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Reproductive cycle and spawning patterns of Lizardfish, *Saurida tumbil* (Bloch, 1795) in southern water of Iran

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Abstract

Reproductive activity of lizard fish, *Saurida tumbil* was assessed using histology. Sex ratio, maturation cycle, fecundity, gonadosomatic index based on 949 specimens collected monthly from north coast of Persian Gulf (Hormuzgan province), between June 2007 to June 2008. The sex ratio of the investigated fish was 1.92:1 (females: males). The results showed that the total length of female specimens ranged from 16.2 to 55.5 cm and total weight extended from 29.93 to 1587.12 g, while male specimen ranged from 18.1 to 44.00 cm and from 30.81 to 724.00g in total length and total weight respectively. The length-weight relationship valued for females and males were $W_{tot}=0.0017L^{3.4214}$ $R^2=0.9578$ and $W_{tot}=0.0018L^{3.4015}$ $R^2=0.9699$, respectively. Different stages of gonad development based on external appearance and histological observation of ovaries, revealed the existence of six stages for oocyte development of female specimens as immature, maturing, ripening, ripe, spawning and spent. The mean monthly values of GSI indicated that the species is a spring and autumn spawner with two peaks from September to November and a minor peak from February to April. Mean length at first maturity (Lm 50%) was 27.4 cm for females and 25.3 cm for males. Absolute fecundity of 30 maturity samples ranged between 48863-211689 as the number of eggs found in each ovary in the size range 40-50 cm.

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Introduction

The lizard fish, *Saurida tumbil,* belonging to the family Synodontidae , is one of the most abundant, and commercially most important, fish species in Indo-West Pacific from east coast of Africa to the Persian Gulf and further east to southeast Asia and Australia. For the past decade, it has been subjected to increasing exploitation. Consequently, overfishing is effective in reducing the spawning biomass of a fishery under desired ranges including maximum sustainable or economic yields. Therefore, detailed reproductive knowledge of *S. tumbil* will provide valuable information for fishery management and stock assessment, which will lead to a sustainable natural resource in south water of Iran in Persian Gulf. Despite the large number of studies describing biological characteristics (Raje *et al*., 2004) biomass and resource management (Valinassab *et al*., 2006) and spawning periodicity (Soofiani *et al*., 2006) there remains a paucity of evidence on sexual maturity, fecundity, and sex ratios of *S. tumbil*, in southern water of Iran. Therefore, this paper attempts to provide some primary information about the reproductive cycle of *S. tumbil* in the Persian Gulf. The reproductive aspects of *S. tumbil* included in the present study are sex ratio, length-weight relationship, spawning, microscopic and macroscopic gonad observation, fecundity and length at first maturity.

Materials and method

Study area

A total of 949 *S. tumbil* were collected on a monthly basis throughout June 2012- 2013 from commercial trawlers and research vessels within three different fishing areas in the south Qeshm Island (N26º 31′ E 55º 46′), Bandar –Abbas (N 27º 02′ E 56º 20′) and Bandar- Lengeh (N 26º 27′ E 54º 56′) (Fig. 1).

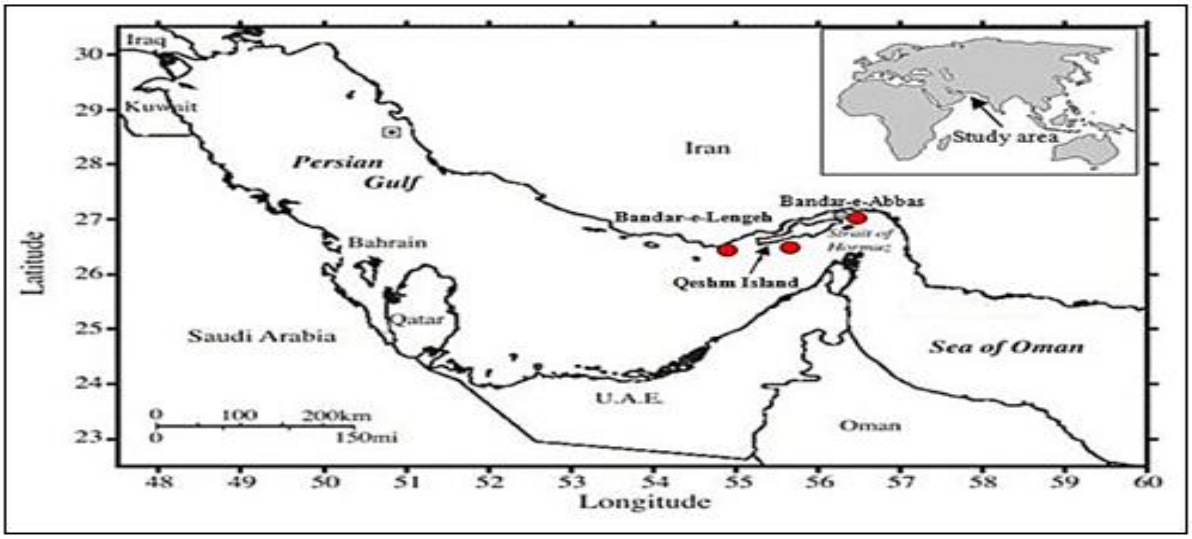

Fig. 1. Location of the sampling sites (●) in the Persian Gulf and Oman Sea.

Length- weight relationship

Total length (TL) of 949 individuals was measured to the nearest 0.1 cm by digital calliper and weighed (W) to the nearest 0.01g by digital balance. The length-weight relationships were estimated by using the following equation.

$W=aL^b$ (Mirzaei *et al*., 2014), Where: W= Fish weight (g), L= Fish Length (cm), "a" and "b" are constant.

Gonad development stages

Morphological maturity stage classification (Table 1) was established by gonadal inspection following a six step scheme based on gonad size and appearance (Hatikakoty and Biswas, 2004). Histological analysis was examined for both sexes using Kinoshita *et al.* (2009) method. The gonad tissue was cut into small pieces (5mm) and was immediately immersed in the Bouin's fixative for 24 hours. The dehydration process was conducted with a series of different

concentrations of alcohol solution to remove the excess water from the gonad specimen. The clearing process was carried out by immersing the gonad specimen in Xylene solution. The gonad specimen was then impregnated with wax to maintain tissue integrity and to provide a firm surface for the microtomy process.

Histological analysis was followed by transferring the gonad specimen to an imbedding process using the Leica EG 1160 (tissue embedding system). After that, the moulding gonad tissue was cut into small thin slices in the sectioning step using a Leica RM 2135 microtome. The staining process was the next step, whereby the glass slides were stained by using dyes to make a better contrast image. This was followed by mounting, where the slides were glued with a cover slip using D.P.X glue.

Gonadosomatic index

Monthly mean gonadosomatic index (GSI) was calculated in 30 specimens using following equation.

$$GSI = \frac{\text{gonad weight(g)}}{\text{fish weight (g)}} \times 100$$ (Sousa *et al.*, 2003; Mirzaei *et al.*, 2013).

Fecundity

Gravimetric method was used for determination of absolute fecundity. The ovaries were rinsed with water and placed in Gilson's fluid to dissolve the connective tissues. Three subsamples taken from the anterior, middle and posterior parts of the ovary. Samples were weighed and average number of eggs in each subsample were directly counted, the mean value was calculated using the equation given below:

$$F = n \times \frac{G}{g}$$ (Nitschke *et al.*, 2001).

Where: F= absolute fecundity, n= Average number of eggs in each subsample, g= subsample weight (g) and G= Ovarian dry weight (g).

Relative fecundity was calculated by the following equation:

$$R = \frac{F}{TW}$$ (Hotos *et al.*, 2000).

R= Relative fecundity, F= absolute fecundity, TW= Total body weight (g).

Length at first maturity

Length at which 50% of individuals reach sexual maturity (Lm50) was considered as length at first maturity (Sinovčić and Zorica, 2006). The female specimens in spawning stage were arranged into 10 mm length classes and their frequencies were scaled to percentages.

Results

Sex Ratio

Monthly frequency of male and female *S. tumbil* showed that the females dominated the natural population over the study period. In total of 949 specimens , 624 females and 325 males were employed to analyze the sex ratio of *S. tumbil* (Fig. 2). The total sex ratio was found to be 1.92 females: 1 male and significantly different from the hypothetical distribution of 1:1 ($p < 0.05$).

Length- weight relationship

Length and weight measurements of specimens were used to describe the length-weight relationship of *S. tumbil.* Length ranges in both sexes were from 16.2-55.5 cm (females) and 18.1- 44.00 cm (males), weight ranges for females and males were from 29.93-1587.12 g and 30.81-724 g, respectively.

The linear regression analysis of length-weight data allowed to estimate 'a' and 'b' constants in females by $W= 0.0017\ TL^{3.4214}$ equation and regression coefficient $R^2 = 0.9578$ (Fig. 3) and $W= 0.0018\ TL^{3.4015}$ with a regression coefficient $R^2 = 0.9699$ for males (Fig. 4).

Gonadal maturity stages

Monthly frequency distribution of gonadal maturity stage arranged by investigation fresh individuals gonads (Fig. 5 and 6).

In both sexes, two different periods can be defined:

(a) in late autumn-winter, when the Percentages of low level gonadal maturity (stages I, II, III) were higher than high level of gonadal maturity (Stages IV, V); (b) in spring-early summer, when an increase in the percentage of high levels gonadal maturity (Stages IV, V) were observed. These results indicate the existence of reproductive activity in late summer and early autumn and to a lesser degree in the early spring.

Table 1. Visual (macroscopic) maturity stages and descriptions for *Saurida tumbil* ovaries from Persian Gulf and Oman Sea.

Stage	Described stage
I	Ovaries are tiny, narrow and string. Occupying a very small part of the body cavity. Testes are narrow, thin and transparent.Ovaries and testes invisible to the naked eye.
II	Ovaries develop in size and rise in weight and volume. Filled approximately 50% the body cavity. Testes grow to be enlarged, rise in weight and volume, in additionally milky white in color. Ovaries and testes observed with the naked eye.
III	Ovaries distended more or less 2/3 of the body cavity with yellowish eggs. Testes expand with increased weight and volume, pinkish and considerably more vascular.
IV	Ovaries are bigger and filling nearly whole body cavity, Ova become bigger, round, transparent, dark yellow. Testes change to reddish colour and increase in weight and volume. Blood capillaries are clearer.
V	Walls in the ovaries are narrow and transparent . Ova from ovary membranes is clear. Several ripe ova appear in the oviduct.Testes are white, flimsy and narrow.
VI	The ovaries become flaccid and sac like, decrease in volume. Some not spawning ova and many of the small ova remain in ovary. Testes become flabby, narrow and whiter color.

Histology

Monthly histological observations indicated that the spawning of females *S. tumbil* was in September and early November, in addition, there was a small amount of spawning in February. Histological maturation of *S. tumbil* oocytes from immature to the spent stage as shown in Fig. 7 (Scale bar = 100 µm). On the chromatin nucleolar stage (I) and Prenucleolar stage (II), nucleoli (ne) was presented in the periphery of the nucleus (n), In addition, cortical alveoli were obvious within the cytoplasm (cy) which was surrounded by the zona radiata (zr). By Vesicle (cortical alveoli) Stage (III), there was a notable improvement in oocyte diameter and the cytoplasm was occupied with yolk vesicles (yv) and cortical alveoli (ca). In yolk granules or vitellogenesis stage (IV) nucleus moved to the periphery of cytoplasm. Maturation and ovulation stage (V) was distinguished by start to hydration and yolk granules changed into a limited number of plates. After spawning the post ovulatory follicles (pof) were observed.

Length at first maturity

Base on Woodhead (1978), the length at which 50% of individuals were in sexual maturity stage (IV , V) will be considered the length at first maturity. Frequency of mature specimens was plotted against different size group (1 cm) for male and females. Males and females became mature at total length of 26.2 cm and 27.4 respectively. Almost all males that were over 33.9 cm (TL) were mature, while, for females, it was 35.4 cm. Generally males reached sexual maturity at a smaller size than female specimens (Fig. 8).

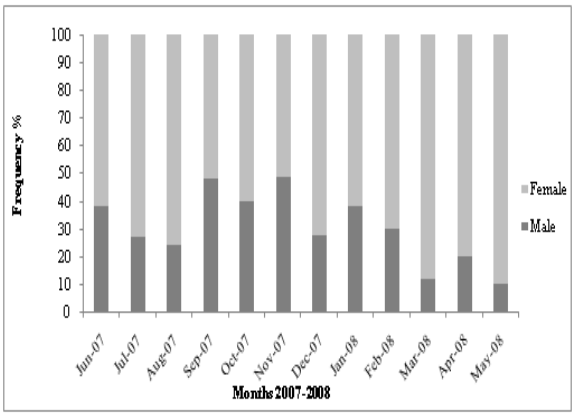

Fig. 2. Monthly variation in Sex ratio of male and female *Saurida tumbil* in Persian Gulf (Hormozgān Province).

Gonadosomatic Index (G.S.I.)

Monthly variations of the gonadosomatic index showed; both sexes followed nearly the same pattern

and values ranged 0.29 - 5.2 for females and 0.5 - 1.7 for males. The results revealed one major peak in November, which suggested that there was one main reproductive season during September to November. A minor peak displayed a small amount of spawning during February to March. Moreover, GSI values during the November - January indicates a lower reproductive activity during the study period (Fig. 9).

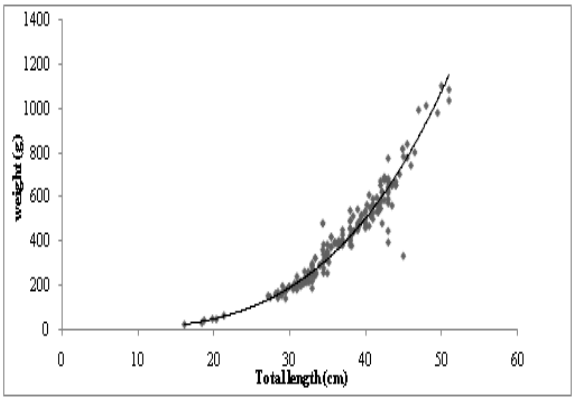

Fig. 3. Length-weight relationship curve for female *Saurida tumbil* from the Persian Gulf (Hormozgān Province).

Absolute Fecundity

Absolute fecundity for 30 of fish with ovaries at stages IV and V were calculated. Minimum absolute fecundity was 48863 (± 356 SD) eggs per gonad, related to species by mean gonad weight of 10 g and mean total weight of 134 g, while the highest absolute fecundity was equivalent to 211689 (±402SD) eggs per gonad related to species by mean gonad weight of 43.5g and mean total weight of 874.5 g.

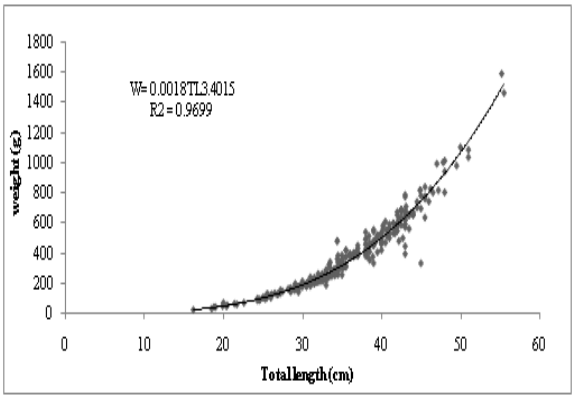

Fig. 4. Length-weight relationship curve for male *Saurida tumbil* from the Persian Gulf (Hormozgān Province).

Fecundity relationship with other parameters

Relationship between Fecundity-total lengths and fecundity-total weight of *S. tumbil* are shown in Fig. 10, 11, respectively. The relationships of this population expressed in linear regression equation were as follows:

F= 8331.TL – 2569, R^2 = 0.567 (Relationship between fecundity and total length (cm)).

F= 227.6 W – 54578, R^2= 0.569 (Relationship between fecundity and weight (g).

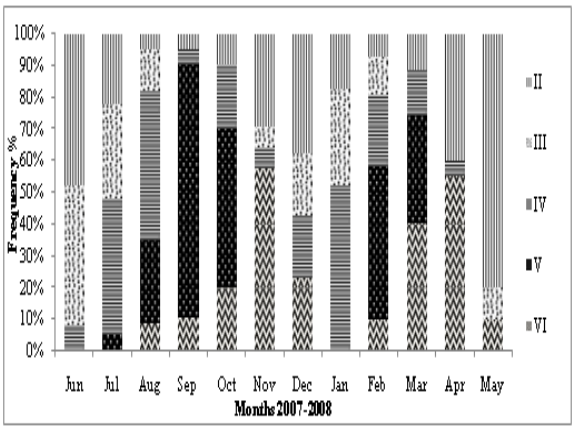

Fig. 5. Monthly distributions of maturity stages of females *Saurida tumbil* in Persian Gulf (Hormozgān Province).

Discussion

The current study found that population structure of *S. tumbil*, length and weight range were from 16.2 - 55.5 cm and 20.93 -1587.12 g, respectively. This shows *S. tumbil* in Hormozgan Province was wider in length and heavier in weight range as compared to studies in Arabian sea and Red sea (Budnichenko and Nor, 1978; Bakhsh, 1996). In this study the length and weight ranges in females were generally higher than males. The maximum length of *S. tumbil* in this study was 55.5 cm which was larger compared to 33cm (Bakhsh, 1996), 39.90 cm (Fofandii, 2011).However, larger specimens of up to 58 cm (Abaszadeh *et al.*, 2013) and 59 cm (Soofiani *et al.*, 2006) have also been recorded from another region of the Persian Gulf.

In the present study, the sex ratio (1.92:1) of females to males of *S. tumbil* indicated the dominance of females over males in most of the months throughout the year. This finding is in agreement with Abaszadeh

et al. (2012); Bakhsh (1996); Raje *et al.* (2011); Soofiani *et al.* (2006) findings which showed sex ratio for *S. tumbil* was significantly female biased.

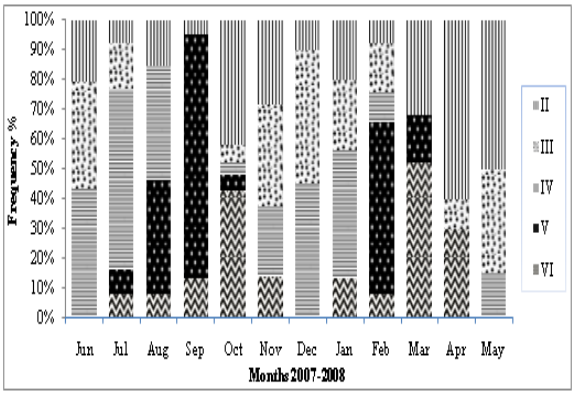

Fig. 6. Monthly distributions of maturity stages of males *Saurida tumbil* in Persian Gulf (Hormozgān Province).

Length-weight relationship of *S. tumbil* showed, the regression line slope of males and females were 3.40 and 3.42, respectively, which indicated an isometric growth in this species. Studies in other regions were closely to our results (Mathews and Samuel, 1989; Fofandii, 2011; King, 2013). These may be due to migration of females toward the shoreline for spawning (Bakhsh, 1996).

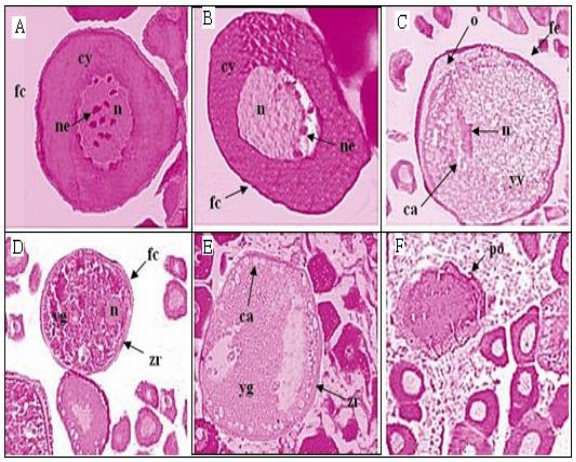

Fig. 7. (A) Chromatin nucleolar stage, (B) Prenucleolar stage, (C)Vesicle (cortical alveoli) Stage, (D) Yolk Granules or Vitellogenesis Stage, (E) Maturation, hydration and ovulation stage, (F) Degeneration stage. Description: n: nucleus, ne: nucleolus, cy: cytoplasm, fc: Follicle, ca: Cortical Alveoli, yv: yolk vesicle, yg: yolk granule, zr: Zona Radiata, pof: post ovulatory follicle.

Monthly distribution of gonadosomatic index (GSI) trend showed maximum GSI value was in September and the second peak occurred in February and early March. Our observation in GSI values of *S. tumbil* in Hormozgan Province, were very close to results of other researchers in the Persian Gulf (Soofiani *et al.*, 2006; Rahimibashar *et al.*, 2012; Abaszadeh *et al.*, 2013). In addition, (Rao, 1983) reported spawning time for *S. tumbil* was from September to March with a peak in November and December in the Bay of Bengal. Budnichenko and Nor (1978) reported that *S. tumbil* with two to four stages of ovarian maturation showed intermittent spawnings throughout the year. This difference may be due to ecological differences is in the behavior of this species. This suggests that a marine fish may have similar characteristics in different places, but environmental factors can create differences such as sexual behavior.

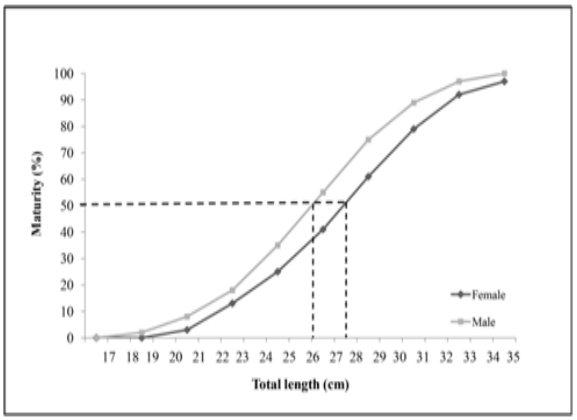

Fig. 8. Size at first maturity of females *Saurida tumbil* in Persian Gulf (Hormozgān Province).

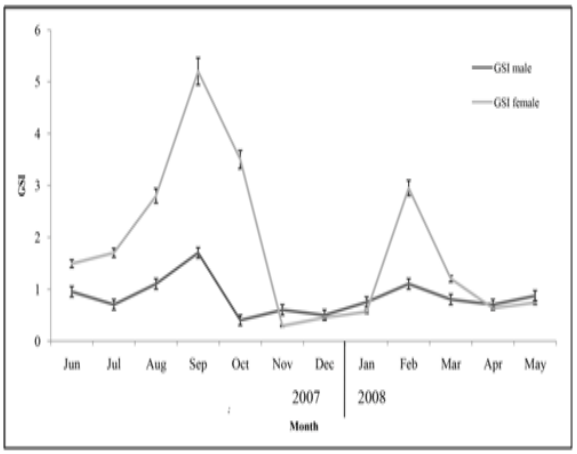

Fig. 9. Monthly variation of Gonadosomatic Index of female *Saurida tumbil* in Persian Gulf (Hormozgān Province).

In current study, monthly histological distribution of *S. tumbil* showed a major spawning and delayed spawning with the highest activity from September to November. Nearly all stages were recorded throughout the year with various rates. Prenucleolar stages (II) and cortical alveoli (III) were in higher percentages during April to July, while yolk granules (IV) stage increased during July, August, and January. The spawning frequency increased progressively from July to October, in addition revealed in February and March. Our observations on the histological analysis of female *S. tumble* in Persian Gulf is in line with the results of most researchers who have investigated lizard fish spawning time and observed that it extended over half of the year (Abaszadeh *et al.*, 2012; Rahimibashar *et al.*, 2012; Rao, 1983).

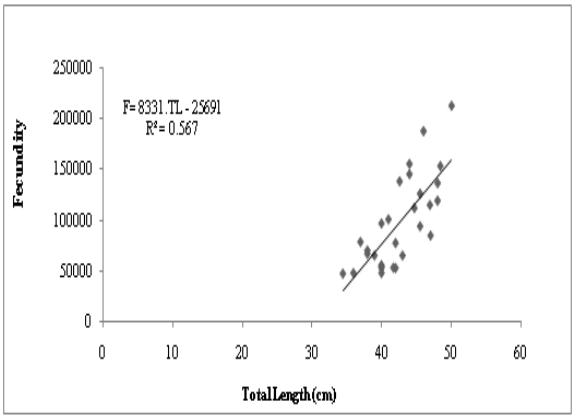

Fig. 10. Relationships between fecundity and total length of *Saurida tumbil* in Persian Gulf (Hormozgān Province).

Based on histological analysis, *S. tumbil* has a prolonged spawning season and can be identified as a synchronous spawner with two sets of oocyte existing at the same time in different gonad development stages.

In the present study, individuals in sexual maturity stage showed 25-28 cm size group whereas the length at which 50% of the species reached to 25.3 cm in males and 27.4 cm in females was length of first maturity. In other regions of Persian Gulf the length at first maturity recorded 27cm (Abbaszadeh *et al.*, 2010), 29.5 cm (Motlagh *et al.*, 2012), 16-18 cm in Gulf of Suez (Latif and Shenouda, 1973), and 14-24 cm in Indian waters (Rao, 1983). These differences in length in first maturity may be due to inherent genetic differences between the populations and effects of environmental factors could be driving the differences.

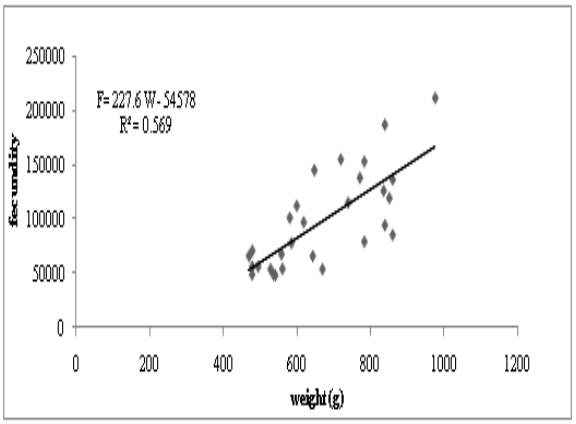

Fig. 11. Relationships between fecundity and total length of *Saurida tumbil* in Persian Gulf (Hormozgān Province).

In the present study, absolute fecundity ranged between 48863 - 211689 eggs with weight and length ranges of 134 - 874.5 g and 40-50 cm, respectively. The present findings seem to be consistent with other research which found absolute fecundity of *S. tumbil*, 24,160 - 1,72,000 eggs with weight range of 230-670 g from Mumbai waters (Metar *et al.*, 2010), 140742-456985 eggs for species with weight range between 399-1470g in Persian Gulf – Bushehr Province (Abbaszadeh *et al.*, 2010) and 74444 - 250452 eggs for species with weight range between 336.5 - 992 g in Persian Gulf- khuzestan province (Soofiani *et al.*, 2006).

Fecundity information is important to understand fish life history and use to estimate the difference between races, generations of survival studies and evaluate the reserves. In addition fecundity depended on several factors like different stock of fish, nutritional level (Gupta, 1968), racial features (Das, 1977) and period of sampling, maturation stage and variations in environmental factors (Bhuiyan *et al.*, 2006).

Results of present study showed, *S. tumbil* was group-synchronous type of oocyte development. Besides that

the female population was approximately twice of male. With consideration of a result of current study, besides over fishing, observe a serious threat for *S. tumbil* population in southern water of Iran. Therefore, if male length of lizardfish differed from females during the year, it leads to improve the sexual structure of population in the future.

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