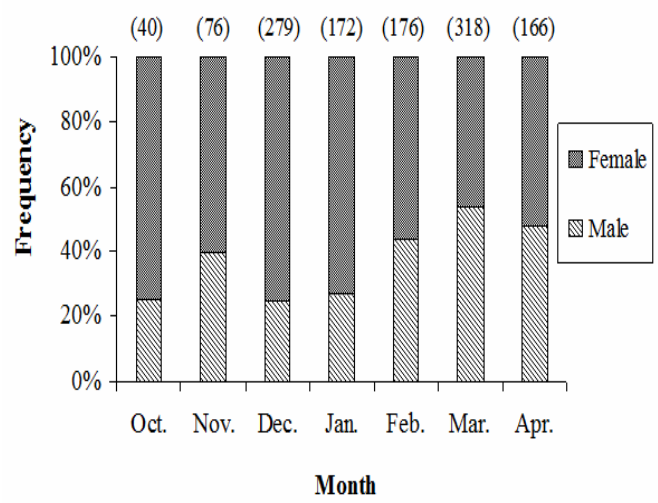

Fig.2. Monthly variations in sex ratio of *R. f. kutum* collected along the southern Caspian Sea (parentheses indicate number of sample size)

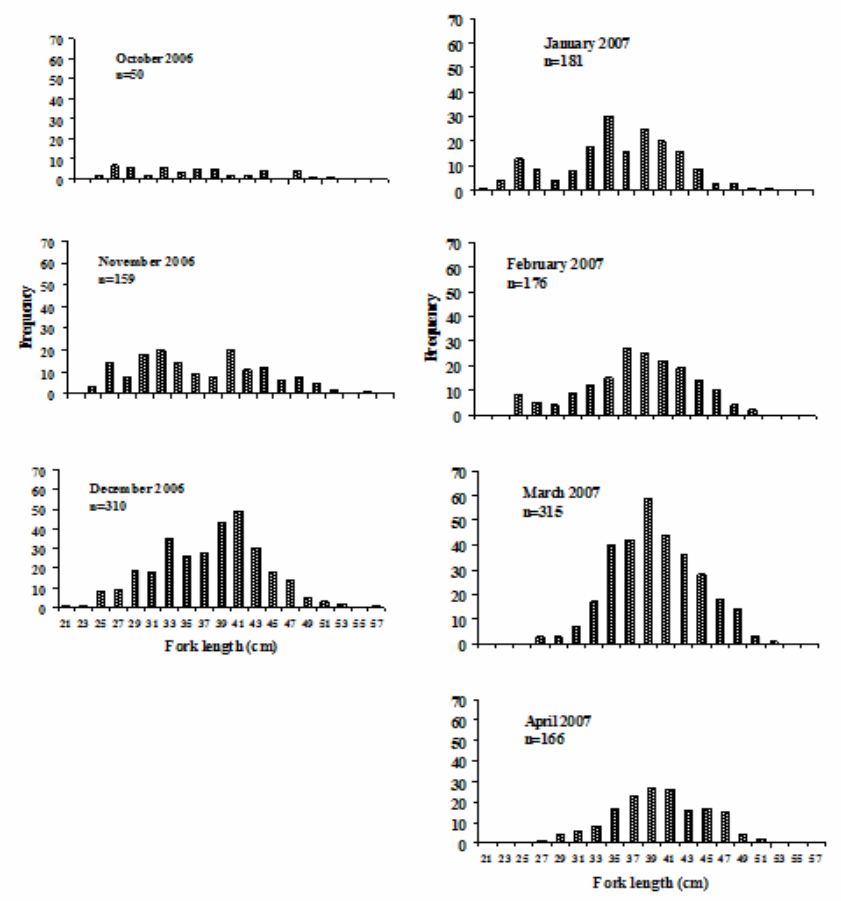

Fig. 3. Monthly length-frequency distribution of *R. f. kutum* sampled along the southern Caspian Sea

Condition factor

The Fulton condition factor (CF) varied from October (average 1.2) to April (1.3). There was an increase in growth rate from November to December, a decrease in February and an increase during February, March and April, which was coincided with development of gonads (Fig. 4).

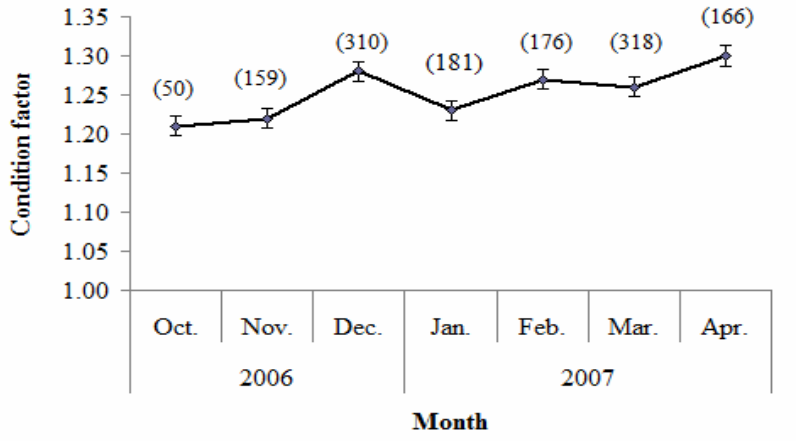

Fig. 4. Mean (± SD) of the condition factor of *R. f. kutum* measured over time (parentheses indicate the sample size)

Von Bertalanffy age-at-length catch curve

Age of 931 fish was determined using their scales. The annual ring appeared as dark and light zones. Annual rings appeared in April and May. Totally, there were nine age-groups. The fish of the youngest group was one year and the oldest were nine years old. The mean age was 3.99 ± 1.08. Totally, there were nine age-groups (nine age-groups for females and seven age-groups for males). The four years old specimens with a mean fork length 39 ± 3.2 cm and 40 ± 3.2 cm, had the highest frequency (52.6 % for males and 35.5 % for females) (Table 1). There was a significant difference in age between males and females (t-test, t = 89.212, $P < 0.05$).

The highest FL growth increments were 70 mm/yr for males and 100 mm/yr for females at three-years old (Table 1). The von Bertalanffy growth parameters were: $L_\infty = 63.00$ cm, $K = 0.21$ year^{-1}, $t_0 = -0.88$ years for both sexes. These parameters were as follows: $L_\infty = 62.03$ cm, $K = 0.21$ year^{-1}, $t_0 = -0.80$ years for females; and $L_\infty = 54.52$ cm, $K = 0.27$ year $^{-1}$, $t_0 = -0.75$ years for males. The growth performance index *(ǿ)* was 2.89 for both sexes (Table 2). The *K* value of males was more than that of females but L_∞ was less than that of females (Fig. 5).

Table 1. Mean fork length (cm) and weight (g) both sexes of *Rutilus frisii kutum* from the southern Caspian Sea

Sex		Age groups								
		1	2	3	4	5	6	7	8	9
Female	FL (cm)	23 (2.4)	28 (1.4)	35 (2.5)	40 (3.2)	44 (3.3)	48 (1.6)	52 (1.6)	55 (1.7)	58
	W (g)	126 (4)	214 (43)	466 (128)	849 (234)	1229 (301)	1510 (225)	1803 (247)	2150 (189)	2450
	N.	21	32	146	200	118	26	11	9	1
Male	FL (cm)	21 (2.1)	26 (2.6)	34 (2.8)	39 (3.2)	43 (2.6)	47 (2.1)	50 (1.4)		
	W (g)	133 (2)	233 (103)	499 (134)	770 (185)	970 (206)	1310 (211)	1639 (70)		
	N	17	15	82	193	49	9	2		

FL = fork length, W = weight, N = sample size, and standards deviations (± SD) are in parentheses.

Table 2. Parameters of the von Bertalanffy growth equation for *Rutilus frisii kutum* from various localities

Area	Sex	L_∞	K	$\acute{o}$	Reference
Bay of Astrabad	F	113.7	0.09	3.04	Berg (1948-1949)
Bay of Kura	F	130.2	0.08	3.14	
Malyi Kyzylagach Bay	F	80.5	0.18	3.07	Abdorakhmanov (1962)
	M	79.0	0.18	3.06	
Anzali lagoon	F	80.4	0.20	3.12	Ralonde and Razavi (1972)
	M	70.6	0.12	2.79	
Anzali lagoon	F	104.2	0.09	3.02	Holcik and Olah (1992)
	M	48.7	0.22	2.72	
Former USSR	F+M	62.2	0.40	3.2	Belyaeva et al (1989)
Southern Caspian Sea	F+M	63.0	0.21	2.89	Present study
	F	62.03	0.21	2.91	
	M	54.52	0.27	2.92	

F= female, M= male, USSR= Union of Soviet Socialist Republic, L_∞ = asymptotical length (cm), K= growth rate, and $\acute{o}$ = growth performance index.

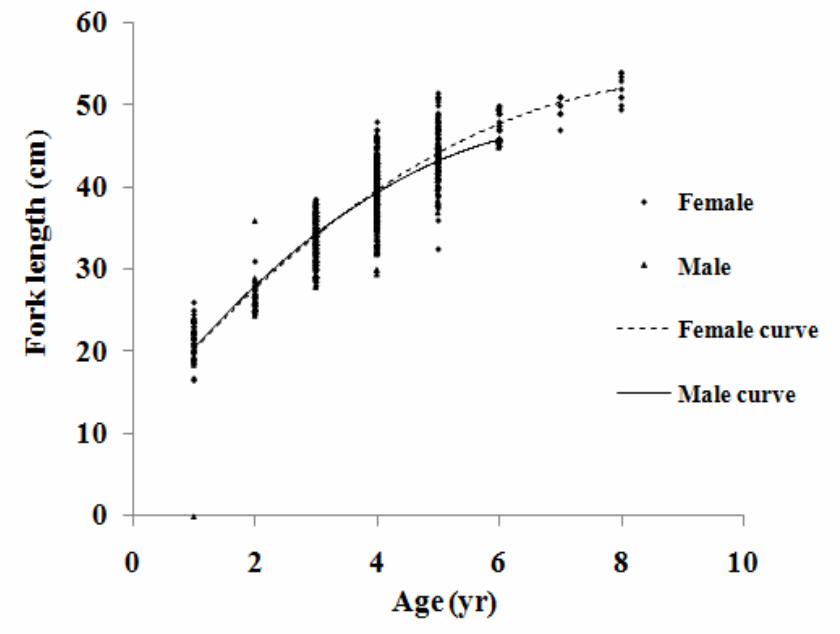

Fig.5. Von Bertalanffy growth curves fitted to the length-age data of *R. f. kutum* sampled along the southern Caspian Sea

Discussion

In the present study, the exponent (*b*) of length-weight relationship was 3.02. Bagenal (1978) found that the exponent usually ranges from 2.30 to 5.50 and is generally above 3. The relationship between fork length and body weight was calculated for each sex. Values of the isometric coefficient (*b*) were 3.19 and 3.16 for females and males, respectively, which were not significantly different from 3, indicating that the growth of *R. f. kutum* is isometric. In contrast, Belyaeva et al. (1989) in former USSR (Union of Soviet Socialist Republic) reported a lower exponent of the Von Bertalanffy equation (b = 2.98) in one specimen of kutum (*R. frisii*). It is thus difficult to compare the values of previous studies with those in the literature, as the recent reported data are insufficient, especially new data in the southern part of the Caspian Sea.

Difference in length and age can vary with geographical location that is probably related to factors such as climate, trophic status and diet, and exploitation. In our study, maximum fork length and weight of *R. f. kutum* obtained 58 cm and 2450 g with age 9 years old. In contrast, Koliev (1997) reported that the total length group and weight of 34-55cm and 658-2920 g of kutum for Kyzylagchskii bay.

At the present study, there was a a decrease in fork length and weight of *R. f. kutum* after three decades because all the fish were less than 60 cm. Ferid-Pak (1968) noted that the length and weight of *R. f. kutum* of 67 cm and 7 kg for southern part of the Caspian Sea. This could be related to destruction of natural habitats, unsuccessful natural breeding, fishing pressure and artificial breeding. Valiopour and Khanipour (2006) reported that an artificial breeding program was taken into account for several reasons including a decrease in catch during the 1960s and 1970s due to over fishing, loss of natural spawning grounds and environmental pollution. Similar reasons were observed in the present study.

The length-frequency distribution has a large span in December. This could be due to migration to the coastal areas for feeding and storage of enough energy to survive before wintering period. This distribution changes from January onward, with 21-25 cm classes being absent from March to April. This could be due to the spawning period and appearance of spawners for migration to rivers. Afraei Bandpei et al. (2009) reported that the highest food items for *R. f. kutum* occurred in November and December and the least food items occurred in January and April.

Generally, the higher values CF were observed in December and April. The increase condition factor in December and April could be due to feeding activity and gonadal development for autumn form and spring form, respectively. Holcik and Olah (1992) reported that there are two spawning migration of *R. f. kutum* to the rivers linked to the southern part of the Caspian Sea. The first run will occur from February to the end of April (99%) while the second run is from November to December (1%).

The condition factor decreased in winter (January) because of decreased food intake and low temperature. In general, the observations regarding the *R. f. kutum* condition factor in the present study is similar to those by other author (Valipour and Khanipour 2006) who reported that Caspian kutum spends the winter in deeper regions of the sea bottom in depths over 100 m and also its feeding activity is low in winter. Females were the dominant sex and also were dominant in length class above 50 cm. Thus, females attained larger length and weight than males.

Negative values of the t_0 are frequent among species with rapid growth during the 1 st year and reduced growth rates in subsequent year (Peres and Haimovic 2004). Difference in length-at age and growth were observed between the males and females of *R. f. kutum* in the southern Caspian Sea. Female fish often attain greater size than males, usually through a faster growth rate (Paker 1992). At the present study for the age group of 1-2 yr and 2-3 yr, the rate increments were 50 mm (24%) and 100 mm/yr (38.5%), for females; 40 mm (17.4%) and 70 mm/yr (26%) for males, respectively. Subsequently, growth rate (length and weight) in females and males trended to decrease and the growth rate differed significantly between sexes. Male *R. f. kutum* grows fast in the third year of the life but, after that, grows more slowly than females (Holcik and Olah 1992). Several factors might be responsible for this growth different between males and females, for example, physiological changes influenced by temperature changes, feeding regimes and productive cycles (Utagawa and Taniuchi 1999).

There are few papers from previous studies about growth parameters in *R. f. kutum* for comparing with results of the present study in the southern Caspian Sea. However, Table 2 gives some comparison between previous and present studies. Branstetter (1987) categorized K value as 0.05-0.10/yr for slowly growing species, 0.10-0.20/yr for species with average growth, and 0.20-0.50/yr for rapidly growing species. Based on these criteria, *R. f. kutum* in the southern Caspian Sea has a rapid growth rate. This could be due to available food resources, sufficient temperature (temperate area), salinity particularly brackish-water and freshwater in the southern coast of the Caspian Sea. Hong-Jing and Cong-Xin (2008) reported that there are several factors affecting growth rate such as shortage of food, deprivation cased by migration and changes of temperatures. The K and L_∞ ratio are important parameters in the

growth patterns used by Pauly et al. (1988). Female of *R. f. kutum* had relatively high $L\infty$ but low *K* values whereas the $L\infty$ for the male were lower, but the *K* values were higher.

In conclusion, our results showed that *R. f. kutum* in the southern Caspian Sea has a fast growth rate. This could be due to available food resources, sufficient temperature, salinity particularly brackish-water and freshwater in the southern coastal of the Caspian Sea. The finding on age and growth of *R. f. kutum* from this research will help to elucidate the distribution with age of fish and their sustainable management. Moreover, for complete studies on age and growth during annual recommends that further research is needed, particularly from May to September.

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