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A comparative study on some biological parameters in broodstock and juvenile kutum, *Rutilus kutum* in the southern Caspian Sea basin

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ABSTRACT

Some biological characteristics of broodstock and juvenile kutum, *Rutilus kutum*. were investigated using data collected from the estuaries of Tajen and Shirood Rivers (TR and SR) (south Caspian Sea basin) as well as from the Caspian Sea in 2012. The results showed higher condition factors (CF) in the male broodstocks than those estimated in the female broodstock of both TR and SR. The female juveniles displayed a greater level of CF. The Von Bertalanffy's growth equations were calculated as: $L_t = 40.67(1 - e^{-2.27(t-18.84)})$ and $L_t = 50.11(1 - e^{-0.48(t+1.814)})$ for the broodstocks of SR and TR, respectively, and for the juveniles as: [$L_t = 48.36 (1 - e^{-0.537 (t+ 0.913}$]. The males of SR presented a negative allometric growth pattern. The females and males of both SR and TR presented similar isometric growth patterns. Both male and female juveniles from TR exhibited a positive allometric growth pattern. The calculated equations for total length and weight were as: $W = 3E{-}06\ L^{3.2069}$ and $W = 5E{-}07\ L^{3.4745}$ for the male broodstock of SR and TR, respectively, and as: $W = 5E{-}07\ L^{3.4745}$ for the juveniles. The measured parameters may reflect the role of fish habitat characteristics such as food availability, population density, and age classes depending on sex and season.

Keywords: *Biology, Caspian Sea, kutum Rutilus kutum, Shirood River, Tajen River*

INTRODUCTION

Cyprinidae is an important family of fish with over 2000 species distributed throughout the world (Kirpichnikov, 1972). The kutum, *Rutilus kutum* (family Cyprinidae) is one of the most commercially valuable fish species in the southern coast of the Caspian Sea that has adopted to inhabit the brackish water of the Sea and the surrounding lagoons (Razavi, 1991; Abdollahi, 2010). The foremost distribution of kutum is from Kura River to Gomishan region (northeast of the Caspian Sea), hence, 90% of them are native to the Sea. Shirood and Tajen Rivers are among the zones to which this species migrates for reproduction (Khavval, 1996). *R. kutum* has two populations; the spring and fall populations, which spawn in the surrounding rivers on March and October, respectively (Razavi, 1995). This profitable species has been reported to depend on conservation procedures because of overexploitation of the natural stocks (Abdoli and Naderi, 2008).

It is of particular importance to identify the exploitable resources and reserves of commercial fish species with respect to biology, population dynamics, stock assessment, economics, etc. in order to plan programs for the development of fisheries and catch industries. Because the fishery industry intends to increase the capture rate and to use water resources responsibly, it can be stated that without a scientific and precise knowledge of the condition of resources and reserves, any management program will not be successful.

One of issues in the science of aquatic animal studies is to yield an optimal product without interrupting the balance in the natural stocks. With precise understanding of the biology of aquatic animals, it is possible to find a model to

evaluate the current condition and future prediction of catch effects upon fish populations (Hashemi *et al.,* 2008).
Identification of population factors of a given aquatic animal can effectively open the way for consistent harvest from the natural stocks (Khara, 2006). Both the beneficial value of kutum especially for the residents of the region, and its importance in the biodiversity of the Caspian Sea were the incentives to conduct the present research in order to provide more knowledge on the status of this species. It, therefore, seems necessary to carry out basic and biological studies including age, growth, and reproduction of kutum. To date, *R. kutum* has been the target of sparse investigations concerning various aspects such as effects of water salinity, phototaxis, light spectrum, and photoperiod on growth and survival of this species (Amiri, 2008; Imanpoor, 2006), induced spawning of kutum (Paykan Heyrati, 2007), water temperature and migration time **(**Khara *et al*., 2012**)**, and study of blood parameters (Nikoo, 2010).

The principal aim of this study was to provide data on the biology of the fish including growth pattern, length-weight relationship, condition factor, and Von Bertalanffy growth equation, between broodstock and juvenile kutum in the spawning season and also during the time when they live in the Sea. Besides, attempts were made to find out whether populations of brood stock and Juvenile kutum inhabiting three different habitats exhibit environmentally related variations in their life history traits.

MATERIALS AND METHODS

The present study was conducted on two groups of both broodstock and juvenile kutum populations from the Caspian Sea. Broodstock kutum were caught from the estuaries of Tajen and Shirood Rivers, in the south Caspian Sea, between March and May 2010. The juvenile fish were captured from the Sea by a local catchment company between January and February 2010. The captured samples underwent biometry according to Bagenal (1978). The length and weight of the fish were measured by a biometry ruler (up to the nearest 1 mm) and a digital scale (up to the nearest 1 g). For age determination, the scales between the dorsal fin and lateral line were used. Following washing and drying, the scales were placed between two lamellae on a loop and then the annual cycles were counted (Bagenal, 1978).
To determine the fish growth pattern, the Pauly formula was applied (Froese and Binohlan 2000):

$$t = \frac{\text{sdLnl}}{\text{sdLnw}} \times \frac{|b-3\ |}{\sqrt{1-(\text{r})^2}} \times \sqrt{\text{n}-2}\ ,$$

where SdLnl is the length standard deviation from natural logarithm, SdLnW is the weight standard deviation from natural logarithm, r^2 is the correlation coefficient between length and weight, *b* is the regression line gradient between length and weight, and n is number of samples. The condition factor (CF) was calculated using Foltun equation (Biswas, 1993):

$\frac{W \times 100}{L^3} = K$, where W= average weight (g), and L= average length (cm).

Length-weight relationship

To analyze the variations in the averages of both total length and weight, an equilibrium equation was used to determine their relationship (Sparre *et al.,* 1989):

$$W = aL^b$$

where W= total weight (g), *a* = initial width, *L* = total length (cm), and *b*= line slope.
Using Von Bertalanffy formula and Ford-Walford method, the following values were assessed: indefinite length, growth rate until indefinite length, and fish age at the time of length=0 (Von Bertalanffy, 1957; Sparre and Venema 1992):

$$L_t = L_\infty(1 - e^{-k(t-t_0)})$$

where L_t= fish length at a certain age, L_∞= indefinite length, *k* = growth rate until indefinite length, *t* = age, t_0 = fish age at L = 0.

RESULTS AND DISCUSSION

Growth pattern

The current study investigated 64 and 51 broodstock kutum from Shirood and Tajen Rivers, respectively, and 48 juvenile kutum from the Caspian Sea. The male kutum of Shirood River presented a negative allometric growth pattern, whereas the females and males of both Shirood and Tajen Rivers displayed similar isometric growth patterns. For the juvenile male and female kutum of Tajen River, positive allometric growth patterns was detected (Table 1).

Table 1. Growth patterns of broodstock and juvenile kutum broken down by gender.

Population		t (table)	t (calculated)	*df*	*b*	Growth pattern
Broodstock	Male (Shirood)	1.697	2.148	30	2.8693	Neg. allometric
	Femal (Shirood)	1.697	0.9118	30	3.0085	Isometric
	Male (Tajen)	1.684	0.9729	38	3.0234	Isometric
	Female (Tajen)	1.833	4.44	9	3.1839	Positive allometric
Juvenile	Male (Caspian)	1.701	19.35	28	3.3824	Positive allometric
	Female (Caspian)	1.746	7.725	16	3.1699	Positive allometric

Growth is an important aspect of fish life history that has an immense flexibility at the population level (Mann, 1973). In addition to explaining biological differences among populations, growth is indicative of biological properties, hence being of particular importance in ecological studies (Kovac and Copp 1996). Zalachowski et al. (1997) found various Bertalaneffy's growth parameters within populations and/or genders with different growth rates. Likewise, the current study detected dissimilar growth rates for both genders in the broodstock kutum population together with diverse indefinite lengths and growth paces. Though, the males and females in the juvenile population displayed comparable growth patterns together with almost similar indefinite lengths and growth rates. The intra-population variation between genders in the Bertalaneffy's growth parameters is an indicative of variability in selective forces acting on the genders in a population (Goldspink, 1978).

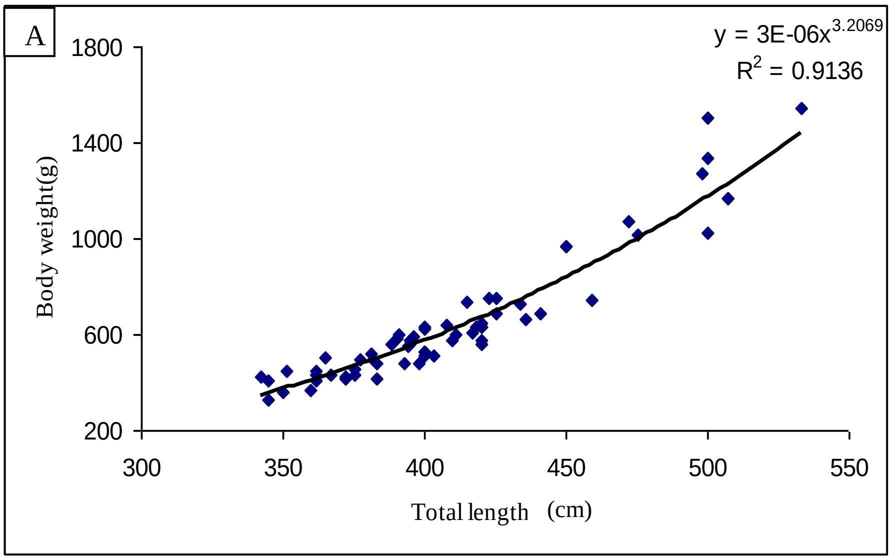
Length-weight relationships

Table 2 shows average length and weight of kutum measured in the current study at the three habitats. The male kutum of Shirood River was significantly different with respect to both length and weight from the males of Shirood and Tajen Rivers, females of Tajen, and the juvenile males and females. The female kutum of Shirood, male kutum of Tajen, and the juvenile males and females were not significantly different with respect to both length and weight ($p > 0.05$). The results also showed significant difference ($p < 0.05$) between length and weight of female kutum of Tajen River and those of the other experimental fish.

Table 2. Average length and weight of broodstock and juvenile kutum broken down by gender

Population		Number	Average length (± SD) (min-max)	Average weight (±SD) (min-max)
Broodstock	Male (Shirood)	32	39.61±2.74 ^{a} (34.50-45.90)	523.90±107.91^{a} (330-745)
	Female (Shirood)	32	42.47±5.46 ^{b} (34.20-53.30)	787.65±327.34^{b} (410-1545)
	Male (Tajen)	40	44.03±2.70 ^{b} (39.oo-50.80)	784.87±184.43^{b} (510-1500)
	Female (Tajen)	11	47.50±4.19 ^{c} (40.40-54.50)	1187.09±339.63^{c} (339.63-1700)
Juvenile	Male (Caspian)	30	42.46±3.66 ^{b} (34.00-47.00)	797.28±247.14^{b} (366.90-1500)
	Female (Caspian)	18	42.05±3.66 ^{b} (36.00-51.50)	729.69±236.27^{b} (422.6- 1500)

The total length-total weight relationship for the Shirood kutum was estimated as W= 3E-06 $L^{3.2069}$, while it was calculated as W= 3E-07 $L^{3.4745}$ for the Tajen kutum. The equation for the juvenile fish was as W= 1E-06 $L^{3.323}$ (Fig. 1, A & B). Assuming equal lengths, the differences between weights in both broodstock and juvenile populations were significant ($p < 0.05$). The length values were also statistically different ($p < 0.05$).



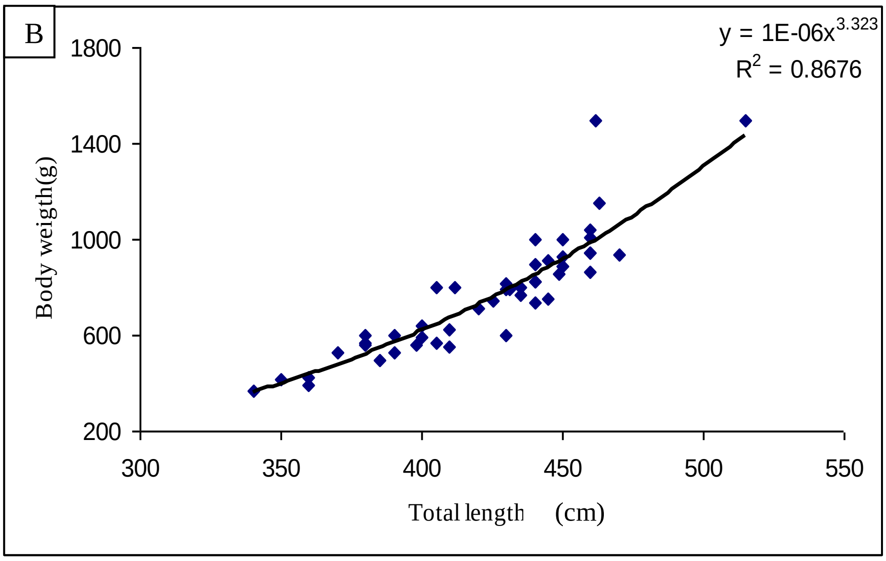


Fig 1. Length-weight relationships in the broodstock kutum from Shirood (A) and Tajen (B) rivers, southern Caspian

Bertalaneffy's growth equation

The Von Bertalanffy growth equation was calculated as $L_t = 40.67(1 - e^{-2.27(t-18.84)})$ and $L_t = 50.11(1 - e^{-0.48(t+1.814)})$ for the broodstock of Shirood and Tajen Rivers, respectively. This equation for the juvenile fish was as $L_t = 48.36\ (1 - e^{-0.537\ (t+\ 0.913)})$ (Fig. 2, A & B). The life history traits of *Rutilus kutum* differed markedly among the three different habitats. This may agree with Nikolski (1969) and Wootton (1992), who noted that length and weight changes during fish growth can be explained as acclimations to environmental conditions such as temperature, nutrients, food quality, kind of water system (river or lake), and genetic variations.

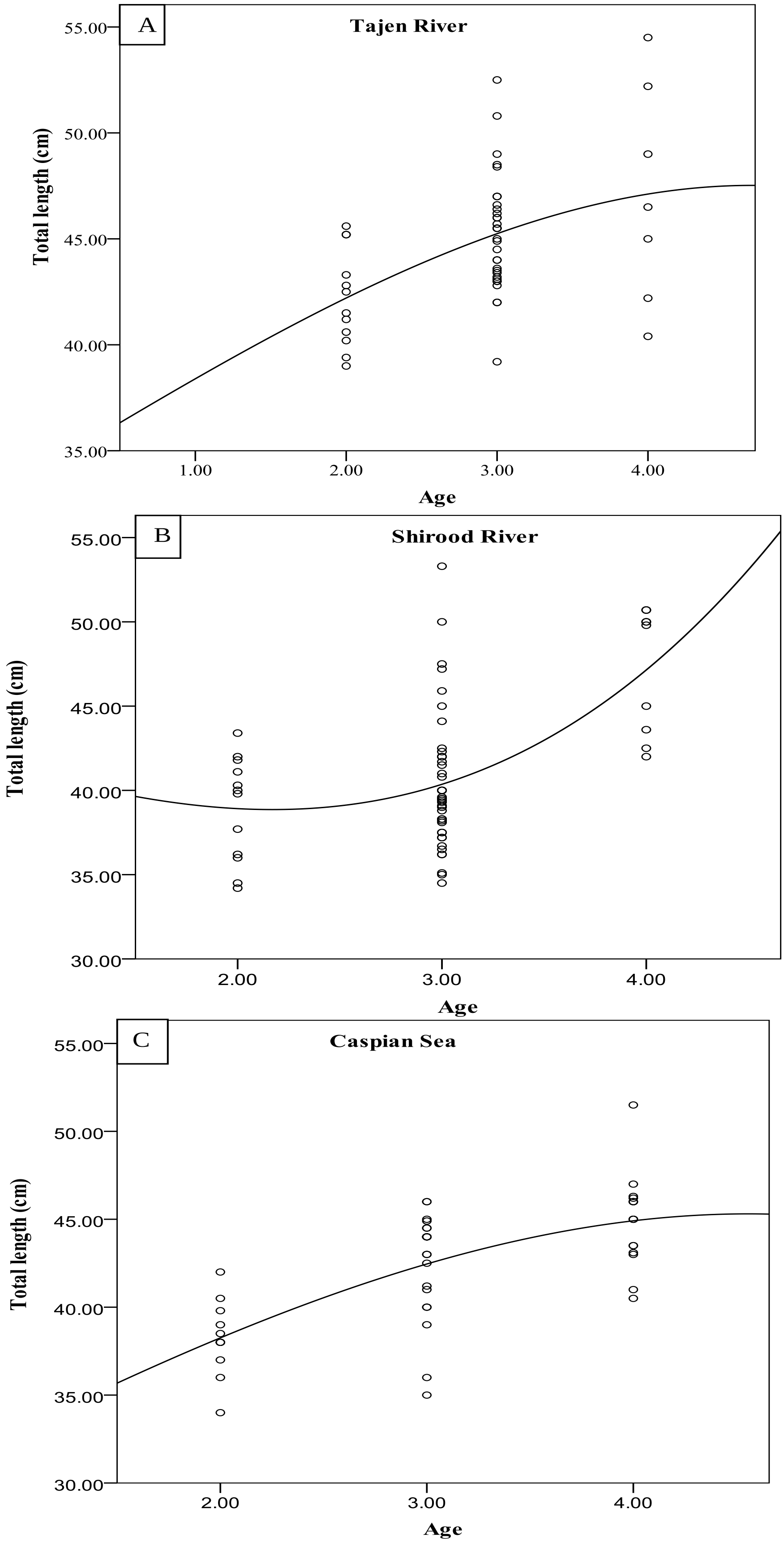


Fig 2. von Bertalaneffy's growth equation calculated for broodstock and juvenile kutum in the Tajen (A) and Shirood (B) Rivers, and the Caspian Sea (C).

For the calculation of Bertalaneffy's growth parameters, the back-calculated lengths from previous studies (Valoukas et al. 1996; Tarkan et al. 2005; Naddafi et al. 2005) were used. Accordingly, it was found that differences in Bertalaneffy's growth parameters depend on the growth rate and gender longevity. In addition, these differences may be dependent upon elimination of larger samples (selective catch and/or natural elimination) on one hand, and/or ecological conditions of the habitat on the other hand (Turkmen et al. 2001; Balik *et al*. 2004).

The calculated indefinite length (L_∞) for the broodstock kutum of Tajen and Shirood Rivers were 50.11 and 40.67, respectively, whereas for the juvenile kutum caught from the Caspian Sea an indefinite length of 48.36 was estimated (Fig. 2 A, B, & C). According to Turkmen et al. (2000), variations of indefinite length within populations of a species can be attributed to size differences of the biggest samples at each population and to variability of population characteristics of a species occurring under dominant environmental conditions, in particular, temperature and feeding situations. Also, Holt and Beverton (1957) stated that such environmental factors as food availability and population density affect indefinite length, whereas the rate of growth to reach such a length is influenced by genetic and/or physiological parameters (Rahmani, 2008).

Condition factor

The condition factor (CF) calculated separately for the broodstock kutum populations of both Tajen and Shirood Rivers and the juvenile male and female kutum (Table 3). Ghorbani et al. (2012) reported CF values of 0.80±0.05 to 1.60±0.18 for five Cyprinidae species in the Anzali wetland, southwest of the Caspian Sea. Kasyanov et al. (1995) suggested that variability of CF can be because of variations in benthos products, non-homogeneity of foodstuff, and different catch seasons. Our results showed higher CFs for the male compared to the female kutum, with greater values in Tajen than those in Shirood River; in the juvenile kutum, however, the females revealed higher CFs than the males. Tesch (1968) demonstrated that the value of CF varies depending on the fish species, gender, season, and nutrition as well as the size classes of age groups. The relatively vast variations of CF also pertain to individual variation (with diverse length and weight) within each age class. It has been shown (Goldspink, 1978; Oliva-Paterna, 2002) that CF tends to be highest at the first sexual maturity being afterwards a function of changes in energy expenditure (biological strategy). Similarly, the CF values measured in this study were greater in the broodstock than those in the juvenile populations.

Table 3. Condition factor (CF) of broodstock and juvenile kutum broken down by gender.

Population		Number	CF Average ± SD (min-max)
Broodstock	Male (Shirood)	32	**1.346±.082 (1.19-1.52)**
	Female (Shirood)	32	**0.947±.0767 (0.79-1.16)**
	Male (Tajen)	40	**0.831± 0.106 (0.68-1.32)**
	Female (Tajen)	11	**0.532±0.0725 (0.41-0.64)**
Juvenile	Male (Caspian)	30	**0.241±.0319 (0.18-0.35)**
	Female (Caspian)	18	**0.506±.0421 (0.45-0.59)**
	Total	163	**0.79±0.376 (0.18-1.52)**

CONCLUSION

The observed different growth coefficients of *R. kutum* (broodstock populations of both Tajen and Shirood Rivers and the juvenile male and female) from different areas are possibly due to spatial and temporal changes in their different nutritional, hydrographical and climatic conditions. To confirm the individual role of these parameters, comparative studies with the populations of this species are required.

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بررسی مقایسه‌ای برخی خصوصیات زیست شناسی در ماهی سفید مولد و غیر مولد در حوضه آبریز دریای خزر

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چکیده

در این مطالعه برخی خصوصیات زیست‌شناسی ماهی سفید مولد و غیر مولد *Rutilus kutum* با جمع‌آوری اطلاعات از منطقه مصبی رودخانه‌های تجن و شیرود و دریای خزر تخمین زده شد. میزان فاکتور وضعیت در ماهیان سفید مولد در رودخانه‌های تجن و شیرود در جنس نر بیشتر از جنس ماده بود، ولی در ماهی غیرمولد میزان این فاکتور در جنس ماده بیشتر از نر برآورد شد. معادله رشد وان برتالانفی برای ماهیان مولد رودخانه شیرود $L_t= 40.67(1 - e^{-2.27(t-18.84)})$ و رودخانه تجن $L_t= 50.11 (1 - e^{-0.48 (t +1.814)})$ و این معادله برای ماهیان غیر مولد به صورت $L_t= 48.36 (1 - e^{-0.537 (t+ 0.913)})$ محاسبه گردید. الگوی رشد برای ماهیان سفید نر شیرود آلومتریک منفی بود در حالی که الگوی رشد برای ماهیان ماده شیرود و نر تجن یکسان، و به صورت ایزومتریک یافت شد. الگوی رشد برای ماهیان نرو ماده غیر مولد و ماده تجن به صورت آلومتریک مثبت برآورد گردید. رابطه طول کل– وزن کل برای ماهیان شیرود به صورت $W= 3E\text{-}06\ L^{3.2069}$ و در ماهیان نر تجن به صورت $W= 5E\text{-}07\ L^{3.4745}$، و برای ماهیان غیرمولد به صورت $W= 1E\text{-}06\ L^{3.323}$ بدست آمد. خصوصیات اندازه‌گیری شده می توانند نقش ویژگی‌های زیستگاه ماهی مانند دسترسی به غذا، تراکم جمعیت، و گروه‌های سنی را بسته به جنس و فصل منعکس کنند.

*مولف مسئول