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Reproductive Biology of the Tiger Tooth Croaker, *Otolithes ruber* (Bloch and Schneider, 1801) in the Iraqi Marine Waters

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ABSTRACT

This study was carried out to determine the reproductive biology characterizations of the tiger tooth croaker (*Otolithes ruber*) in Iraqi marine water northwest of the Persian Gulf. Test organism – *Otolithes ruber*, a total of 221 fish and around (8.1– 46.6 cm) in length were collected using bottom gill net and trawl. An upward trend was observed in the gonadosomatic Index (GSI) in March. It found that the sex ratio of females was more than males during the breeding season. Five stages of the sexual development of the gonads were identified. The length at first maturity (Lm_{50}) was 27 cm. The absolute fecundity rate of *O. ruber* is 436636 eggs. The months of January and February recorded the predominance of the developing stage of females, which will participate in reproduction. The breeding period was determined from March to April, reproduces once a year. The results of the study support the dynamic applications of *O. ruber* stock, which will help in the management choices for a sustainable stock for future generations.

INTRODUCTION

Otolithes ruber belongs to the Sciaenid family, an important economic species in the Persian Gulf and Oman Gulf. The main methods of fishing are bottom trawls, Submersible gill nets, and angling fishing **(Farkhondeh *et al.*, 2018)**. This fish is distributed throughout the western Indian Ocean, Australia, and Japan, except the Red Sea **(Fischer and Bianchi, 1984)**. and along the Iranian coast at the Sea of Oman and the Persian Gulf **(Eskandari, 1997)**. It inhabits marine coastal waters with muddy bottoms at 40 m depth of estuaries **(Navaluna, 1982)**. Approximately 5.0-10.5% of the total fisheries in the Sea of Oman and the North Persian Gulf waters, respectively **(Valinassab *et al.*, 2016)**. It is present all year round in Iraqi marine waters northwest of the Persian (Arabian) Gulf, and the peak of fishing is reached during the spring, and the amount of fishing for the unit of effort is 3 $kg.hour^{-1}$ during March 2004 and its annual catch was 1.86 $kg.hour^{-1}$ **(Resen *et al.*, 2010)**. The stock of *O. ruber* in Iraqi marine waters is considered underexploited **(Mohamed and Al-Hassani, 2021)**.

There are several biology studies about *O. ruber* fish in many countries around the world, including age and growth **(Brash and Fennessy, 2005)** in South Africa, Length-weight relationship **Al-Zaidi (2020)**, Bilateral asymmetry in size of otolith **(Jawad *et al.*, 2021)** in Iraqi marine waters. While, some studies were concerned with the reproduction of *O. ruber* **(Hussain and Abdullah,1977; Abu-Hakima, 1984; Dadzie and Abou-Seedo 2004; Dadzie 2007)** in Kuwaiti waters., and in Iranian waters, **Kamali *et al*. (2012)** in the Hormozgan region, and **Farkhondeh *et al*. (2018)** in the Oman Gulf, and **Lanzuela *et al*. (2020)** studied the reproductive biology of *O. ruber* fish in Philippine waters.

The current study aims to assess the changes in the most significant features of Reproductive biology of *O. ruber* fish in Iraqi marine waters because of changing environmental conditions in the area and increasing fishing efforts. The study included the presence of lengths according to months, the various mature fish percentages with length, monthly changes in sexual maturity and their ratio, gonad morphology, and for benefit (utilizing) From this information as an initial contribution to the community dynamics study and stock assessment investigations at future to develop the managing strategies for *O. ruber* fish resources had economically important.

MATERIALS AND METHODS

1. Study area

The Iraqi marine waters form a coast that starts from the Umm Qasr border area with the State of Kuwait and is narrow when it ends in the Ras Al-Bishah area in the Faw border area with the Republic of Iran, then it begins to widen to reach this distance to 50 km with a total area of about 900 km^2 (fig. 1), it is dominated by river sediments carried to it by the waters of the Shatt al-Arab. and it is located at the northwestern end of the Arabian Gulf between longitudes 48° 30′- 48◦ 55′ east and latitudes 29° 35′–29° 55′ north **(Hussein *et al.*, 1989)**. The fishing area in these Iraqi marine waters is divided into three areas: the Shatt al-Arab estuary area, the Khor Abdullah fisheries, and the deep port fisheries **(Ali *et al.*, 1998)**. The study area is affected by the expenditures coming from the Shatt al-Arab, which in turn depends on the water coming from the Tigris River only after the Euphrates and Karun Rivers were cut off from it, according to the data of the Water Resources Department. In addition, the expenditures of the Shatt al-Arab in terms of the annual average amount to 53.7, 39.1, 49.9 $m^3. sec^{-1}$ for the years 2014, 2015, and 2016 respectively **(Qasim, 2018)**.

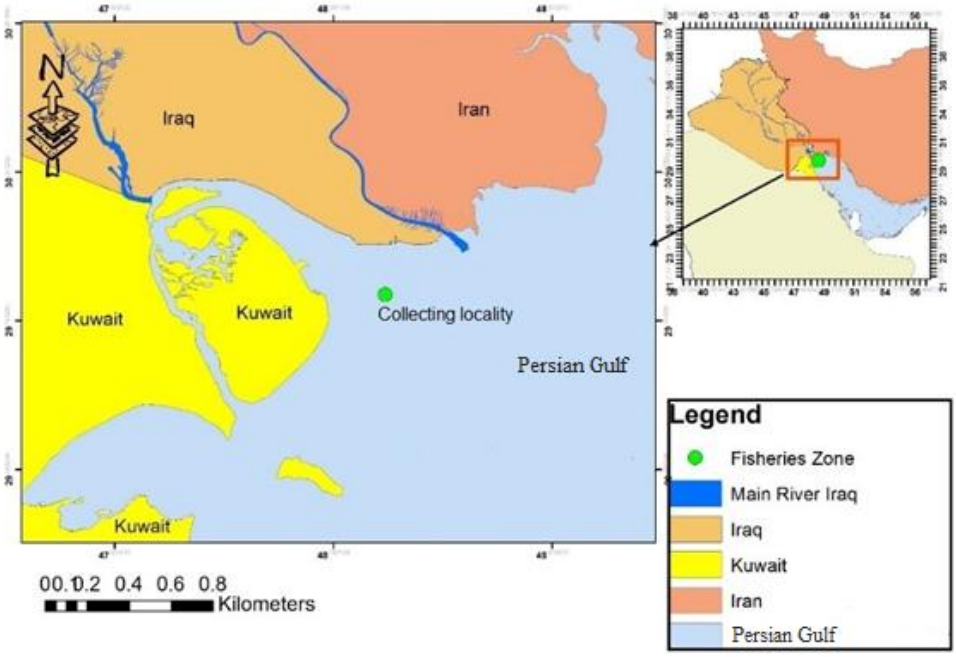

Fig. 1. Map of sampling collecting in Iraqi marine water**.**

2. Fish sample collection

The total number of *O. ruber* fish studied attained 221, including 78 males and 74 females, and 69 immature fish. Fish were collected from Iraqi marine water of the Khor Abdullah and Khor Al-Amaya (Fig. 1) from January to December 2021 using different sizes of gill nets and trawl nets. The total length (cm) to the nearest 0.1 mm and body weight (g) of each fish to the nearest 0.1 g were Measured in the laboratory.

3. Gonadosomatic Index (GSI)

Fish dissected for sex determination, gonads were extracted and weighed to the nearest 0.001 g. The reproductive season was estimated using four indicators, the monthly changes in the gonadosomatic function. According to the gonadotropic function (GSI), which shows a function of maturity as a monthly rate by based on the equation:

GSI (%) =Gonad weight / Bodyweight (g)×100 (Nikolski, 1963)

4. Macroscopic examination of gonads

For explanation, the successive quarterly maturation, the stages of maturity of the sex glands were studied by morphological examination using the characteristics of the physical sensory examination, represented by the transparency degree, texture, presence of blood vessels, vision of eggs and sperm, and the form of discoloration of the gonads **(Kesteven, 1960; white *et al*., 1998)**.

5. Sex ratio

The Chi-square test was performed to determine the divergence of the sex ratio from the expected 1:1 **(Sokal and Rohlf, 1995)**.

6. length at first maturity

The total length of maturity was calculated (Lm_{50}) based on the shortest length have 50% individuals at maturity state **(Bagenal, 1978)**.

7. Fecundity

Absolute Fecundity was calculated as the total number of mature eggs in the ovary at the full maturity when preserved in a modified Glyson solution **(Simpson, 1951)**. The Gravimetric sampling method was used to determine fecundity, in which the entire weight of the washed eggs is computed, then a random sample of 500 eggs is counted and weighed, and finally, the total number of eggs in ovary is calculated According to the equation: **F = n G/g**

where F is the fecundity, n is the number of eggs in the secondary sample, G is the weight of ovaries, and g is the weight of the sample at the same unit **(Holden and Raitt, 1974)**. Relative fecundity was calculated based on the absolute fertility value divided by the total body weight.

Statistical analysis

Use Excel under Office2016 options on Drawing shapes, mathematical calculations, and statistical analysis.

RESULTS

The longitudinal structure (Fig. 2) appears the frequency distribution for the length totals of the 221 *O. ruber* fish samples whose length ranged from 8.1 to 46.6, as the 24 cm group showed clear dominance and constituted 15.1% of the total frequency distribution of *O. ruber* fish, While the 42 cm group recorded the lowest appearance during the study period, and the length groups from 10 to 30 cm recorded the highest percentages. August was Features by the appearance of small fish 7.2 cm in length

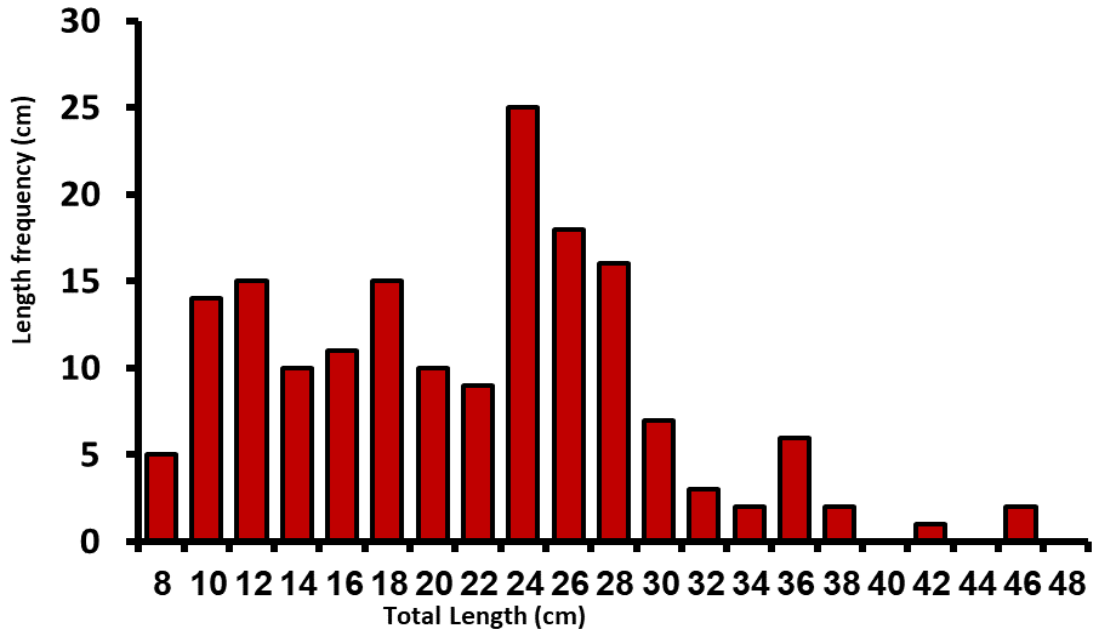

Fig. 2. Frequent distribution of length totals of *O. ruber* fish collected from Iraqi marine waters.

(Fig. 3) Shows the monthly distribution of average lengths for males and females of *O. ruber* fish in Iraqi marine waters from January to December 2021. The highest average length was the females from January and during the spawning months. And the discrepancy between the longest disappeared after August and even at the end of the year.

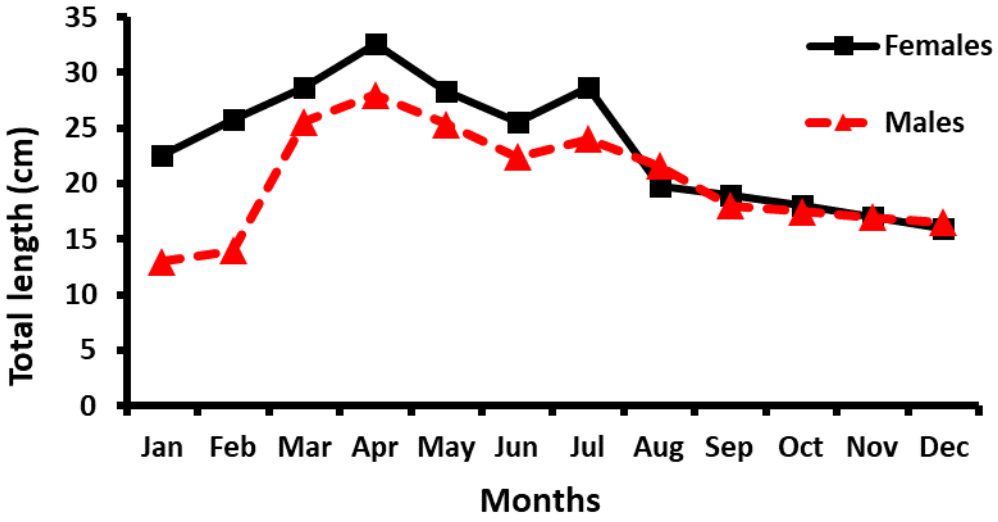

Fig. 3. Average monthly length of mature male and female *O. ruber* fish in Iraqi marine waters.

Sex ratio: The sex ratio fluctuated during the spawning season in the Iraqi marine waters and the total sex ratio was 1:1.21 in favor of females, with no significant differences (at the probability level of 0.05 p-value = 0.121) with the ratio of 1:1 using the Chi-squared test. The percentage of females outnumbered males, except for February when males outnumbered females. There were no significant differences during the spawning season to the normal value of 1:1. Except for August, where significant differences were found (p-value = 0.005) (Table 1).

Table 1. Monthly sex ratio of O. ruber fish in Iraqi marine waters.

Month	No. of fish	Female		Male		ratio	Chi-square
		No.	%	No.	%		
Jan	12	9	75	3	25	1:3	0.083
Feb	45	20	42	25	58	1:0.8	0.452
Mar	33	22	67	11	33	1:2	0.058
Apr	15	5	33	10	67	1:0.5	0.202
May	12	7	58	5	42	1:1.4	0.564
Jun	6	5	100	1	0	1:5	0.102
Jul	27	12	44	15	56	1:0.8	٠.٠٠٢*
Aug	32	24	75	8	25	1:3	0.005*
Sep	30	17	43	13	57	1:0.76	0.465
Oct	22	10	50	11	50	1:1.1	0.763
Nov	15	7	53	8	47	1:1.5	0.439
Dec	10	6	40	4	60	1:0.67	0.527

(Fig. 4) shows the monthly changes in the gonad function index for O. ruber males and females, when summer and winter, (May to December), whereat recorded the lowest values, the females attain less than 1.4 and males less than 0.8. The resting and developing stage is the dominant stage for the development of the gonads, and they rose in November and quickly reached the peak in March for females and males (9.12 -3.17), respectively. After that, it decreased to return to its previous rates for both sexes.

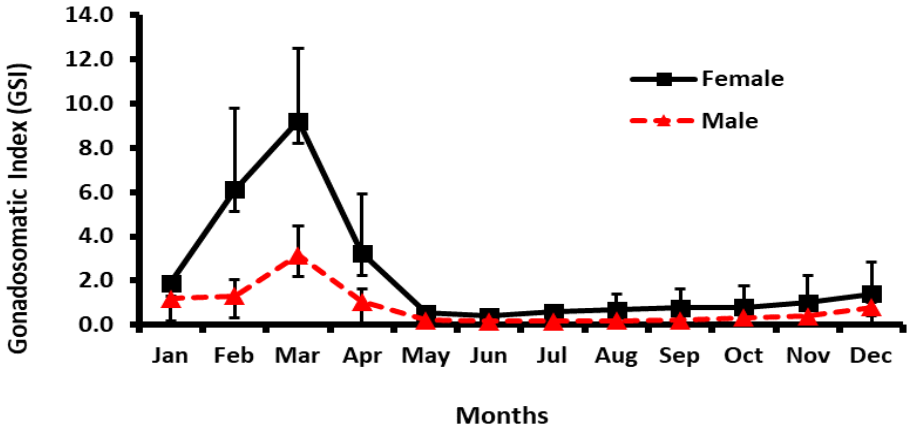

Fig. 4. monthly changes in the gonadosomatic index of female and male O. ruber.

The gonads for females and males of *O. ruber* fish were examined, five stages of gonad development and maturation, which ranged between immature and resting (Recovery) stages (Table 2).

Table 2: Describe the stages of sexual maturation of the gonads of the O. ruber.

Classification	Description
Immature	The gonads are very small and it is difficult to distinguish sex with the naked eye. Ovaries are pink transparent. Testicles are white.
Developing	Females: the gonads are small and transparent، Males: Testicles are reddish-white, tending to pink
Running (Ripe)	Females: Ovarian swelling and granulation appearing with yellowish-pink color. There are no transparent eggs. Males: Enlarged testicles are white to cream.
Spent	Females: the gonads look like an empty sac, tend to be bloody red, and the walls are disintegrating, the ovary is flabby, the absence of mature eggs Males: tends to be reddish-brown (bloody) with some eggs or sperm
Resting (Recovery)	The gonads are small, flabby, completely transparent, and whitish pink.

Length at first maturity ($Lm_{50\%}$):

The smallest mature female fish, with a length of 232 mm and a weight of 135.4 g, was caught in March and had a gonad index of 11.74 recorded in the Running stage. During the same month, the smallest mature male fish with a length of 19.1 cm and a weight of 68.6 g in the Running stage with a gonad index of 0.16 was recorded. The results showed that males were sexually mature at a lower length than females. The emergence of the advanced stage in the summer and winter months for both sexes' first mature length (Lm_{50}) attained 27 cm.

(Fig. 5) shows the distribution of the main stages of gonad maturation of the female samples, as the immature stage appeared in the summer months in particular, and the emergence of the developed stage in the summer and winter months, January and February record the predominance of the developing stage of females, which will participate in reproduction. While the Partial spent, which indicates the occurrence of spawning, appeared during March and April. They also mastered the Running (Ripe) stage during March and April, while May was characterized by the fact that all fish were in the Resting (Recovery) stage and continued until September, which was characterized by a second appearance of the developed phase.

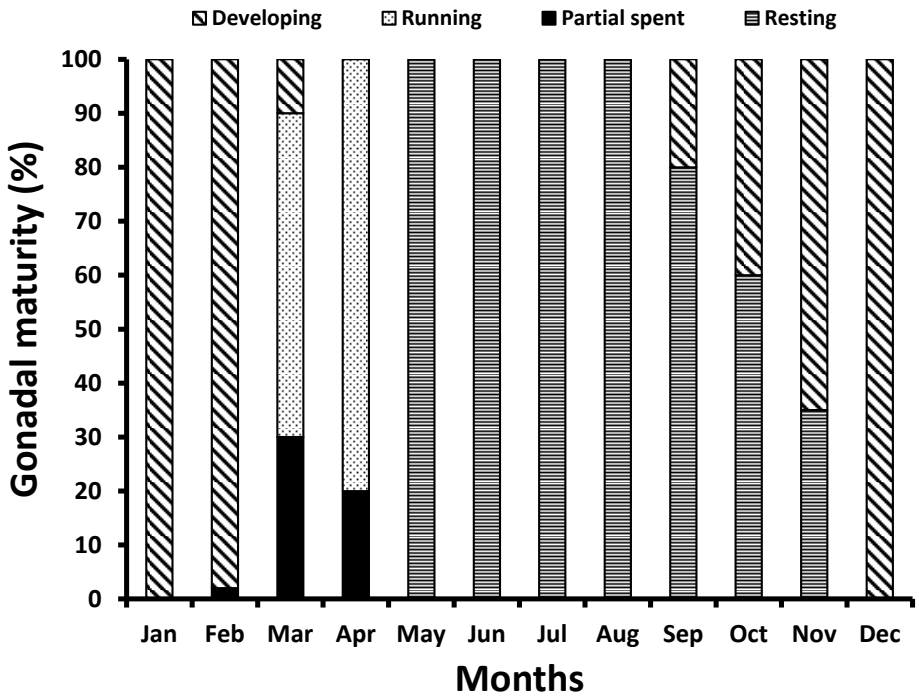

Fig. 5. Distribution of the Percentage contribution of the maturity stages of females *O. ruber* fish collected in Iraqi marine waters.

Fecundity: The absolute fecundity rate was 436636 eggs, with a range of 114,750 - 1024,874 eggs, in fish with a length of 23.2 - 46.5 cm. For the same size, the relative fertility rate and range were 999 eggs and 930-1128 eggs/g, respectively.

DISCUSSION

In agreement with previous findings, the present study revealed synchronized development of male and female gonads throughout the breeding season in February, other than their absence during the other months. The running and partial spent mature stages appeared in March. In contrast, the appearance of juveniles was recorded only in August and September, indicating that these fish breed once a year in Iraqi marine waters.

By determining the percentages of maturity stages and GSI during the study period, the reproductive activity of *O. ruber* was determined from March to April. As a result, Iraqi marine waters are a reproductive and nursery region for this fauna, which agrees with earlier studies in the Kuwaiti marine water adjacent to the Iraqi waters **(Hussain and Abdulah, 1977 ؛ Abu-Hakima,1984)**. A similar finding of a study of the male and female gonads for *O. ruber* was reported the reproductive period extending from March to April and added its ability to spawn several times during the breeding season (multiple batches) in Kuwaiti waters **(Dadzie and Abou-Seedo, 2004)**. This result was consistent with a study by **Eskandari, *et al.*, (2012)** that found the breeding period for *O. ruber* in Iranian waters northwest of the Persian Gulf. Otherwise, **Farkhondeh *et al.* (2018)**

demonstrated the reproductive period of *O. ruber* species varied within the Persian Gulf and the Gulf of Oman accordingly. *O. ruber* has been observed breeding throughout the year in San Miguel Bay of Philippine and Indian waters **(Lanzuela *et al*., 2020; Prashant *et al*., 2005)**. Variation in findings may be attributed to the change in the spawning time of *O. ruber* in habitat zones, which may be due to asymmetry in population, temperature, and currents **(Lone, *et al*., 2008)**.

The gonadosomatic index (GSI) is a ratio of gonad wet weight to the total *O. ruber* wet weight that reflects the degree of gonadal development. As a reliable reproductive measure, the GSI serves as a simple index to track the changes. March was the month with the highest average GSI for species. Thus, the estimated spawning season of this species represents the peak of reproduction in Iraqi marine waters. The changes in the average GSI of *O. ruber* were in good agreement with previous studies in Kuwaiti waters **(Dadzie and Abou-Seedo, 2004)**.

In *O. ruber* species, the first maturity length $Lm_{50\%}$ analysis reached 27 cm. It is noteworthy that the calculated Lm_{50}% value is considered low compared to earlier studies of different marine sites. **Emami (2006)** recorded 35 cm of $Lm_{50\%}$ adjacent to Iraqi marine waters. Also, **Eskandari *et al*., (2013)** reported the size of 28 cm of this species for the same region. Lm_{50} was estimated as 33.7 cm in the southern Persian Gulf in Hormozgan by **Kamali *et al*., (2012)**. Studies on the first maturity length $Lm_{50\%}$ of *O. ruber* species have also been conducted in different regions. In Kenyan waters, it was recorded at 28.8 cm **(Mzingirwa, *et al*., 2020),** while in South Africa, the lengths of adult fish ranged from 22 to 24 cm over the spawning season **(Brash and Fennessy 2005).** The reason for this variation of estimated $Lm_{50\%}$ values may be attributed to the increase in intensive fishing pressure caused by the total quantities of catch that have increased consistently during the last decade **(Zhao, *et al*., 1997).**

The results of the current study showed that the total sex ratio of females: to males =1.33: 1 for *O. ruber*, which is significantly skewed from the expected 1:1 in favor of females at $P < 0.05$. Based on the observed sex ratio in this species, females have dominated males for most of the study period **(Farkhondeh, *et al*., 2018; Kamali, *et al*., 2012)**. **Lanzuela *et al*. (2020),** on the other hand, reported that males outnumbered females in Philippine waters. Such variations could be attributed to several factors: migration **(Collignon, 1960)**, Adaptation **(Reynolds,1974),** behavior **(Polonsky and Tormosova, 1996)**, differences in growth, mortality, and reproductive activity **(Pawson and Giama, 1985; Stergiou, *et al*.,1996)**, and the influence of hunting and sampling methods.

The spawning effort is one of the important indexes of the fish stock dynamics. In Iraq marine waters, under the present study, the mean fecundity of 436636 eggs (114750-

1028874 eggs) in *O. ruber* species is less than 34349 - 236431 eggs in a study **(Mohamed *et al*., 1998).**

The mean fecundity under investigation recorded differences according to the study area and other waters from 779737 eggs (190000 – 1753247 eggs) in Kuwaiti marine waters **(Dadzie and Abou-Seedo, 2004)**, 451163 eggs in the Gulf of Oman under Iranian waters **(Azhir, 2008)**, 1128401 eggs in Hormozgan waters **(Kamali, *et al*., 2012)**, (81726 – 1483369 eggs) in the northwest of the Persian Gulf **(Eskandari, 1997)** and (31480 - 119080) eggs and the relative fecundity of 600 eggs/g in Philippine waters **(Navaluna, 1982)**. The variations in the mean of fecundity may be due to the size of the ova of the test organism under consideration, the size and general condition of the fish, and environmental influences and measurement methods.

The current study revealed the breeding time of fish in Iraqi marine waters during March and April. Its peak was in March, confirming that Iraqi marine waters are considered a spawning and nursery area. So, it is a call for management actions and consultations with stakeholders to maintain the sustainability of the *O. ruber* fish stock in the northwest Persian Gulf. Furthermore, the study results be dedicated to dynamic applications of the *O. ruber* stock for long-term stock management.

CONCLUSION

According to the study, there were no differences in the reproductive period of *O. ruber* fish in the northern Persian Gulf marine waters of Iraq, Iran, and Kuwait. The study also found differences in the reproductive period and reproductive pattern of *O. ruber* fish between the Persian Gulf region and other regions of the world.

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