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# The Environmental Effect on Spawning Time, Length at Maturity and Fecundity of Kutum (*Rutilus frisii kutum,* Kamensky, 1901) in Southern Part of Caspian Sea, Iran

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**Abstract:** Fish sampling were carried out using beach seines during the fishing season from early October 2006 to mid April 2007. The gonadosomatic indexes (GSI) in range and average for female and male were 0.03 to 40.28 (5.70 ± 6.48) and 0.13 to 16.71 (3.39 ± 2.33), respectively. The GSI indicated that the reproductions of *R. f. kutum* were occurred during March-April, with the highest average value of 6.52 for males and of 17.00 for females in April. Fifty percent of length maturity ($L_{m50\%}$) at FL = 37.78 cm was recorded. The absolute fecundity ranged from 15,723 for a three-year old to 130,737 eggs for an eight-year old female, with a mean of 60435 ± 24889. The relationship between fecundity (F) and fork length (cm) was represented by the formula: Fec. = 6616FL+25916. The von Bertalanffy growth parameters was: $L_8$=67.5cm, $K$=0.21 year$^{-1}$, $t_0$=-0.10 for throw population of kutum. The maximum spawning migration into the rivers based on GSI occurred significantly in April but it be affected by environment of sea water layers. The results showed that the length at first maturity and fecundity of *R. f. kutum* reduced in southern part of Caspian Sea.

**Key words:** Length at maturity · Fecundity · GSI · Rutilus frisii kutum · Caspian Sea

## INTRODUCTION

In March and April, *Rutilus frisii kutum* species migrates from Iranian waters (southern part of Caspian Sea) into estuaries and rivers for spawning. This species has a life span of 9-10 years in southern part of Caspian Sea with males and females attaining sexual maturity between 2-3 and 3-4 years, respectively [1-3]. Caspian Kutum constituted about 78% of bony fish harvest and about 76.6% of the whole income of fishermen in the 2008-2009 fishing season in the southern part of Caspian Sea [4, 6]. The average annual catch of Caspian Kutum of Iranian coasts were about 9,600 tonnes/year during the period 1991-2001 and increased to 16,000 tonnes in 2006 [5, 7]. Since 1982 due to reducing Caspian Kutum population and in order to restock this valuable species in Caspian Sea, Iranian Fisheries Organization (IFO) has been annually releasing up to 200 million fry (average weight 1 g) into the rivers and estuaries that discharged into southern part of Caspian Sea [7, 8].

The economical and ecological point of view, *R. f. kutum* species is one of important and major commercial species in the southern part of Caspian Sea, but sufficient information are not available regarding to the maturity and reproduction of this specie in Iranian waters. The valuable of information is important, because of ecological changes occurring in the sea at this moment due to the appearance of *Mnemiopsis leidyi* in 1999 [9, 10] and its artificial propagation which commenced in 1982. Therefore, the present study was undertaken to investigate some life history traits of *R. f. kutum* in Iranian waters, including relationship between fecundity and fork length, body weight, ovary weight and age as well as length at first maturity and gonadosomatic index variations of the species through the analysis period.

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## MATERIALS AND METHODS

The samples areas that located in hunting regions with longitude and latitude were 48° 58' to 53° 12' E and 37° 57' to 37° 02' N, respectively of southern part of Caspian Sea (Fig. 1). The samples were collected using beach seines during the fishing season from early October 2006 to mid April 2007. From May through September, the fish catch are banned in coastal water of southern Caspian Sea. Fork length (to the nearest 1 cm) and total weight (to the nearest 0.1 g) were determined for all specimens. Macroscopic staging of the gonad was validated histological, following ovaries staging according to criteria described by [11] method. Maturity classifications are categorized in six macroscopic distinguishable stages of ovarian development such as stages I and II (immature), III (almost ripe), IV (ripe ovary), V (running rip ovary) and VI (spent ovary), respectively. Absolute fecundity was calculated by [12] method. From 121 females' samples, three different subsamples were collected from each of it at stages IV and V for counting of oocytes. The number of oocytes in these three subsamples was used to calculate absolute fecundity. The total number of oocytes in the ovary was calculated as follows:

- T. Occytes No. = ovary weight × No. of oocytes (in subsamples)/weight of subsamples.

The Age of fish was determined by scale analysis. The scale was taken from mid-body behind the pectoral fins above the hypothetical lateral line, because these are uniform and well readable. The lengths at first maturity were analyzed for fish were collected during seven months (October through April). Females were considered mature when classified into macroscopic stages III. The proportion of mature fish per 2 cm fork length class interval was calculated for females using a binary logistic regression. For estimation of the length at which 50% of the fish where mature, a logistic function was fitted to the proportion of the mature individuals by size classes.

**The Function:** $P = 1 / [1 + e^{(-r(L - L_m)}]$, was used following by [13] method, where $P$ = mature proportion in each size classes, $r$ (slope) = parameter controlling the shape of the curve, $L_m$ = size at 50% maturity.

- The gonadosomatic index (GSI) was calculated as follows: GSI (%)= [Ovary weight (g) / Body weight (g)] ×100.


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

The statistical analyses were performed with SPSS 11.5 software package and a significance level of 0.05 was adopted [14].

## RESULTS

**Age-Length Structure:** The ages of 515 fish were determined using by scale. The eldest was 9 years old (population was found to range between I and IX). The mean of age was 3.99±1.08 years old. Totally nine age-groups (9 ages groups for females and 7 ages groups for males) were represented in this study. The highest frequency (52.6% for males and 35.5% for females) were occurred in 4 years old. The mean fork length for male and female were 39±3.2 cm and 40±3.2 cm, respectively. A significant difference was found in the age between males and females (T-test, t=89.212, $p$ <0.05). Totaly, the von Bertalanffy growth parameters was: $L_8$=67.5cm, $K$=0.18 year$^{-1}$, $t_0$=-0.10 for throw population of kutum (Fig. 2).

**Ovary:** Fig. 3 shows the histology oocytes development of Kutum from II to V stages. In V stage the yolk coalesced to form yolk plates. Immature ovaries were found to be about 65.7% in October and declined to less than 50% in February. But in stages IV and V were increased to the highest value (98%) in March and April coinciding with the spawning period. From October to December the I-III maturity stages increased (av. 75.6%), reaching (90%) in January. In February I-III stages decreased (67.5%) and subsequently, from March to April they decreased rapidly (av. 5.2%) which coincided to the spawning period. About 33.5% of fish was in IV stage which coincided to autumn forms as shown in Fig.4.

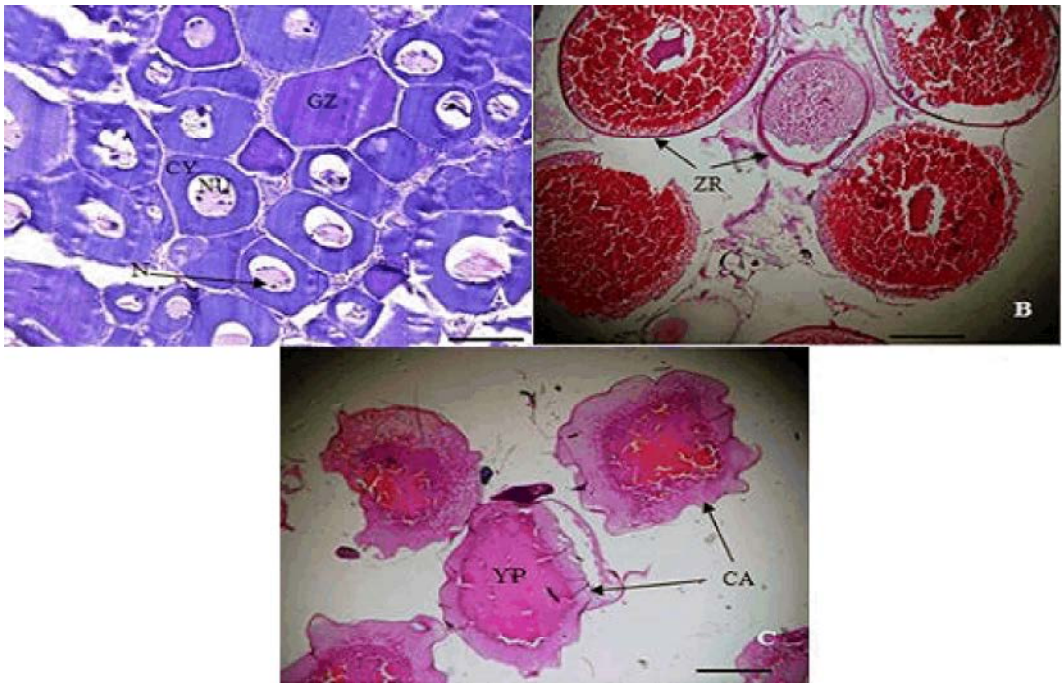


Fig. 2: Histological section of *R.f.kutum* ovary showing oocytes development. Notes: (A) is stages II, (B) IV, (C) V, CY is the thick cytoplasm around a light nucleus of pre-vitellogenic oocytes, NU the nucleus, N the nucleoli at periphery of nucleus, GZ the germinative zone, ZR the zona radiata, YP the yolk coalesced to form yolk plates, CA the cortical alveoli. Scale bars 10 µm.

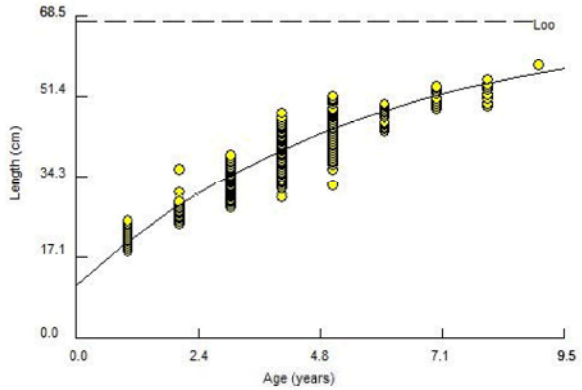


Fig. 3: The von Bertalanffy growth curve of *R. f. kutum* from the southern part of Caspian Sea Notes: the $L_8$=67.5cm, $K$=0.21 year$^{-1}$, $t_0$=-0.10, n=515.

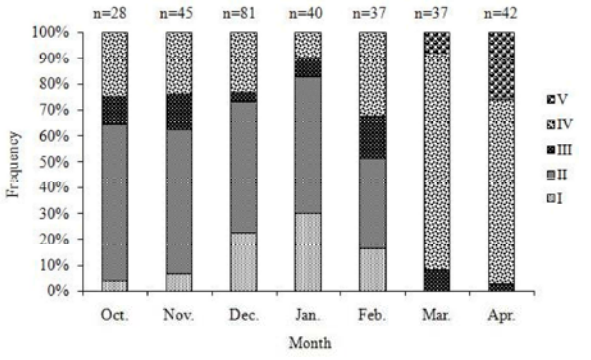


Fig. 4: Monthly variations of ovarian maturity stages of *R. f. kutum* from the southern part of Caspian Sea. Notes: stage I, II= Immature, stage III= almost ripe, stage IV= ripe ovary, stage V= running ripe ovary.

**Age Maturity:** Sexual maturity was characterized by the presence of III stage gonads. This stage represented about 9.1% of two-year old for males and 20.7% of three-year old females. The age and maturity stages results are summarized in Fig. 5. The maturity stage of male and female Kutum have been developed with increasing age. Generally, the results showed that age maturity of male occurred sooner than the female. The III and IV maturity stages observed in age two for male (20%) while for female was in age three (10%). After age three, the highest male was in the V maturity stage. Consequently, from age four to nine whole females were in the IV maturity stage which coincided to peak of spawning period.

**Fecundity:** The absolute fecundity of *R. f. kutum* was ranged from 15723 to 130737 eggs, with a mean of 60435 ± 24889 (Tab. 1). Table 1 also shows that the minimum and maximum of mean individual absolute

Table 1: Relationship between mean absolute fecundity (*F* in thousands) of *R.f.kutum* and fork length classes.

| | Fecundity (× 103 ) | | |
|---|---|---|---|
| Fork length (cm) | Range | Mean | No. Fish |
| 34-36 | 15.7-39.6 | 32.7 | 7 |
| 36-38 | 31.9-54.6 | 40.7 | 8 |
| 38-40 | 25.2-91.3 | 45.1 | 9 |
| 40-42 | 25.3-82.1 | 50.8 | 14 |
| 42-44 | 24.1-99.1 | 58.1 | 25 |
| 44-46 | 21.2-99.3 | 67.2 | 20 |
| 46-48 | 25.4-110.0 | 72.7 | 23 |
| 48-50 | 22.1-130.7 | 75.5 | 12 |
| 50-52 | 58.3-105.8 | 87.9 | 3 |

Table 2: Mean absolute fecundity (×$10^3$) of *R.f.kutum* and fork length classes in different years.

| | References | | |
|---|---|---|---|
| Fork length (cm) | Ferid-Pak (1968) | Razavi Sayad *et al.* (1972) | Present study 2006-2007 |
| 30-35 | - | - | 35.3 |
| 35-40 | 53.9 | - | 40.5 |
| 40-45 | - | 58.52 | 57.3 |
| 45-50 | - | - | 72.5 |
| 50-55 | - | - | 87.9 |
| 55-60 | | - | - |
| 60-65 | 174.4 | - | - |

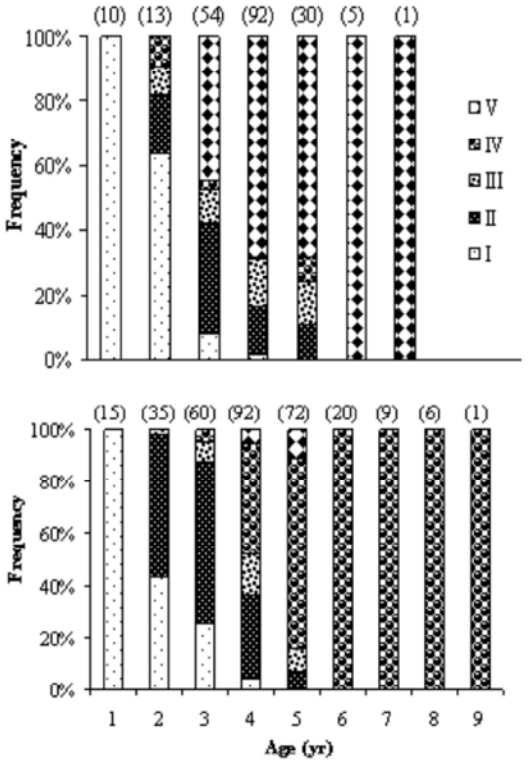


Fig. 5: Age maturity male (up) and female (down) of *R.f.kutum* in the southern part of Caspian Sea. Notes: stage I, II= Immature, stage III= almost ripe, stage IV= ripe ovary, stage V= running ripe ovary.

fecundity were varied from 32.7 x $10^3$ (34-36 cm FL) to 87.9 x $10^3$ (50-52 cm FL), respectively. Absolute fecundity was determined on 121 ripe females caught in October and April increased from 3 to 8-year old females. A minimum value of 15,723 eggs was calculated for a 3-year old and maximum value of 130,737 eggs was recorded in a 8-year old fish and a; size and age were positively correlated with absolute fecundity. Relative fecundity to total weight fluctuated from 240 to 687 oocytes/g, with a mean value of 354.3 ± 65.9.

The relationship between fecundity and fork length were significant and calculated with equation of *F*ec. = 6616.7FL+25916 ($r^2$ = 0.99, F = 704.45, n = 121). There are relationship between fecundity and fork length (FL in cm), fecundity and body weight (*W* in g), fecundity and age (year) and fecundity and ovary weight (*O* in g) as shown in Fig. 6. However, a comparison mean absolute fecundity between previous and present study (Table 2).

**Gonadosomatic Index (GSI):** Fig. 7 shows that the gonadosomatic index (GSI) for female and male of *R. f. kutum* in different months. The GSI were ranged from 0.03 to 40.28 with mean (± SD) (5.70 ± 6.48, N = 310) for females and from 0.13 to 16.71 (3.39 ± 2.30, N = 205) for males. The mean GSI increased from 2.08 in October to 17.00 in April for female and 0.73 in October to 6.52 in April for male.

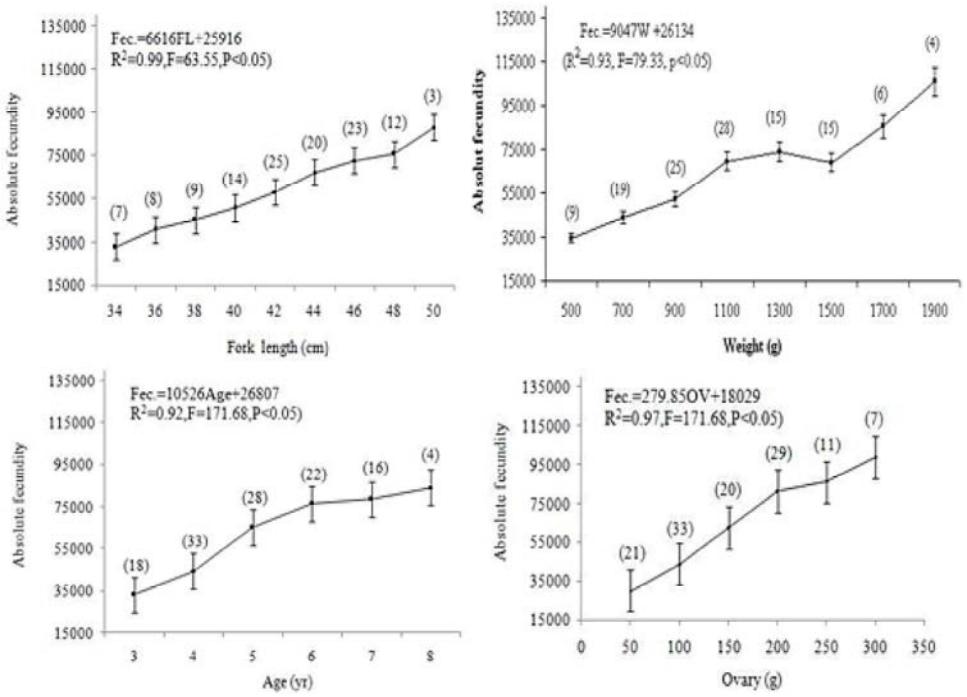


Fig. 6: Relationship between mean (±SD) absolute fecundity and fork length (cm), weight (g), age (yr) and ovary weight (g) in *R. f.kutum* from the southern part of Caspian Sea. Note: Vertical bars indicate standard deviations. Figures in parentheses indicate number of sample size.

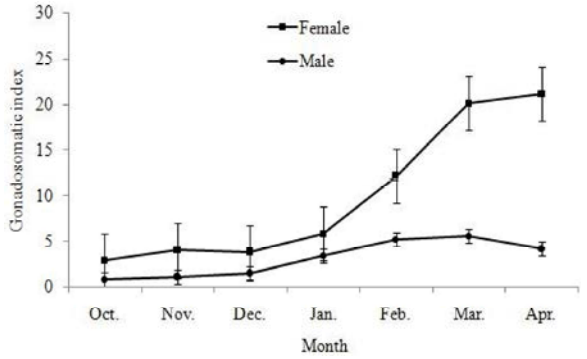


Fig. 7: Monthly variation of GSI in *R. f. kutum* from the southern Caspian Sea. Note: Vertical bars indicate standard deviations.

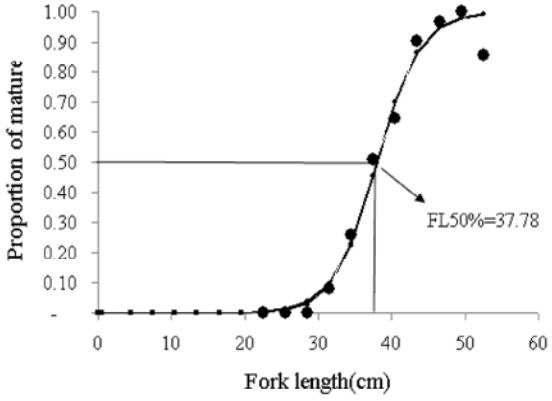


Fig. 8: Maturity ogive showing length at maturity of *R.f.kutum*, from the southern Part of Caspian Sea.

Table 3: Relationship between GSI and fork length (cm), gonad weight (g) and combined of *R.f kutum* in the southern part of Caspian Sea. Notes: *GSI* is the gonadosomatic index, *FL* is fork length and $W_g$ is gonad weight.

| | Parameters | N. | *r* | *b* | *a* | *t(b)* | *P*-value |
|---|---|---|---|---|---|---|---|
| Combined | *GSI-FL* | 515 | 0.99 | 0.281 | 0.245 | 778.01 | 0.001 |
| | $W_g$-*FL* | 515 | 0.75 | 7.49 | -10.58 | 27.55 | 0.001 |
| Female | *GSI-FL* | 310 | 0.63 | 5.18 | -7.58 | 15.32 | 0.001 |
| | $W_g$-*FL* | 310 | 0.79 | 8.42 | -12.o6 | 24.91 | 0.001 |
| Male | *GSI-FL* | 205 | 0.28 | 1.74 | -2.34 | 4.29 | 0.001 |
| | $W_g$-*FL* | 205 | 0.64 | 4.84 | -6.42 | 11.79 | 0.001 |

The GSI differed significantly between males and females during the period of study months ($r^2 = 19.517$, $p < 0.05$). Table 3 shows that the correlation coefficient between GSI and fork length in female was significantly higher than the male (ANOVA, F=276.50, df = 514, $p<0.05$). Gonads were macroscopically visible for individuals = 21 cm FL for males and= 23 cm FL for females corresponding to 2-year old specimens. The ovary began to develop between October and April after a quiescent period of 6 months (when the fish catch is forbidden in the southern pat of Caspian Sea). Reproduction phase is extended from February to April, peaking in March, with the highest average values of 5.52 for males in April and with highest average of 17.00 for females. From October to January, the GSI has steady trend for female and male. Afterwards from February to April, GSI increased for both sexes which coincided to peak of spawning time in April. The GSI of both sexes followed the same pattern and during the reproductive period, the average values of males and females differed significantly (t-test, F = 18.69, $p < 0.05$).

**Length at Maturity of Female:** The sexual maturity logistic curve for females of *R. f. kutum* is shown in Fig. 8. The fork length of 37.78 cm corresponded to 50% of the sexually mature female ovary samples.

## DISCUSSION

The maturation age was observed with two years old for males and three years old for females with most spawners at three years (males) and at four years (females) in Anzali lagoon [15]. At the present study, sexual maturity was characterized by the presence of stage III gonads. This stage represented about 9.1% and 20.7% of two-year old for males and females, respectively. Based on the collected specimens, the frequency of stages III-V increased from three-year old to eight-year old for female and seven-year old for male. The spawning migration times into the rivers that discharged to southern part of Caspian Sea in such as Sefidroud River early March with 9.0°C of water temperature and the peak of spawning was observed at April with 11°C [8]. In contrast, a report shown that the spawning migration of this species into Terek River begins in early spring with a water temperature of 8.0°C and the peak of spawning is observed in late April with a water temperature of 13-15°C [16]. At the present study, the mean water temperature was 9.9°C ± 1.8 in March, coincided with spawning migration to the rivers that discharged into southern part of Caspian Sea as reported previously [2]. This could be due to geographical location of area and water temperature changes.

There is a widespread trend for fecundity in fish to be positively correlated with length [17]. The fecundity-body weight relationship can probably be used to discriminate between the different stocks of the same species of fish due to variable growth rates in different localities [18]. The fecundity of *R. f. kutum* was positively correlated to fish size (length or weight). Maximum and mean fecundities (absolute and relative) estimated in this study were lower than those obtained for middle and southern part of Caspian Sea [8, 19, 20]. The variation of absolute fecundity of *R. f. kutum* of this study were 15 723 to 130 737 (av. 60 435) with similarity to compare with other research [21, 22] varied from 33 768-124 712 (av. 86 000) and 19 718-147 696 (av. 74 774) oocytes, respectively with less average in southern part of Caspian Sea. The comparison of fecundity for this study with previous studies suggests that fecundity of *R. f. kutum* has fluctuated in all length classes. This fluctuation is probably due to lack of data for damaging of spawning grounds in the rivers; artificial propagation was applied in this area since 1982. The reason that fecundity decreases is related to an increase in species population and decline food sources [23]. The fecundity is affected by many factors, such as the size, age of females, life history strategy, food supply and temperature [24-26]. The present study, spawning period started from March and peaked in April in the southern Caspian Sea. This is similar to other studies [3] in second half of March migration into Sefiedroud River and other Iranian rivers but was different from other report about reproduction peak during late April in Terek River [16]. This could be due to different geographical conditions, sufficient temperature and high water flow of the rivers especially for anadromous species.

A report [27] shown that the difference were observed between two estimates of $L_{m50\%}$ from one species could be the result of including samples from fish caught in area throughout the sampling period and/or estimation methodology. At the present study, length maturity of *R. f. kutum* decreased compared to previous study [8] was reported that the length maturity of *R. f. kutum* (40 cm) for the Anzali lagoon. This could be due to different method for sampling, e.g fish caught by beach seine in the present study (October-April) whereas cast net and gillnet used for spawners of Kutum for artificial propagation programme (March-April) in Anzali lagoon. The catch ratio of bony fishes decreased in 1960s and 1970s from 2745 tonnes to1659 tonnes which coincided to fellow

down water level of Caspian Sea and follow that decrease water level of lagoon and rivers, destroyed feeding and spawning grounds because of *R. f. Kutum* is a anadromous fish in the Caspian Sea [8]. These events can be effected on the some biological carachterestics *R.f. kutum* in the area.

Gonadosomatic index (GSI) indicates gonadal development and maturity of fish [28]. The difference between male and female GSI suggests that energy invested in gamete production by male is probably less than that invested by females [29]. Generally, the results show that GSI of males were lower than those of the females. This could be due to physiological and hormone effects on the gonadal development of fish. The results were shown that the GSI increase for both sexes in April. This could be due to close to spawning period and development gonads. The spawning migration of *R. f. kutum* from sea to the rivers (spawning ground) were take placed in Iranian coastal part of Caspian Sea in March and April [2]. Lower GSI values coupled with lower fecundity in the southern Caspian Sea could be interpreted as lower energetic investment in reproduction. The GSI female of Kutum increased from October (2 ± 0.6) to April (18 ± 1.9) and the maximum GSI value was observed in spring while females were in stage V of maturity [30, 31]. These results are in accordance with the results of the present study. The feeding intensity were decreased that described by increment of GSI in March and April. The feeding intensity of Kutum were increased from October to December and then decreased from February to April [31].

## COCLUSION

At the present study was shown that the reduction of length at first maturity ($Lm_{50\%}$) and a lower number of oocytes production (low absolute fecundity). There are several possible explanations for these life history parameters. Moreover, for complete studies on length at first maturity during an annual cycle further research is needed, particularly from May to September.

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