

Length-weight, length-length relationships and condition factor of *Rutilus kutum* (Actinopterygii: Cyprinidae) from the southern Caspian Sea, Iran

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Abstract

Fish stock assessment in the Caspian Sea requires employing some growth indicators such as length-weight relationship (LWR). Size determination in fish is more biologically relevant than age, because several ecological and physiological indicators are more size-dependent compared to age-dependent. This study aims to examine the length-weight relationship and condition factor of *Rutilus kutum* (Kamensky) from the southern Caspian Sea. 218 fish samples were caught using a gill net from Anzali, Astara, Kiashahr, Sari and Torkaman Port from September 2018 to February 2019. Negative allometric growth patterns were observed in Sari and Torkaman Port and positive allometric growth patterns were found in Anzali, Kiashahr and Astara stations. The fish caught from Anzali displayed the maximum condition factor. LWRs are not continuous over the year and LWR indices may vary significantly due to biological, food availability, temporal and sampling factors, and also by fish health and sex. Relative weights in fisheries studies can be used for comparing condition across different populations and species. Investigations carried out indicate that growth of *R. kutum* in recent years has decreased.

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Introduction

Length-weight relationship (LWR) and length-length relationship (LLR) of fishes can indicate species status in an environment and characterize patterns of growth (Froese, 2006; Kharat et al., 2008; Bibak et al., 2012). The length-weight relationship is very important in fisheries assessment. One of the most important pieces of information in stock assessment evaluation models is knowing the coefficients of length-weight relationships of a species. Length-weight measurements can provide information on stock composition, longevity, mortality, growth, and production (Bibak et al., 2013).

Rutilus kutum (Kamensky) is a species common to the Caspian Sea (Fig. 1). They can reach a length of 67 cm (rarely 71 cm) and a weight of 4 kg (rarely 5 kg), although the mean lengths from commercial catches are naturally 40–49 cm and average weights are 1.0–1.7 kg (Trushinskaya, 1975). The adults feed on benthic organisms, generally mollusks and other aquatic

invertebrates (insect larvae, crustaceans). Migration from sea to freshwater (rivers) for spawning begins when water temperatures reach 9–10 °C, around mid- to late February.

Rutilus kutum is the main component of Iranian Caspian Sea fisheries (Abbasi et al., 2019) and a main target of artisanal fishing in Iran, that use mostly beach seining (Kavan et al., 2009; Safari, 2016). The species represents over 50% of the total bony fish catch, and provides more than 60% of the fisherman's income (Abdolmaleki and Ghaninezhad, 2007; Afraei-Bandpei et al., 2009).

The species is a migratory anadromous fish which spawn in rivers in March and April (Berg, 1948; Sattari et al., 2019) including in the Iranian portion of the Caspian Sea waters (Afraei Bandpei et al., 2009; Sattari et al., 2019). Fisheries management based on incorrect estimates of fish age and growth indicators may lead to unreliable stock assessment (Beamish and MacFarlane, 1983).



Figure 1: A specimen of *Rutilus kutum* collected in this study from the southern Caspian Sea.

Size determination in fish is more biologically relevant than age, because several ecological and physiological indicators are more size-dependent compared to age-dependent (Bibak et al., 2012; Imanpour Namin et al., 2013). Therefore, the aim of this study is the investigation of length-weight, length-length relationships and condition factors of *R. kutum* in the southern Caspian Sea.

Material and Methods

A total of 218 fish specimens were obtained in two seasons, autumn and winter (2018–2019), from five fisheries regions in the south of the Caspian Sea including, Anzali (44 samples in two seasons), Astara (44 samples in two seasons), and Kiashahr (44 samples in two seasons) in Guilan Province, Sari in Mazandaran Province (42 samples in two seasons), and Torkaman Port in Golestan Province (44 samples in two seasons) (Fig. 2).

All samples were collected using gill nets from September 2018 to February 2019. The samples were preserved on ice and transported to the Laboratory of Fish Biology, Faculty of Natural Resources, University of Guilan, Sowmeh Sara, Iran and stored in a freezer for further analyses.

Total length (TL, from the tip of the snout to the end of the caudal fin) (cm), standard length (SL, from the tip of the snout to the beginning of the caudal fin) (cm), and body weight (W) (g) were measured for each specimen. The LWR was estimated by power relationship based on the following equation:

$$W = a * L^b$$

where L is the total length (cm), and W is the body weight (g). Logarithmic transformation was applied (Zar, 1999) on variables to estimate the required constant, in which *a* is the intercept of the regression and *b* is the regression coefficient (slope) (Ricker, 1975).

$$\text{Log}(W) = \text{log}(a) + b \text{ log}(L)$$

The relationship between total and standard lengths (TL and SL) was determined according to the power regression model. The condition factor (K) was measured by the following equation:

$$K = 100 * W / L^3$$

Where, W is the total weight (g), L the standard length (cm), and K the condition factor (Froese, 2006).

The calculations were carried out using SPSS software version 16 and Microsoft® Excel 2013.

Results and Discussion

The sample size, minimum, maximum and mean length, weight (\pm SD) and the relationship parameters are presented in Tables 1 and 2.

As shown in Table 1, the minimum and maximum of total length in all of the sampling regions are as follows: Kiashahr, 29 and 50 cm; Astara, 30 and 48 cm; Anzali, 16.5 and 51 cm; Sari, 34.2 and 43 cm; and the Torkaman Port, 35.2 and 41.5 cm, respectively.

Also, the minimum and maximum weights when sampling were, Kiashahr 265–1220 g, Astara 275–1195 g, Anzali 50–1525 g, Sari 456–820 g, and the Torkaman Port 479.8–720 g, respectively (Table 1).

Significant differences were observed in the body weight of fish samples collected from different fisheries regions ($P < 0.05$). The minimum and maximum length and weight of all samples were 16.5–51 cm and 50–1525 g, respectively. The condition factor was 1.15 ± 0.107 . In the present study, a negative allometric growth pattern was found in specimens from Sari and the Torkaman Port ($b < 3$) (Table 2) and a positive allometric growth pattern was found at Anzali, Kiashahr and Astara sampling stations in Guilan Province ($b > 3$). All length-weight relationships were highly significant ($P = 0.001$) (Table 2).

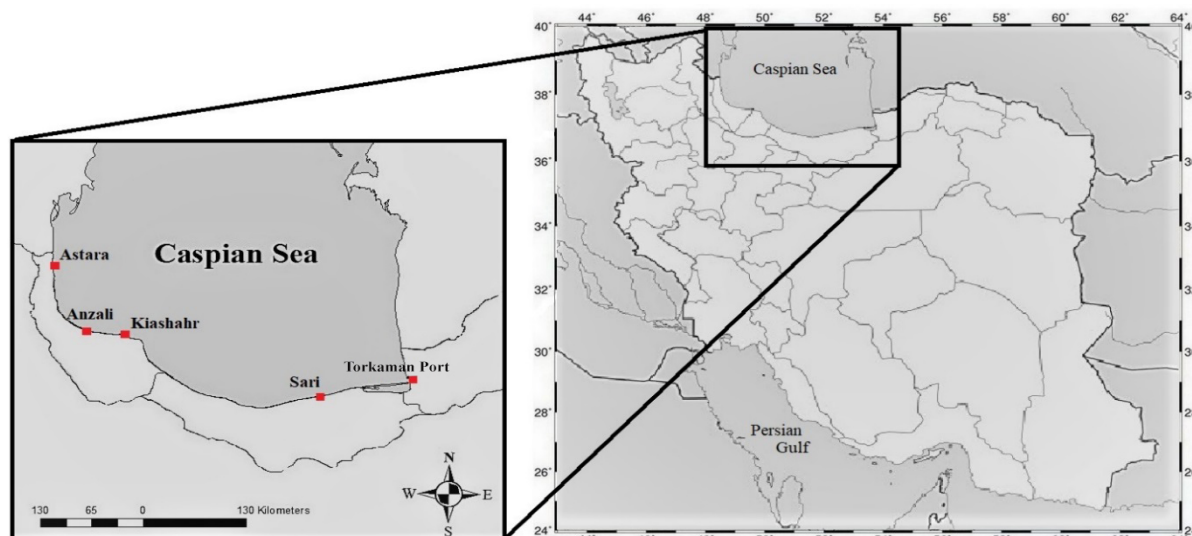


Figure 2: Map of the study area in the southern Caspian Sea, Black dots indicate locations of sampling.

Table 1: Minimum, maximum, mean and standard deviation (\pm SD) of LWR for *Rutilus kutum* from the southern Caspian Sea.

Region	No.	Total length (cm)			Weight (g)			Standard length (cm)		
		Min.	Max.	Mean \pm SD	Min.	Max.	Mean \pm SD	Min.	Max.	Mean \pm SD
Kiashahr	44	29	50	39.6 \pm 6.1	265	1220	674.3 \pm 319.3	25.5	44	34.5 \pm 5.6
Astara	44	30	48	40 \pm 0.4	275	1195	687.5 \pm 217.7	25	41.5	34.3 \pm 4.1
Anzali	44	16.5	51	38.5 \pm 9.1	50	1525	660.1 \pm 375.8	13.5	45	33.3 \pm 8
Sari	42	34.2	43	39 \pm 2.1	456	820	645.4 \pm 107.7	29.9	37	34 \pm 1.8
Torkaman Port	44	35.2	41.5	38.8 \pm 1.49	479.8	720	627.9 \pm 56.05	30.4	36.5	33.8 \pm 1.4

Table 2: Descriptive statistics and parameters of LWR for *Rutilus kutum* from the southern Caspian Sea.

Region	LWR parameters			LLR parameters		
	<i>b</i>	95% CL(<i>b</i>)	<i>r</i> ²	<i>b</i>	95% CL(<i>b</i>)	<i>r</i> ²
Kiashahr	3.10	2.99–3.20	0.959	0.99	0.97–1.005	0.98
Astara	3.07	2.96–3.17	0.993	0.99	0.97–1.008	0.99
Anzali	3.03	2.93–3.12	0.951	0.99	0.97–1.002	0.98
Sari	2.56	2.46–2.65	0.882	0.98	0.96–0.99	0.91
Torkaman Port	2.72	2.62–2.81	0.855	0.92	0.90–0.93	0.95

The K was observed to be higher at the Anzali shore than in the other regions, reflecting that the fish had better condition in this region. Generally, higher levels of condition factor ($K > 1$) indicate healthier fish populations. In this study, the fish population at Anzali displayed the maximum condition factor value (1.15) reflecting the best situation for growth compared to other regions (Fig. 3).

The length-weight relationship can also be used to determine the status of fish growth (Ricker, 1975). These parameters are essential for evaluating the relative condition of *R. kutum* as well as its management, fisheries and stock assessment in the southern Caspian Sea basin. Pollution can be detrimental to biological aspects of fish, such as growth rate (LWR), feeding, and reproductive behavior (Tarkan et al., 2006).

Ghotbi-Jokandan et al. (2015) reported a negative allometric pattern in *Alosa caspia* (Eichwald), similar to the results of the present study, while Erguden and Goksu (2009) found positive allometric patterns in *R. kutum*, contrasting with samples from Sari and the Torkaman Port but similar to Anzali, Kiashahr and Astara.

Rozdina et al. (2018) reported that the LWR for *R. kutum* in Bulgaria was negatively allometric, so their study showed similar results to this study from Sari and the Torkaman Port. Moradinasab et al. (2012) reported that the growth of *R. kutum* was similarly negatively allometric in the Caspian Sea.

Huo et al. (2011) determined that the growth in *R. kutum* in Xingjiang, China was positively allometric, and their results are similar to our results from samples at Anzali, Astara and Kiashahr.

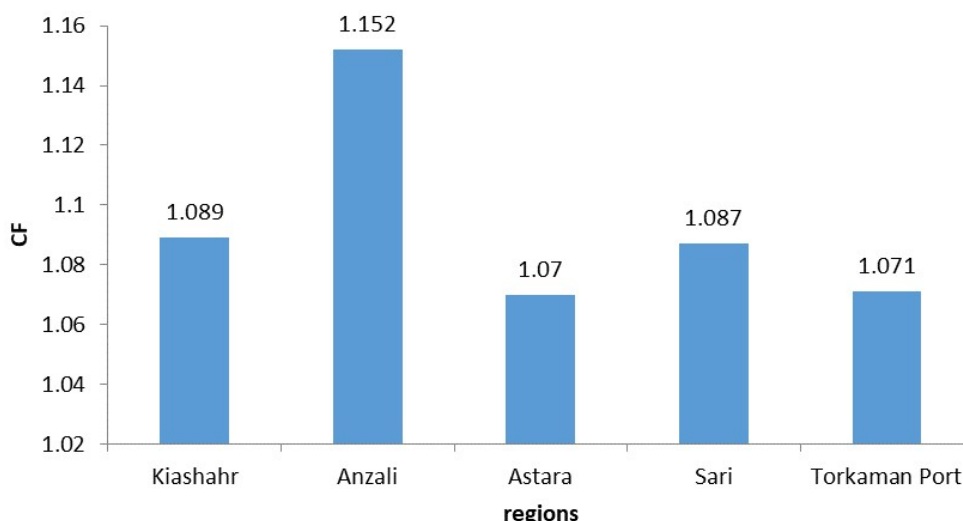


Figure 3: Condition factor (CF) for samples of *Rutilus kutum* from the five studied fisheries regions.

Length-weight relationships may vary seasonally according to the degree of sexual maturity, sex, diet, stomach fullness, and sample preservation techniques (Wootton, 1992). LWRs are not continuous over the year and LWR parameters may vary significantly due to biological, food availability, temporal and sampling factors, health and sex (Froese, 2006); however, all these factors were not considered in this study. Since all the samples were collected over several seasons, data obtained does not represent a specific season of the year. The parameters *a* and *b* should be considered only as mean annual values.

The rate of fishing has risen sharply over the past two decades compared to previous decades. Abdolhay et al. (2011) reported that due to the artificial reconstruction of *R. kutum* stocks, the catch of this fish has also increased.

However, the reconstruction of fish stocks has played an important role in increasing the fish stocks and catch rate but it should be noted that the condition factor has declined in the last two decades (Abdolmaleki and Ghaninezhad, 2007).

Increasing the number of fish larvae and releasing them can lead to strong food competition between them and may negatively affect growth and production (Vignon and Sasal, 2010).

Several factors influence the growth of fish, such as hereditary characteristics, food reserves, environmental factors and pollution (Yedier et al., 2019). Previous investigations indicate that the growth *R. kutum* in recent years has decreased (Abdolmalaki and Ghaninezhad, 2007).

Thus, the declining trends in *R. kutum* in the last two decades, which may be due to declining food availability, has led to weaker adult fish (Fazli et al., 2012).

These results are suitable for the estimation of length-weight relationships since, the values of *b* are within the range of values for this parameter usually

estimated in fishes; which according to Froese (2006) lie between 2.5 and 3.5. Relative weight in fisheries studies can be used to compare condition across different populations and species (Froese, 2006).

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Conflict of interest

All the authors declare that there are no conflicting issues related to this research article.

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