

**Reproductive biology of the Salema, fish *Sarpa salpa* (Osteichthyes: Sparidae) along the eastern coast of Libya.**

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**ABSTRACT**

In the current work, the overall ratio between males and females of *Sarpa salpa* was 1:0.32. The first sexual maturity of males was recorded at length group (21.1-24cm) by 66.6% and the female was recorded at length group (24.1-27) by 50%. Ovaries of *S. salpa* were examined. The smallest mature female had a total body length of 29 cm and 387.73 gm weight with absolute fecundity of 2,978,440 eggs. The largest female had total body length of 39 cm and body weight of 918.86 gm with absolute fecundity 1,685,729 eggs. Based on the results of maturity stages, gonadosomatic indices (G.S.I) and ova diameters, the study showed clearly that spawning season of *S. salpa* in the Libyan coast of the Mediterranean waters extends from October to December.

**Keyword:** *Sarpa salpa*, Salema fish, reproduction, Mediterranean Sea

**INTRODUCTION**

Reproduction is acyclic phenomenon which occurs periodically in fish, usually once or several times a year but some time once every two or three years. Rhythm is defined as succession of reproductive cycles, rhythmicity can hardly be an innate characteristic, since the cyclic reproductive activity is usually considered from adaptation to changing environment mediated through the endocrine system (Billard & Breton, 1978).

Coordination of the environmental and the reproductive cycles is achieved by proximate timing factors, these and few generalization are possible, day length and temperature are commonly important variables, but many others are involved and it is the interplay of many Libya factors including those stimulating gonad regression, which achieves the regulation of the cycle and the coordination of cycles population individuals (Sott, 1979). Both & Buxton (1997) studied the biological properties of *Pterogymnus laniaries* on the shores of South Africa. There are some studied conducted on some fishes of family sparidae in south Sinai coasts; *Rhaldosargua haffara*, *Diplodus noct* and *Rhabdosargus sarba* (Ahmed, 1999). Also study was conducted on the fish *Pagellus eirythrinus*, the overall ratio of males to females was 1: 3.16, the duration of reproductive season was from April to October and the peak in spawning activity occurred in August – September (Belgin & Raziye, 2003). In a study conducted on *S. salpa*, along the Italian Mediterranean coast, two distinct spawning periods were observed. One in spring from March to May and the other in autumn from end of September to November (Alessandro *et al.*, 2006). The abundance of *S. rivulatus* (more than *S. luridus* and native fish species *S. salpa* and *Sparisoma cretense*) was in the eastern region of the Libyan coast. In the Gulf of Sirt region the exotic herbivore *S. luridus* was more abundant than *Sianus rivulatus* and the native fishspecies *S. salpa* and *Sparisoma cretense* (Shakman, 2008). This work aims to study the reproductive biology in vicinity of sex ratio, monthly variations in

maturity stages, egg diameter, Gonado index. Besides studying the length at first maturation and fecundity. This information helps keep these *S.salpa* in the spawning season.

## MATERIALS AND METHODS

### 1- Sex ratio:

Sex of *S. salpa* was determined after dissection and the gonads were removed and wet weighed to the nearest mg. The sex ratio of fish population refers to the frequency or the percentages of males to females in the population or catch, which was determined visually.

### 2- First sexual maturity:

The length at first sexual maturity is defined as the length at which 50% of fish reach sexual maturity (Pitt, 1970). Such information is essential for the conservation of an exploited fish stock through the estimation of minimum legal size, which is needed to secure spawning part of fish population.

### 3- Maturity stages:

Fish maturity was classified to five stages according to Hjort (1910):

- I- Immature; the ovaries and testes were transparent and thread – like. In this stage the two sexes were very difficult to differentiate. However, male gonads are ribbon shaped, while female gonads are more cylindrical.
- II- Maturing; testes and ovaries are reddish in color and occupy one – third of the body cavity. The male gonads are clearly flattened, while female gonads are cylindrical.
- III- Mature; the male and female gonads are enlarged in size and occupy about two – third of the body cavity. The testes are reddish or partially white; blood vessels are seen within the developing tests. The ovary is yellow in color and also invaded with blood vessels. Some small ova start to be visible to the naked eye.
- IV- Spawning (running); in this stage, the testes and ovaries are in their maximum development. In ovaries, more advanced eggs can be seen, which can be extruded upon applying a very slight pressure on the belly.
- V- Spent; at the end of spawning season the ovaries and testes decreased sharply in weight and became flaccid, inside the ovary few ova left but most of the tissues are empty follicles after extruding most of the ova to the water. Usually this stage is difficult to identify with naked eye but identified clearly with histology; generally it is added for this reason to immature stage.

In the present study, it was difficult to distinguish precisely each stage separately, therefore it was grouped together to be easy distinguish as follows:

- 1- Stages I & II are grouped together and classified as immature.
- 2- Stage III which was easily recognized and was considered as mature.
- 3- Stage IV was classified as spawning.

Gonads of the specimens were preserved in 4% formalin for detailed study.

### 4- Gonado – Somatic Index (G.S.I)

A widely used method to index reproductive condition has been expressed as gonad weight as a percentage of body weight (De Vlamming *et al.*, 1982). The monthly Ganado – Somatic Index (G.S.I) was calculated from the following formula

$$\text{G.S.I} = \text{wet weight of gonad (gm.)} / \text{wet weight of fish (gm.)} \times 100$$

### 5- Ova diameters:

Ova diameters were measured to the nearest micron by using an eye piece micrometer. Ova were separated from ovarian tissues, as it immersed in saline solution (0.99% NaCl) for 24 hours and measured under the microscope at a magnification power of 40 ×. The averages of the largest 10 Ova were calculated.

### 6- Fecundity:

Fecundity was estimated by counting all mature yolky eggs found in the female ovary just prior to spawning season. A small piece of fish ovary was taken and put in small divided Petri – dish, ova were separated from other tissues with the aid of dissecting needle and the yolky ova were counted under binocular microscope.

## RESULTS

### 1-Sex ratio

Generally there is a tendency for more male (58 fish= 14.9%) than female (19 fish = 4.9%) for the whole population, overall sex ratio was (1:0.32) for males to females (Table1). The sex ratio was not constant throughout the different months.

The maximum percentage of females was recorded in the period from October to December 2010 (17.4%), while the maximum percentage of males was recorded in November (72%).

Table 1: Monthly variations in sex ratio of *S. salpa*.

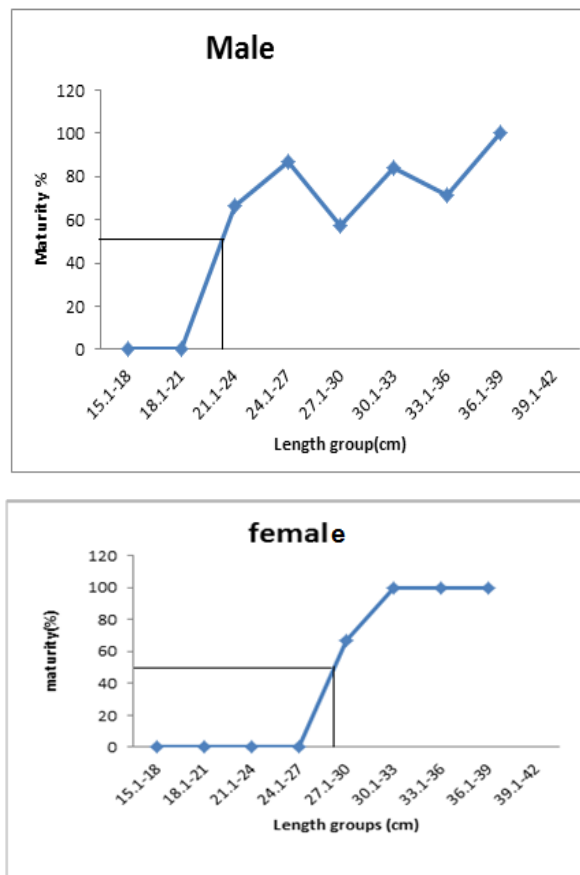
Monthly	No. of fish	Male No.	Female No.	Sex ratio
<b>May 2010</b>	26	4	1	1:0.25
Jun.	25	1	-	-
Jul.	25	1	2	1:1.2
Aug.	25	11	1	1:0.1
Sep.	21	3	-	-
Oct.	23	10	4	1:0.4
Nov.	25	18	7	1:0.4
Dec.	23	2	4	1:1.2
<b>Jan 2011</b>	25	1	-	-
Feb.	21	5	-	-
Mar.	25	1	-	-
Apr.	25	-	-	-
May.	25	-	-	-
Jun.	25	1	-	-
Jul.	23	-	-	-
Aug.	25	-	-	-
<b>Total</b>	<b>387</b>	<b>58</b>	<b>19</b>	<b>1:0.32</b>

### 2-First sexual maturity

The first appearance of mature males was recorded at length group (18.1-21cm) (Table 2) and the smallest mature male of *S. salpa* attained at length group (21-24 cm) (Fig. 1). The first sexual maturity was reported at 22.5 cm. The first mature female was recorded at length group (24.1-27cm) and the size at which 50% of females were mature was 28.5 cm.

Table 2: Percentage frequency distribution of mature and immature fishes per length groups of *S. salpa*.

Sex Length	Males				Females			
	Immature		Mature		Immature		Mature	
	No.	%	No.	%	No.	%	No.	%
15.1 - 18	-	-	-	-	-	-	-	-
18.1 - 21	-	-	-	-	-	-	-	-
21.1 - 24	1	33.3	2	66.6	-	-	-	-
24.1 - 27	2	13.3	13	86.6	-	-	-	-
27.1 - 30	6	42.8	8	57.1	1	33.3	2	66.6
30.1 - 33	3	16.6	15	83.8	-	-	7	100
33.1 - 36	2	28.5	5	71.4	-	-	4	100
36.1 - 39	-	-	1	100	-	-	5	100

Fig. 1: Length at first sexual maturity for both sexes of *S. salpa*.

### 3-Maturity stages:

Data of monthly changes in maturity stages are illustrated in Table (3) and represented graphically in Fig.2. In males, the testes were immature in May, June and July 2010 (100%); this immaturity continued to be 36.3% in August 2010 and reached 66.6% in September then decreased in the following months. The maturing stage in males was first recorded in August (45.4%) and increased gradually to the maximum percentage in December (2010) 100%. The first sign of ripe testes was recorded in August (18.1%). The highest value recorded in October (90%).

The ovaries were following the males trend; they were immature in May, June and July 2010 (100%); immaturity decreased gradually from August and reached the lowest value in January (20%). In the female, the maturing stage was first recorded

in December 25%. The first sign of ripe ovaries were recorded in October (75%), increased in November (50%) and increased in December (75%).

Table 3: Monthly variations in maturity stages, for both sexes of *S. salpa*.

Monthly	Male %				Female %			
	No. of fish	Immature	Mature	Spawning	No. of fish	Immature	Mature	Spawning
May 2010	4	100	-	-	1	100	-	-
Jun.	1	100	-	-	-	100	-	-
Jul.	1	100	-	-	2	100	-	-
Aug.	11	36.3	45.4	18.1	1	100	-	-
Sep.	3	66.6	33.3	-	-	-	-	-
Oct.	10	-	10	90	4	25	-	75
Nov.	18	50	50	-	7	50	-	50
Dec.	2	-	100	-	4	25	25	75
Jan 2011	1	20	60	20	-	-	-	-
Feb.	5	100	-	-	-	-	-	-
Mar.	1	100	-	-	-	-	-	-
Apr.	-	-	-	-	-	-	-	-
May.	-	-	-	-	-	-	-	-
Jun.	1	100	-	-	-	-	-	-
Jul.	-	-	-	-	-	-	-	-
Aug.	-	-	-	-	-	-	-	-

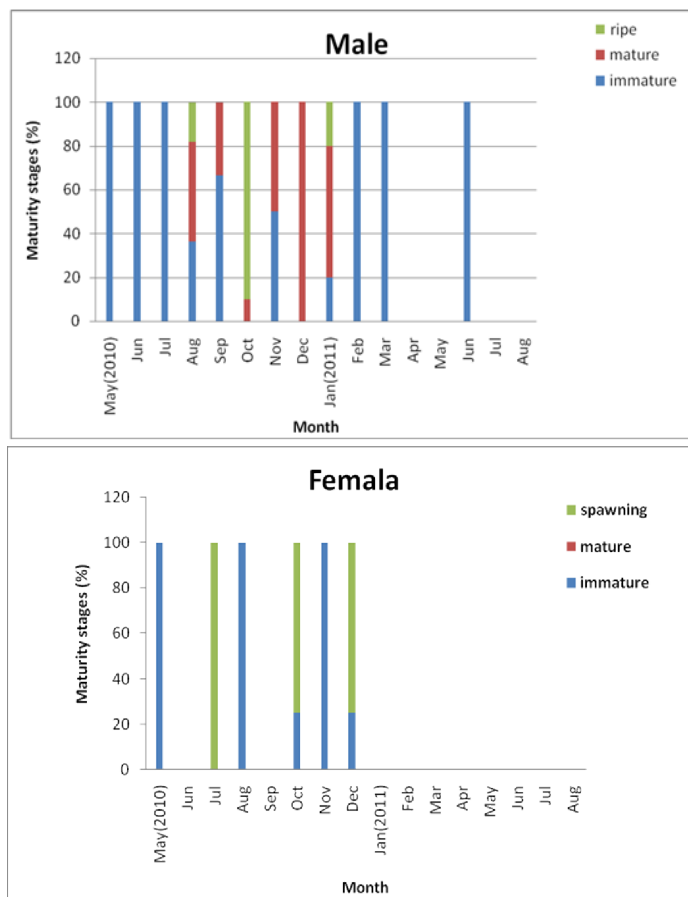


Fig. 2: Monthly variations of the maturity stages in *S. salpa* in both sexes.

#### 4-Gonado-Somatic Index (G.S.I)

The monthly changes in G.S.I. are represented in Table (4) and Fig. (3). *S. salpa* has a definite breeding season which extends from October to December. The average

G.S.I. for males increased gradually from May (0.3) to reach (3.5) in November the maximum values in October (2.5) and November (3.5).

In females the minimum G.S.I. (0.5) was recorded in May 2010, while the highest values were recorded in October (3.1) and November (8.1).

Table 4: Monthly variations of Ganado – Somatic - Index for males and female of *S. salpa*.

Monthly	No. of fish	male			No. of fish	Female		
		Minimum	Maximum	Aver		Minimum	Maximum	Aver.
May 2010	4	0.2	0.3	0.3	1	-	-	0.5
June	1	-	-	0.3	-	-	-	-
July	1	-	-	0.4	2	0.1	4.1	2.1
Aug.	11	0.2	2.6	0.6	1	-	-	0.5
Sept.	3	0.2	0.5	0.4	-	-	-	-
Oct.	10	0.6	4.2	2.5	4	1.5	5.6	3.1
Nov.	18	1.9	6.3	3.5	7	5.3	10.4	8.1
Dec.	2	0.3	0.6	0.5	4	0.8	2.9	1.6
Jan 2011	1	-	-	0.7	-	-	-	-
Feb.	5	0.5	2	1.2	-	-	-	-
Mar.	1	-	-	0.7	-	-	-	-
Apr.	-	-	-	-	-	-	-	-
May.	-	-	-	-	-	-	-	-
June.	1	-	-	0.3	-	-	-	-
July.	-	-	-	-	-	-	-	-
Aug.	-	-	-	-	-	-	-	-

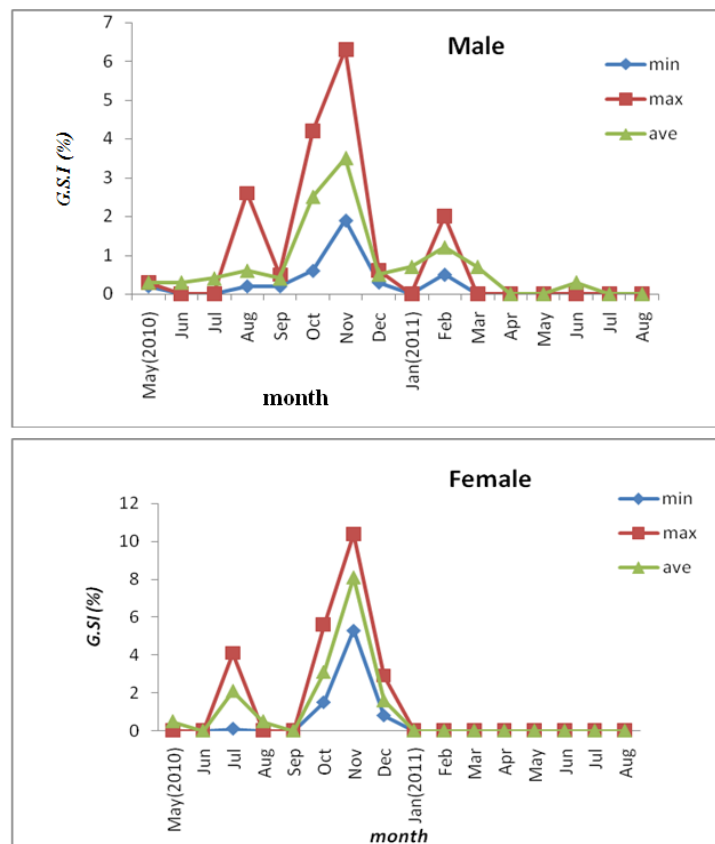


Fig.3: Monthly variations in the average gonado –somatic index for both sexes of *S. salpa*.

### 5- Ova diameters:

The recorded average ova diameters of *S. salpa* during the whole period of study are represented in Table (5) and Fig. (4). Egg diameters were very minute and difficult to measure in the period, April, May 2011 and October, December 2011. The lowest value of the egg diameters was recorded in July and August 2010 (0.2  $\mu$ ), while the highest one was recorded in November 2010 (2.7  $\mu$ ). The maximum average oocytes diameter was recorded from October to December.

Table 5: Monthly variations of ova diameters of *S. salpa*.

Monthly	No. of fish	Ova -diameter ( $\mu$ )		
		Minimum	Maximum	Aver.
<b>May 2010</b>	1	0.2	0.4	0.3
June.	-	-	-	-
July.	2	0.1	0.3	0.2
Aug.	1	0.3	-	0.2
Sept.	-	-	-	-
Oct.	4	0.4	2.5	1.6
Nov.	7	2.1	3.4	2.7
Dec.	4	1.8	3.3	2.5
<b>Jan 2011</b>	-	-	-	-
Feb.	-	-	-	-
Mar.	-	-	-	-
Apr.	-	-	-	-
May.	-	-	-	-
June.	-	-	-	-
July.	-	-	-	-
Aug.	-	-	-	-

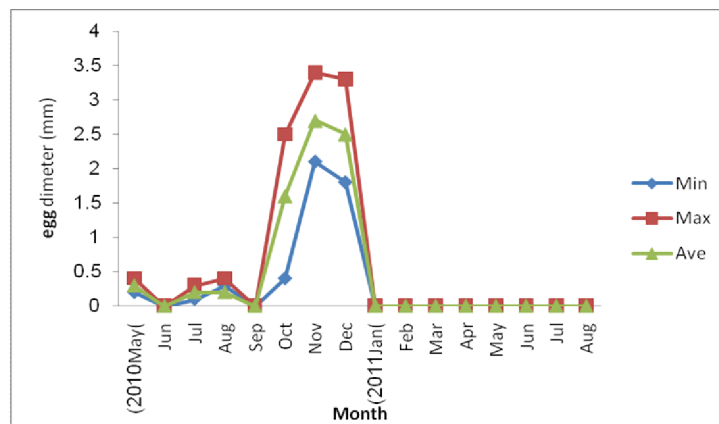


Fig. 4: Monthly variations of ova diameters of females of *S. salpa*.

### 6- Fecundity

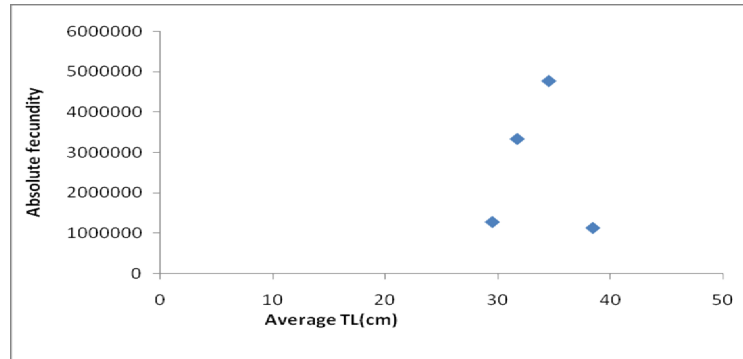
Two terms are applied in fish fecundity work; the absolute fecundity which is the total number of mature eggs in the ovary and the relative fecundity which is the number of eggs per unit length or weight of the fish (Nikolsky, 1963).

The relationship between the length and absolute fecundity of *S. salpa* is given in Table (6) and Fig. (5).

The absolute fecundity ranged from 22952 to 15,123,096 eggs/fish. (Fig. 5). It is clear that absolute fecundity and relative fecundity increased with the increase of the total length (TL).

Table (6): The relationship between fecundity and total length (cm) of *S. salpa*.

Total Length (cm)	No. of fish	Aver. TL (cm)	Absolute fecundity			Relative fecundity f/l
			Min.	Max.	average	
27.1- 30	3	29.5	166,750	2,978,440	1,283,204	43,498
30.1- 33	7	31.7	22,952	9,602,072	3,344,140	105,493
33.1- 36	4	34.5	38,658	15,123,096	4,782,124	138,612
36.1- 39	5	38.4	283610	2,791,404	1,136,999	29,609

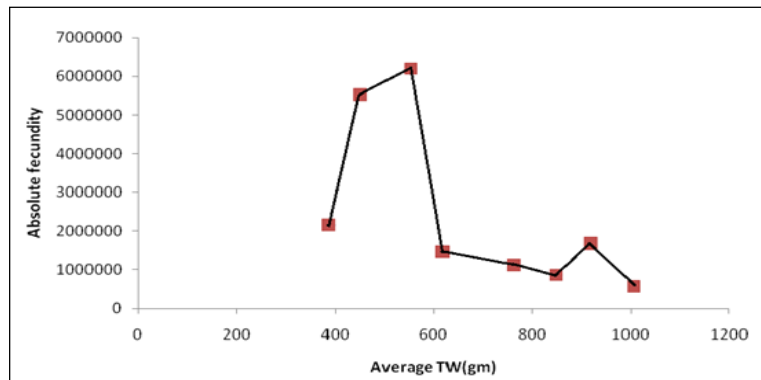
Fig. 5: Relationship between total length (cm) and average absolute fecundity of *S. salpa*.

The results of the relationship between the absolute fecundity and body weight are given in Table (7) and Fig. (6). Absolute fecundity ranged from 22, 952 to 15, 123, 096.

It is clear that the absolute fecundity increased with increasing of body weight to 400 gm.; then decreased after that to reach its minimum value at 1000 gm, body weight (WT).

Table 7: Relationship between fecundity and total weight (gm) of *S. salpa*.

Total weight (gm.)	No. of fish	Aver. wt. (gm.)	Absolute fecundity			Relative fecundity f/w
			Min.	Max.	Average	
300.1-400	3	386.1	704,424	2,978,440	2,158,089	5,589
400.1-500	3	449.9	166,750	15,123,096	5,528,183	12,287
500.1-600	3	553.1	2,208,440	9,602,072	6,205,509	11,219
600.1-700	3	617.2	22,952	2,841,868	1,477,886	2,394
700.1-800	1	761.6	-	-	1,124,875	1,476
800.1-900	4	849.0	38,658	2,791,404	866,540	1020
900.1-1000	1	918.8	-	-	1,685,729	1,834
1000.1-1100	1	1006	-	-	571,764	568

Fig. 6: Relationship between total weight (gm) and average absolute fecundity of *S. salpa* (hand made curve).



## DISCUSSION

Salema's trophic role in coastal ecosystems was quite well understood, but few studies in the past have researched into the biological parameters of this species, especially in the Mediterranean. Therefore, in this study we tried to furnish new data on its life cycle. Analysis of gonads confirmed that *S. salpa* is a protandrous hermaphrodite species; therefore, it changes sex from male to female during its life. Proterandric hermaphroditism in salema has already been observed in the Mediterranean sea (Lissia-Frau, 1966; Lissia-Frau and Casu, 1968), in the eastern Atlantic Ocean (Mendez-Villamil *et al.*, 2002), and in the western Indian Ocean (Van der Walt and Mann, 1998). The overall ratio between males and females of *S. salpa* was 1:0.32 such differences could be due to migration and or behavioural differences between sexes (Polonsky and Tormosova, 1969). Ahmed, (1999) found that in south Sinai coasts, females outnumber the males in *S. salpa*. In these species sex change in an alternative reproductive style that enables individuals to maximize their life time reproductive success by functioning as one sex when small and the other sex when large (Buxton and Garratt, 1990).

Ahmed (2012) studied the reproductive biology of crenidens (family sparidae), a leptocephalian migrant species inhabiting Libyan eastern coast and he found that the overall sex ratio was 1:1.03 for male to female.

In the present study the fish *S. salpa* show that the breeding season runs from August to November (Both & Buxton, 1997; FAO, 2000; Hood & Johnson, 2000; Ahmed, 1999). The eastern coast of Libya, salema spawn during two period of the year autumn (September-November).

A similar reproductive cycle has been observed in along the Tunisian waters (Sellami and Bruslè, 1975; Anato and Ktari, 1983), and in the Canary Islands (Mendez-Villamil *et al.*, 2001), salema spawn during a single period that extends throughout the autumn and winter months. The size-at-maturity of males (21.1 cm) didn't differ significantly from the value observed in the Canary Islands 22.6 cm (Mendez-Villamil *et al.*, 2002).

Fecundity is an important item in studying the fish reproduction (Nikolosky, 1965). It shows a wide variation among different species, and also with the same length and age. It also fluctuated according to different environmental conditions (Amein, 1996). Even within a stock, fecundity is known to vary annually, undergo long term changes (Horwood *et al.*, 1986) and has been shown to be proportional with fish size and environmental condition. Larger fish produce more eggs, both in relative and absolute terms to body mass. For a given size female in better conditions exhibit higher fecundity (Kjesbu *et al.*, 1991). Moyle and Cech (1982) mentioned that fecundity is related to food supply. As results, well fed fish can produce more and larger eggs. On the other hand, parasitic infection densities, with corresponding increase in behavioral interactions, may cause a reduction in fecundity (Kipling and Frost, 1969; Bangenal, 1971 and Hanaffy and Gaballa, 1998).

Absolute fecundity ranged from 1,136,999 to 4,782,124 in the total length ranged 27.1-39 cm as well as from 571,764 to 6,205,509 in total weight range 300.1-1100 g.

These values agree or disagree with the results of others depending on the different methods of counting and geographical and environmental conditions surrounding fishing grounds. The data obtained represents only a first step in the study of *S. salpa* as it is important to analyse the influence that salema, one of the most abundant species in areas characterized by rocky bottoms and seagrass meadows

(Verlaque, 1990 and Dulcic *et al.*, 1997 & Francour, 1997), exerts on the coastal fish assemblages.

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## ARABIC SUMMARY

## دراسة بيولوجية لتكاثر سمكة (السربا سلبا) على الساحل الليبي للبحر المتوسط

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أوضحت الدراسة أن نسبة الذكور إلى الإناث لسمكة الشلابة هي ٠.٣٢ : ١. وقد لوحظ وجود تغيرات بين نسبة الذكور والإناث مع الأشهر المختلفة. كما تم تحديد أقل حجم للنضج الجنسي للذكور في مجموعة الأطوال (٢١.١ - ٢٤ سم) بنسبة ٦٦.٦% وتم تحديد أول نضج جنسي للإناث في مجموعة الأطوال (٢٤.١ - ٢٧ سم). وبفحص المناسل وجد أن أصغر أنثى ناضجة كان طولها ٢٩ سم ووزنها ٣٨٢.٧٣ جرام وخصوبة مطلقة ٢,٩٧٨,٤٤٠ بيضة أما أكبر انثى ناضجة كان طولها ٣٩ سم بوزن ٩١٨.٨٦ جرام وخصوبة مطلقة تقدر ١,٦٨٥,٧٢٩ بيضة. اعتمداً على نتائج مراحل النضج الجنسي ومعامل الدليل المنسلى (G.S.I.) وقطر البيويضات، وجد أن موسم التكاثر يمتد من أكتوبر إلى ديسمبر.