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# Reproductive biology of *Mullus surmuletus* (Linnaeus, 1758) from the Egyptian Mediterranean Sea (Port Said).

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**ABSTRACT**

This study aimed to assess some biological characteristic, the sex ratio, gonadosomatic index, length at first sexual maturity and fecundity of *Mullus surmuletus* in the Egyptian Mediterranean waters. Monthly samples of *Mullus surmuletus* were collected from the commercial trawl catches during the period from January to December 2012 from the Mediterranean Sea off Port Said. The overall sex ratio was 1.0: 1.75(M: F). The length at 50% mature was estimated to be 11.9 cm for males and females. The spawning behavior was investigated based on determination of gonad somatic index. The maximum GSI values were recorded in May for females and males; spawning occurred in spring season. About 35 ripe ovaries were used to estimate the absolute fecundity of *Mullus surmuletus*. The mean absolute fecundity ranged from 19640 to 83448 for fish length ranged from 14-19.9 cm. and weight from35to 64.9 gm. The obtained relationships were explained with power curves ($Fa = 0.0255\ L^{5.031}$, $R^2 = 0.9733$and $Fa = 0.8707\ W^{2.7382}$ $R^2 = 0.9859$).The mean relative fecundity increased from 1363.9 to 4392.0 for the same length ($Fr= 0.0255\ L^{4.031,}$ $R^2 = 0.9844$), and fluctuated from 512 to 1330 for the same weights ($Fr= 0.8708\ W^{1.7382,}$ $R^2 = 0.9973$).
A management plan for this important fish species, *M. surmuletus* should be proposed depending on knowledge of the fecundity that can be utilized to determine the time and number of recruitments, minimum landing size, associated to length at first sexual maturity, and proposing a closed fishing season.

## 1. INTRODUCTION

The study of reproduction of fishes is an important item in fish biology; so far, it has its practical importance in solving some fishery management questions such as the determination of spawning stock. The availability data based on reproductive parameters and environmental variation lead to a better understanding of observed fluctuation in reproductive output and enhances our ability to estimate recruitment (Kraus *et al*., 2002).

The striped red mullet *Mullus surmuletus* (Linnaeuse, 1758) belongs to the family Mullidea is very common along the coasts of the Mediterranean Sea, Adriatic Sea and Atlantic Ocean (Hureau, 1986).

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Red mullet is an economically important species in the catch of the trawling fishery in Port Said.

The catch is composed mainly of two species; *Mullus surmuletus* and *Mullus barbatus*; information on its biology is very limited. There were some studies on its sexual cycle and reproduction (Menu and Girin 1978; Gharbi and Ktari 1981; Sanchez *et al*. 1983; Morales-Nin 1991; N'Da and Daniel 1993; Reñones*et al*. 1995). In Turkish waters, there were few studies on this species that referred to some aspects of its biology (Moldur 1999; İlhan *et al*. 2009; Üstün 2010; Arslanand İşmen 2013; Kherraz, *et al*.2014).

In the Egyptian Mediterranean waters, the only previous study concerning the biology of *M. surmuletus* was that of Hashem (1973) and Mehanna (2009), who studied growth, mortality and spawning stock biomass of *M. surmuletus*, in the Egyptian Mediterranean waters. The present study aims to evaluate the spawning period, length at first sexual maturity, and fecundity which are represented important biological parameters and play a significant role in evaluating the commercial potentials of *M. surmuletus* stocksin the Mediterranean Sea off Port Said.

## 2. MATERIALS AND METHODS

Monthly samples of *Mullus surmuletus* were collected from the commercial trawl catches in the Mediterranean Sea, Port Said harbour. A total of 559 specimens **(**160 males, 282 females and 117 immature) were obtained during the period from January to December 2012. Specimens were firstly sexed and total lengths (cm), total weight (g) were measured

### 2.1 Sex ratio

Sex ratio was determined as the monthly percentage of males to females (M: F).Chi-Square test at (0.05) significance level was used to find if the sex ratio is significantly different from 1:1.

**2.2 Maturity stages** were determined based on the scale of Nikolsky (1963) as follow:

I- Immature: gonads are thread – like and thin, testes are whitish and opaque, while ovaries are pinkish and translucent.

II- Maturing and recovering: gonads become larger and occupying one third to half of the body cavity. Ova are minute and visible with slight yolk.

III- Nearly ripe: gonads occupy about two-thirds of the length of the body cavity. In ovary, the eggs become larger, yellow and easily extruded with pressure. Testes have pure white colour and their walls become thin.

IV- Ripe: gonads occupy the entire body cavity. Testes are white milt run from the vent of males and eggs from females on pressure from their abdomen.

V-Running: Ovaries are compact, reddish organ, rounded with wide anterior edge and vascularized with blood vessels .Testes decrease in size and appear flaccid and flabby

VI- Spent: gonads are flaccid. Ovary has dark red color and few residual eggs are visible. The testes have gray brown color and there may be a little residual milt.

### 2. 3 Gonado- somatic index (GSI):

Gonado-somatic index (GSI) was determined described by a formula by De Vlaming and Chapman (1982) as follow:

$GSI = 100 \times G/W$

Where, (G) is the gonad weight and (W) is the body weight.

### 2.4 Length at first sexual maturity($L_m$):

The length at which 50% of *Mullus surmuletus* reach their sexual maturity was estimated by fitting the percentage maturity against mid lengths (king, 1995).

### 2.5 Fecundity

About 35 specimens were carefully removed during the breeding season (May to September 2012).Ovaries were washed , weighed to the nearest 0.01 gm. and then preserved in 4 % formalin .Three sub-samples from each ovary were taken and weighed to the nearest 0.01g. Each sub-sample was placed in a Petri-dish containing a drop of distilled water and eggs were counted under a binocular microscope

(X16).The diameters of the ova ready to be spawned in each subsample were also measured to the nearest 0.001mm.

The two types of fecundity, absolute and relative fecundity were calculated according to Bagenal (1978) as follow:

Absolute Fecundity = No. of eggs in sub sample × Gonad weight/ Weight of sub sample.

Relative fecundity =Absolute fecundity/Total fish length or weight

The relationships between fecundity and body length and weight were explained with power curves and represented by the following equations:

$F= aL^b$, $F= aW^b$

Where F is absolute fecundity and, L is the total fish length, W is total fish weight a is constant, b is the exponent

## 3. RESULTS AND DISCUSSION

The length *M. surmuletus* population varied from 10.4 to 19.9 cm for males, and 11 - 19.8 cm for females (Table1). The most frequently recorded size class was17-17.9 cm (91.7%) and 18-18.9 cm (80%), while the highest percentage of males were recorded in length intervals 10-10.9 cm, 12-12.9 cm (100% and 52.6%, respectively). Additionally, females were dominant in all length intervals. These results good agreed with findings of Kherraz *et al.* (2014) in Algeria.

Table 1: Variations of sex ratio with length for *M. surmuletus* from the Mediterranean Sea off Port Said during January-December 2012

| Length group (cm) | Fish no | Males | | Females | | Sex ratio (M / F) | P-value | $X^2$ |
|---|---|---|---|---|---|---|---|---|
| | | No. | % | No. | % | | | |
| **10-10.9** | 2 | 2 | 100 | 0 | 0 | 1:0 | 0 | 0 |
| **11-11.9** | 6 | 4 | 50 | 2 | 50 | 1:1 | 0.414 | 0.667 |
| **12-12.9** | 51 | 30 | 52.6 | 21 | 47.4 | 1:0.9 | 0.208 | 1.588 |
| **13-13.9** | 111 | 55 | 48.2 | 56 | 51.8 | 1:1.07 | 0.924 | 0.009 |
| **14-14.9** | 109 | 24 | 22.2 | 85 | 77.8 | 1:3.5 | 0.00 | 34.138 |
| **15-15.9** | 98 | 32 | 39 | 66 | 61 | 1:1.56 | 0.001 | 11.796 |
| **16-16.9** | 50 | 11 | 20.8 | 39 | 79.2 | 1:3.81 | 0.000 | 15.680 |
| **17-17.9** | 9 | 1 | 8.3 | 8 | 91.7 | 1:11 | 0.020 | 5.444 |
| **18-18.9** | 5 | 1 | 20 | 4 | 80 | 1:4 | 0.180 | 1.800 |
| **19-19.9** | 2 | 1 | 50 | 1 | 50 | 1:1 | 0 | 0 |
| **Total** | 443 | 161 | 36.34 | 282 | 63.66 | 1 : 1.75 | | |

*Significance (F = 33.050, P<0, 05

### 3.1 Monthly variations of sex ratio

Of the 443 sexed *M. surmuletus* specimens, the number of males was 161 representing 36.34%of the total number, while the number of females was 282 representing 63.66% of the total number, with sex ratio of (1males: 1.75females).

Monthly variations of sex ratio of *M. surmuletus* collected from Port Said during the period from January to December 2012 showed that females were higher in numbers than males throughout the whole period of study (Table 2). This result agreed well with Hashem (1973) who mentioned that the female of *M. surmuletus* predominated the samples. The highest percentage of males (48%) was observed in February, while the lowest percentage (16.1%) was in August. On the contrary, the highest percentage of females (87.1%) occurred in August and the lowest value (52%) was recorded in February. The percentages of male and female were close during June and July when the running stage was recorded for both sexes.

The value of Chi-Square showed highly significant difference between both sexes. ($F = 33.050$; $P < 0.05$).

Table 2: Monthly variations of sex ratio of *M. surmuletus* from the Mediterranean Sea off Port Said during January-December 2012

| Month | No. of Fish | Males | | Females | | Sex ratio | P value | $X^2$ |
|---|---|---|---|---|---|---|---|---|
| | | No. | % | No. | % | (M/F) | | |
| Jan. | 40 | 19 | 47.5 | 21 | 52.5 | 1:1.1 | 0.10 | 0.75 |
| Feb. | 50 | 24 | 48.0 | 26 | 52.0 | 1:1.08 | 0.80 | 0.77 |
| Mar. | 42 | 9 | 21.4 | 33 | 78.6 | 1:3.7 | 0.00 | 13.70 |
| Apr. | 45 | 19 | 42.2 | 26 | 57.8 | 1:1.7 | 0.297 | 1.089 |
| May | 31 | 10 | 32.3 | 21 | 67.7 | 1:2.1 | 0.48 | 3.903 |
| Jun. | 29 | 13 | 44.8 | 16 | 55.2 | 1:1.23 | 0.577 | 0.310 |
| Jul. | 30 | 14 | 46.7 | 16 | 53.3 | 1:1.14 | 0.715 | 0.133 |
| Aug. | 31 | 5 | 16.1 | 27 | 87.1 | 1:5.4 | 0.00 | 15.125 |
| Sep. | 34 | 8 | 23.5 | 26 | 76.5 | 1:3.25 | 0.002 | 9.529 |
| Oct. | 35 | 13 | 37.1 | 22 | 62.9 | 1:1.7 | 0.128 | 2.314 |
| Nov. | 35 | 12 | 34.3 | 23 | 65.7 | 1:1.91 | 0.63 | 3.457 |
| Dec. | 40 | 15 | 37.5 | 25 | 62.5 | 1:1.66 | 0.114 | 2.500 |
| Total | 443 | 161 | 36.34 | 282 | 63.66 | 1:1.75 | 0.000 | |

*Significant (F = 33.050; P<0.05)

### 3.2 Monthly distribution of maturity stages:

### 3.2.1 In males

Five maturity stages; (mature, nearly ripe, ripe, spawning running, and spent) were observed in April (Figure1). The mature stage had higher percentages in December (86.7%) and January (84.2%). The highest percentage (54.5%) of ripe stage was recorded in May.

The spent stage started to appear in April with spawning stage, but the spent stage appeared with the maximum percentage of 61.5% in June.

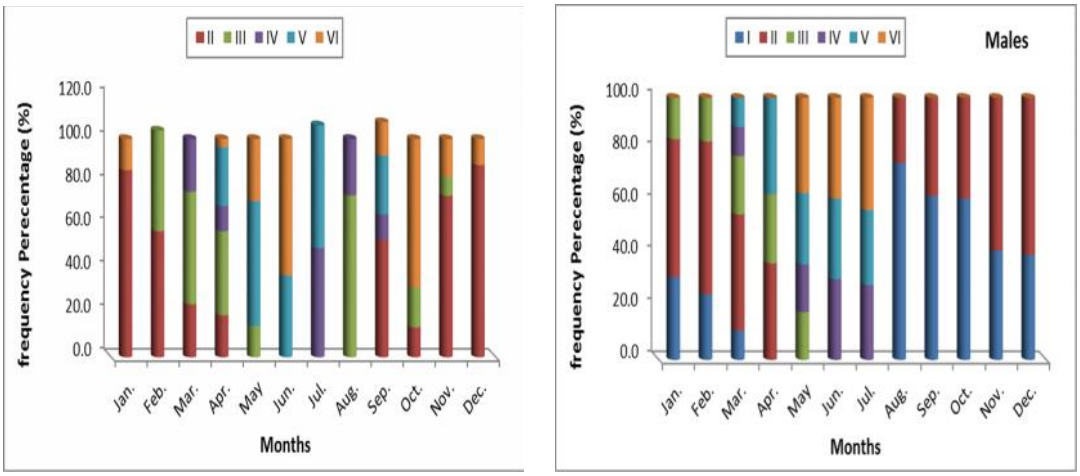


Fig. 1: Monthly distribution of maturity stages of males and females of *M. surmuletus* from the Mediterranean Sea off Port Said during January-December 2012

### 3.2.2 In females

Mature stage was existed during the whole study period except from May to August. The maximum value (88.0%) was recorded in December and the minimum (13.6%) in October. The nearly ripe ova values ranged between 8.7% and 74.1% in November and August, respectively. The ripe ova stage, was represented in March, April and July-September, with a maximum value of 50% in July and a minimum value of 11.5% in April and September. Spawning stage was recorded in the period April-July and September with a maximum value (57.1%) in May. This means that the spawning season began in April and continued throughout May-September, simultaneously with the spent stage which

began in April and ended in January, except July and August with highest values in June (62.5%) and October (68.2%).

**3.3 Gonadosomatic index (GSI):**

The GSI reached its peak value in May (2.97 and 4.2) for male and female, respectively. Afterward the GSI decreased reaching its minimum value in December for males (0.13) and in October for females (0.26).In the present work; females acquired higher mean GSI than males because the size of ovary was larger than that of testes at the same maturity stage. GSI in males started to increase in January, while in females started from November (Fig. 2).

Haidar (1970) and Gharbi & Ktari (1981) distinguished four phases in *M. surmuletus*, which are successive and definite in sexual cycle; these are; phase one which is slow maturation, phase two, repaid maturation, phase three, spawning and phase four, the rest stage. The variations in GSI can clarify these different phases. The phase of slow growth usually lies in autumn and early winter. Rapid growth is in January to March, while spawning time starts by the end of March to the end of June, finally, the rest phase, starts after spawning and lasts for one or two months.

From the above mentioned data, it is evident that *M. surmuletus* had one peak in May, revealing that spawning season starts in April and ends in June, with a condensed spawning in May (spring months). These results agree with the results given by Hashem (1973) in Mediterranean waters. The reproductive period of *M. surmuletus* recorded in our study was similar to that reported for this species in the other areas. In previous studies, Morales-Nin (1991), Campillo (1992), N'Da and Deniel (1993) reported that the spawning season of *M. surmuletus* occurred between April-May, May-August and May-June, respectively. These results indicated that the reproductive activity of females enters on spring. Additionally, Moldur (1999) and Üstün (2010) reported that the spawning season was during summer in the Marmara Sea. Arslanand İşmen (2013) showed that the spawning period was during spring months in Saros Bay. Moreover, Kherraz, *et al*. (2014) stated that the spawning season was through spring in Algeria coast.

**3.4 Size at first sexual maturity**

The length at first sexual maturity $L_{50}$ is very an important parameter in fisheries research to determine the optimum mesh size and minimum legal size that may be needed to maintain the suitable spawning stock and to ensure at least one spawning for the mature individuals. As shown in (Fig. 3), both males and females of *M. surmuletus* attained their first sexual maturity at length group (11-11.9 cm) by 50% and the smallest male and female of *M. surmuletus* attained its first maturity at the total body length of 11.9 cm which corresponding to the first year of life.

The estimation of length at first sexual maturity showed some variation from the other studies, but the age at first maturity attained at first year for both sexes. These results are similar with the previous studies (Gharbi and Ktari 1981; Sanchez *et al*. 1983; Morales-Nin 1991; Reňones *et al*. 1995; Arslanand İşmen 2013).

Hashem (1973) reported that the$L_{50}$of males and females were 13 cm and 15 cm, respectively in the Egyptian Mediterranean water, corresponding to the first and second year of life. He mentioned that the smallest ripe male was of length 11-12 cm TL, while the smallest female was 13-14 cm TL. Gharbi and Katri (1981) found that the length at first maturity for *M. surmuletus* was 13.8 cm for females and 12.6 cm length for males in Tuniscoast, while Dorel (1986) reported the mean length at first maturity in males (TL=18 cm) and females (TL=16cm) in France. Morales-Nin (1991) found that the mean length of females and males at first maturity was 15.0 cm TL in Mallorca. However, Vassilopoulou and Papaconstantinou (1991) estimated length for first sexual maturity for *M. surmuletus* as 11.5 cm for males and 13.8 cm for females, in the Aegean Sea. Campillo (1992) reported that the mean length of first maturity was TL=14 cm in Lion. Similarly, in the other study

describing the size of first sexual maturity, it was 16.8 cm for females and 14.0 cm for males. Off the Canary Islands, the L50 of male and female reached at 16 cm (Gonzales Pajuelo *et al*. 1993) and off Majorca, the L50 of males and females reached at 15 cm and 16.8 cm, respectively (Reñones *et al*. 1995). Mehanna (2009) reported that length at first sexual maturity of males and females was 15.1 cm T.L. Arslan and İşmen (2013) reported that *M. surmuletus* reached first maturity at 13.7 cm (1 year) for females and 13.2 cm (1 year) for males. Kherraz, *et al*. (2014) stated that red mullet attained sexual maturity during their second year of life, at around 17.70 cm in Algeria coast.

Under different environmental conditions the onset of sexual maturity varies in different species even among the same species, so this explains the differences between all the previous results. Also, this might be due to the large gap of time of investigation between the present study (2012) and all the previous studies which were conducted during the period between 1973 and 2009. During this period of time, several environmental conditions, especially pollution and increasing temperature surrounding the fish in the sea water have been changed and affected the sexual maturity of the fish.

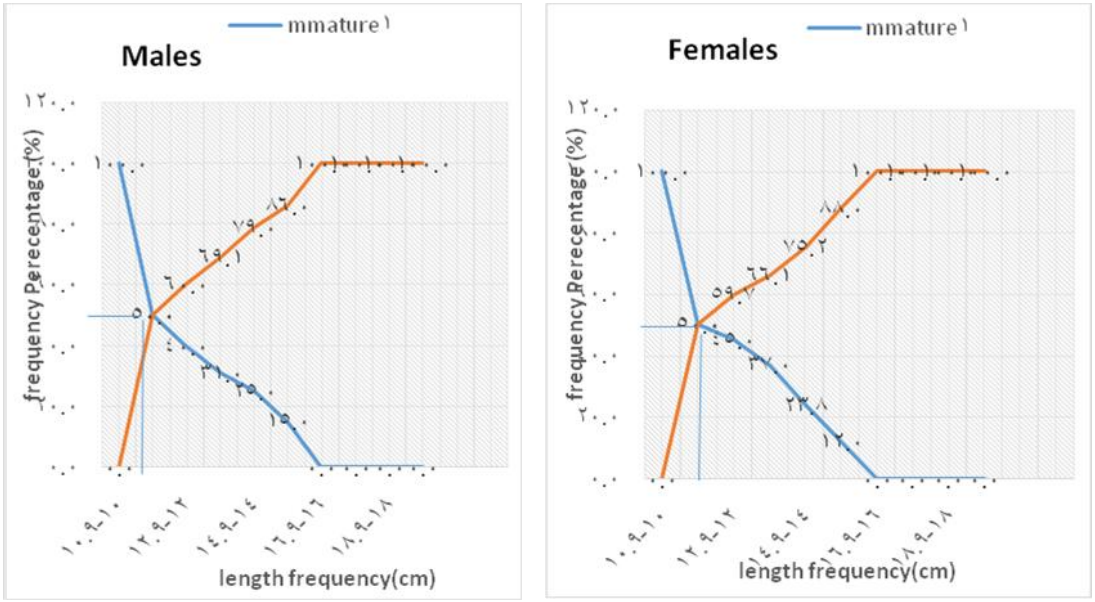


Fig. 3: Length at first sexual maturity for male and female of *M. surmuletus* from Port Said.

**3.5 Fecundity:**

The knowledge of the fecundity of fishes is very important in fisheries, population dynamic and food availability items. In the present study, fecundity estimation and counting of the more advanced groups of eggs was based on the ripe eggs. Specimens were taken for fecundity estimation during the spawning season.

**3.6 Relationship between fecundity and total length:**

For estimation of the absolute fecundity of *M. surmuletus*, 35 ripe females with total length ranged between 14-19.9 cm. were examined. The ripe females were grouped into size classes according to their total range with 1 cm, interval.

Fecundity increased as the fish grow in length and the relationship between fecundity and total length was characterized by a power function equation curve (Fig. 4). The mean absolute fecundity ($F_a$) ranged between 19640 to 83448egg/fish for fish length range of 14-19.9 cm. Concerning the value of correlation coefficient, the relation between absolute fecundity and fish length revealed a strong relationship ($F_a = 0.0255\ L^{5.031}$ $R^2 = 0.9733$).The relative fecundity ranged from 1363.9 to 4392.0 egg/fish, for

fish length ranged from 14.4- 19.9 cm. (Fr= 0.0255 $L^{4.031}$, $R^2$ = 0.9844).

Simpson (1951) pointed out that the relation between fecundity and total length is best expressed by an equation of the type $F=cL^n$ where the value of the exponent (n) is greater than 3.00.By applying this equation the value of the exponent (5.031) exceeded 3.00, pointing out that the fecundity of this species in the Mediterranean waters of Port Said is in a good condition.

Table 3: The mean observed and calculated values for absolute and relative fecundity per length (cm) of *M. surmuletus* from the Egyptian Mediterranean Sea off Port Said during the period from January to December 2012.

| Total Length (cm) | | No. of fish | Observed absolute Fecundity | | | Calc. absolute fecundity | Relative Fecundity | Calc. relative fecundity |
|---|---|---|---|---|---|---|---|---|
| Range | Mean | | Min. | Max. | Mean | | | |
| **14-14.9** | 14.4 | 8 | 19120 | 19930 | 19640 | 17150 | 1363.9 | 1191.0 |
| **15-15.9** | 15.7 | 13 | 22165 | 22630 | 22437 | 26492 | 1429.1 | 1687.4 |
| **16-16.9** | 16.3 | 9 | 31520 | 31590 | 31560 | 31993 | 1936.2 | 1962.8 |
| **17-17.9** | 17.1 | 2 | 42117 | 43015 | 42453 | 40714 | 2482.6 | 2380.9 |
| **18-18.9** | 18.2 | 2 | 46115 | 46900 | 46423 | 55713 | 2550.7 | 3061.2 |
| **19-19.9** | 19 | 1 | 83083 | 83828 | 83448 | 69175 | 4392.0 | 3640.8 |

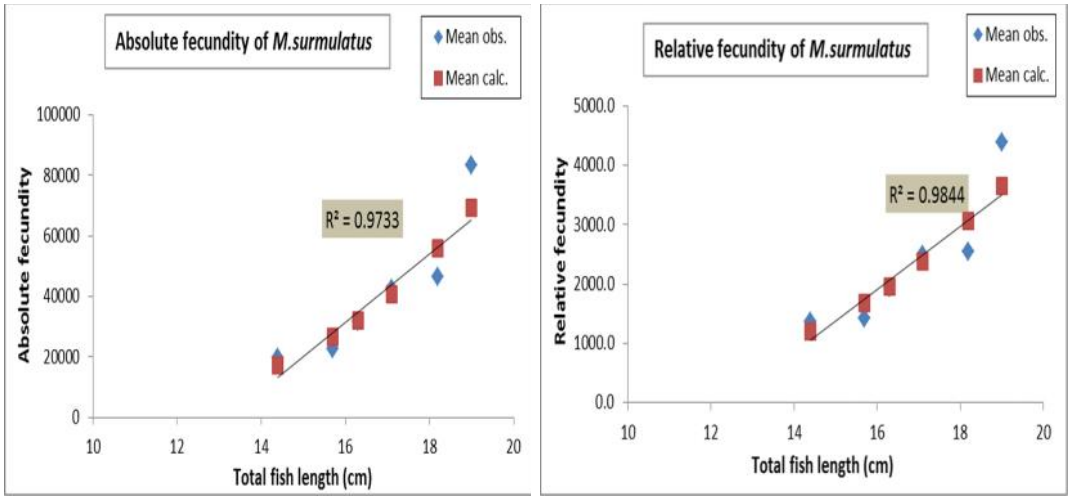


Fig. 4: The mean observed and calculated values of absolute and relative fecundity per length (cm) of *M. surmuletus* from the Egyptian Mediterranean off Port Said during the period from January to December 2012.

### 3.7 Relationship between fecundity and weight

Study of fecundity in relation to weight is important as the fish weight varies with the approach of the spawning season. The observed and calculated values of absolute fecundity were plotted against fish gutted weight (Fig. 5). About 35 specimens of ripe females were grouped according to their gutted weight with five gm. interval. The absolute fecundity increased with increase of total weight, ranging between 19423-83097 egg/fish for fish weight ranged between 35-64.9 gm. (Table 4). Strong relationship between absolute fecundity and fish weight was observed ($F_a$ = 0.8707 $W^{2.7382}$, $R^2$ = 0.9859).The relative fecundity ranged between 512-1330 egg/fish for fish weight ranged between 35-64.9 gm.(Fr = 0.8708 $W^{1.7382}$ ,$R^2$ = 0.9973).The number of eggs produced by females varies greatly according to species, size, age, region, period and techniques used, thus a considerable variability has been shown in different populations of mullets (Oren, 1975).

Table 4: The mean observed and calculated values for absolute and relative fecundity per weight (gm.) of *M. surmuletus* from Port Said harbour from January to December 2012.

| Total Weight (gm.) | | No. of fish | Observed absolute Fecundity | | | Calc. Fecundity | Relative Fecundity | Calc. relative fecundity |
|---|---|---|---|---|---|---|---|---|
| Range | Mean | | Min. | Max | Mean | | | |
| **35-39.9** | 37.9 | 5 | 19130 | 19740 | 19423 | 18302 | 512 | 482.9 |
| **40-44.9** | 41.9 | 8 | 22170 | 22900 | 22535 | 24089 | 538 | 574.9 |
| **45-49.9** | 46.5 | 4 | 31065 | 31635 | 31560 | 32040 | 679 | 689.0 |
| **50-54.9** | 50 | 9 | 42333 | 42930 | 42499 | 39083 | 850 | 781.7 |
| **55-59.9** | 57.4 | 5 | 46218 | 46783 | 46435 | 57032 | 809 | 993.6 |
| **60-64.9** | 62.5 | 4 | 83018 | 82969 | 83097 | 72002 | 1330 | 1152.0 |

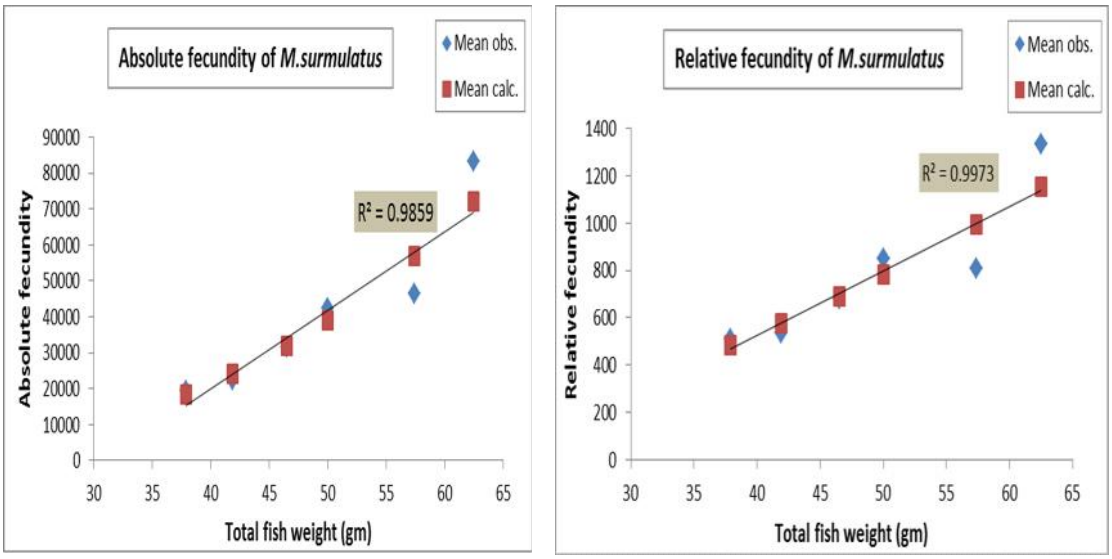


Fig. 5: The mean observed and calculated values of absolute and relative fecundity per Weight (gm.) of *M. surmuletus* from the Egyptian, Mediterranean, off Port Said during the period from January to December 2012

### 3.8 Egg diameter:

The study of egg diameter is important to understand the nature of reproduction during the spawning season and whether the fish spawns of several times a year, to determine the spawning frequency, and also to determine how long is the spawning season extending. In this study, egg diameter of 35 specimens of *M. surmuletus* with length ranged from 14 to 19.9 cm. was measured during the period from May to December.

Study of ova diameter distribution shows a wide range of distribution, with three modes of ova diameters. This might suggest that *M. surmuletus* is fractional spawned and has a stretched spawning season. Ripe eggs in *M. surmuletus* in the present study varied in mean diameter between 0.5 and 0.7 mm, divided into three batches which are (0.50-0.59 mm), (0.60 – 0.69 mm) and (0.70 – 0.79 mm) (Fig. 6). These results for some extent are close to those of Hashim (1973) who stated that the ripe ova ranged in diameter between (0.12 – 0.78 mm) divided in to three batches of (0.12 – 0.27 mm), (0.30 – 0.57 mm) and (0.60 – 0.78 mm).

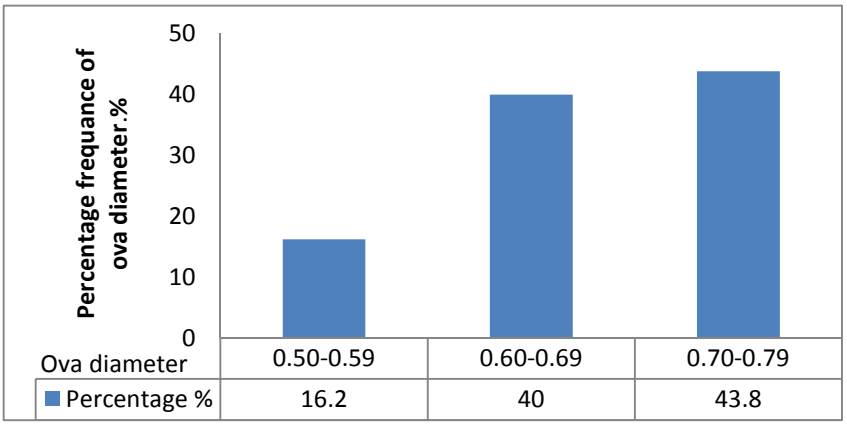


Fig. 6: Percentage frequency of ova- diameter in ripe female of *M. surmuletus* from Port Said Mediterranean during the period from January to December 2012

## 4. CONCLUSION

This study is the first research attempt to gives information about the sex ratio, gonadosomatic index, length at first sexual maturity, and fecundity of *M. surmuletus* from Mediterranean Sea, Port Said. The previous points considered essential information for management plan for this species, where:

The study on sex ratio provide information on the dominance of sex in *M. surmuletus* population and the basic information necessary for reproduction and stock size assessment.

The knowledge of the fecundity of *M. surmuletus* can be utilized to determine the time and number of recruitments.

Management plan depend on minimum landing size, associated to length at first sexual maturity, and closed fishing seasons.

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