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SEXUALITY, REPRODUCTION AND FECUNDITY OF *RAJA MIRALETUS* (L) FROM THE MEDITERRANEAN WATERS OFF ALEXANDRIA.

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ABSTRACT

The annual breeding cycle of Raja miraletus in the Egyptian Mediterranean waters was described. The present results showed that sexual maturity was reached by the male at 28 cm of total length (17 cm disc width, 13 cm disc length), and by the females at 30 cm of total length (19 cm disc width, 15 cm disc length). The vitellogenic activity starts in May, reaches a peakrate in June, July and August. Egg laying spreads over eight months. Ovules are laid in successive waves, between them are some rest period. It is suggested that temperature controls the rate of egg laying and vitellogenic activity. Fecundity of Raja miraletus varies between 90 (maximum) and 32 (minimum). There is a linear relationship between size of fish and fecundity.

INTRODUCTION

Study of reproduction of Rajidae have attracted the interest of some authors, in order to clarify the obscurity of their modes of reproduction (Jardas, 1973; Capape, 1974, a and b; 1976 a and b, 1977; Capape and Quignard, 1974, 1975; Holden, 1976; Hosney, 1982, Ryland and Ajayi, 1984; Brander and Palmer, 1985).

Information on reproduction of rays in Egyptian is still lacking. The present study is a contribution to this problem, as applied to Raja miraletus which is one of the most common rays in the Egyptian Mediterranean waters.

MATERIAL AND METHODS

This study was based on 390 fish of Raja mireletus, collected weakly from professional fishermen during the peroid from January to December, 1983. For each fish the following informations were recorded,

- Total length (T.L.) in cm: the length from the tip of snout to the posterior end of caudal fin.
- Disc length (D.L.) in cm: the distance from the tip of snout to the end of pectoral fin.

- Disc width (D.W.); the distance between the distal ends of pectoral fin.

- Total and gutted weights of the fish to the nearest gram.
- Weight of gonads to the nearest 0.1 gm.

- Presene of mature ova and fertilized eggs (egg sacs) in the oviduct, were noted as well as their diameter, to the nearest mm.
- In case of males, length of pterygopods to the nearest mm, was recorded.

Ovaries were collected from a wide length range of mature females in order to determine the relation between materal length and large yolked eggs. The percentage frequency distribution of ova diameter in female, ovaries out and during spawning season, were recorded for one ovary (right).

Gonado-somatic index for both males and females were obtained according to the formula

$$G.S.I. = \text{wt. gonad (gm)} / \text{gutted body weight (gm)} \times 100$$

Fecundity study was based on 32 females during the spawning season. Fish showing signs of spawning (egg in uterus) were excluded from fecundity analysis.

RESULTS

Sexuality:

Study of the sexuality of this fish depends on both internal and external examinations of the reproductive organs.

In case of males, a puberty in male rays was accompanied by some morphological variations in the reproductive system. Such variations were described before by Capape 1974 (a, b), and 1977 in some ray species including **R. miraletus** in Tunisian water.

To study the attainment of sexual maturity in males we have utilised the relation existing between the pterygopod length and disc length,

$$y = a\,x^b$$

On a logarithmic scale this relation gives a straight line,

$$\log \text{pty} = \log a + b \log L.$$

Where pty = the length of pterygopods in cm
and L = disc length in cm.

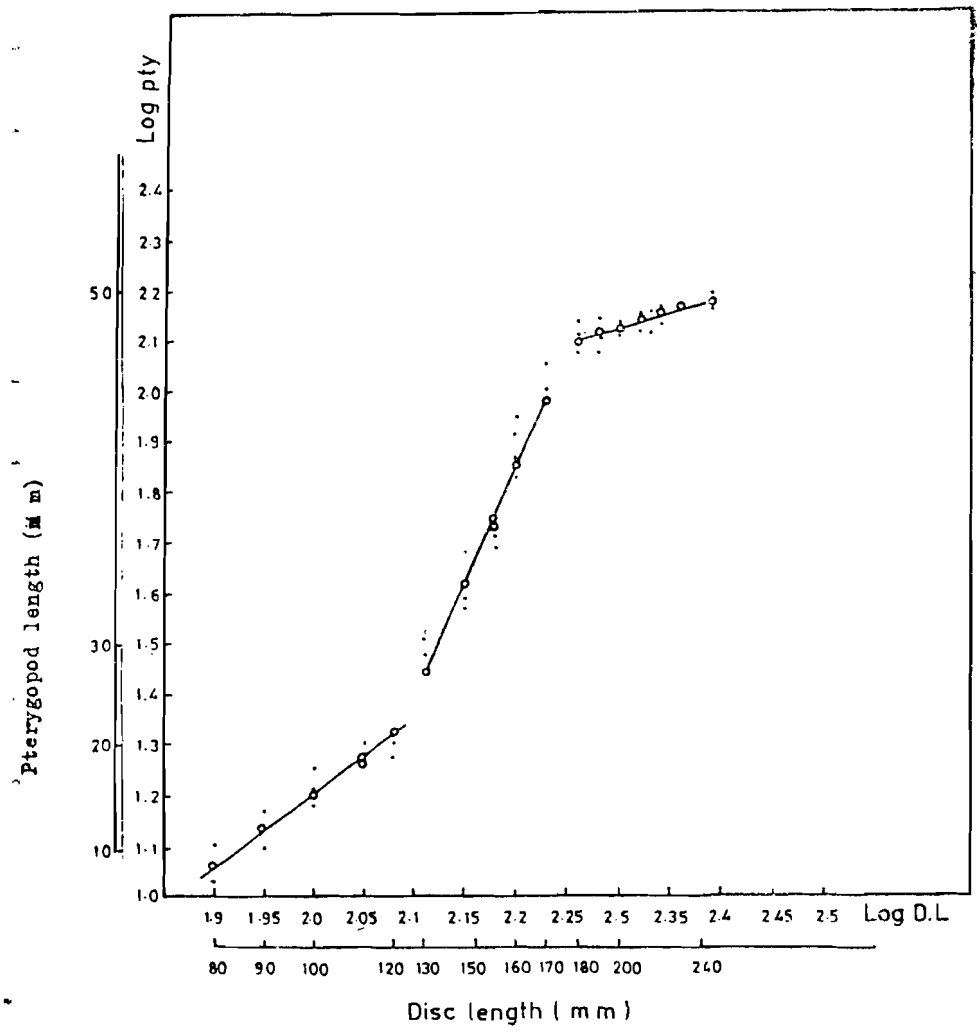

Fig. (1)
Length - Pterygopod relationship of R. miraletus
off Alexandria, 1983.

From Fig. (1) we could distinguish three straight lines of different slopes. Each corresponded to one phase in the sexual life of the male; juvenile phase (I), phase of sexual maturition (II) and adult phase (III). Formulae representing such relations were as follow:

Phase I :
n = 20
Length less than 12 cm D.L. (D.W.17 cm).
Log pty = 1.4376 log D.L. - 1.6729
r = 0.978

Phase II :

n = 42, for individuals having disc length of 13 -17 cm (D.W. = 18 - 22 cm). A sudden acceleration in the rate of growth of claspers (pty).

Log pty = 3.528 log D.L. - 8.1171

r = 0.907

Phase III :

n = 32, all individuals of disc length equal to or larger than 18 cm D.L. (23 cm D.W.). The rate of growth of copulatory organs was slowed down.

Log pty = 0.6251 log D.L. + 0.8630

r = 0.974

In case of females sexual maturity was characterized by development nidamental gland (shell gland) and a high vitellogenic activity in the ovaries.

Three stages of sexual maturity could be defined according to ova size;

1. Females without vitellogenic activity, with minute transparent eggs in the ovary, hardly seen by the naked eye (diameter < 1 mm).

2. Females with vitellogenic activity, with small white and maturing yellow ova in the ovary (diameter from 0.20 - 2.6 cm).

3. Females with encapsulated eggs in the uteri.

From Table (1) it was clear that the first females showing vitallogenic activity measured 30 cm total length (D.L. = 15 cm; D.W. = 19 cm) and from 40 cm total length (20 cm, D.L.; 26 cm D.W.) all females were mature. The table also shows that most females at lengths less than 28 cm (14 D.L., 18 D.W.) total length were virgin fish. For groups from 36-46 cm total length (18-23 cm D.L.; 23-29 D.W.), all females possessed encapsulated eggs in their uteri, and showed vitellogenic activity, in the ovary.

Reproduction:

Monthly variations in gonado-somatic index (G.S.I.) (Table 2, Fig. 2) showed the presence of one peak which started from May and extended to September with maximum value in June, July and August for females. For males the peak was noticed from March to July. Thus it is evident that spawning of **Raja miraletus** is long and lasts for 8 months.

Study of the monthly distribution of maturity stages in female **Raja miraletus** (Table 3, Fig. 3) revealed that most females in winter and spring (January, February, March and April) possessed ovaries with previtellogenic activity. Few numbers however exhibited vitellogenesis. On the other hand, in the period from May to August, the highest percentages of females with vitellogenic activity were observed. Fall (September, October and

Table (1)
Sexual maturity stages in the female **R. miraletus** off Alexandria.

Total Length (cm)	No.	Females without vitellogenic activity		Females with vitellogenic activity		Gravid females (eggs in uteri)	
		No.	%	No.	%	No.	%
28	32	32	100	0	0	0	0
30	24	20	86	4	16	0	0
32	30	25	75	5	25	0	0
34	22	16	73	6	27	0	0
36	30	14	47	14	47	2	6
38	44	4	9	32	73	8	18
40	5	0	0	4	80	1	20
42	12	0	0	6	50	6	50
44	4	0	0	2	50	2	50
46	12	0	0	4	25	8	75

TABLE (2)

Monthly variation in the G.S.I. of females and males of **Raja miraletus** off Alexandria (1983).

Month	G.S.I Males	G.S.I Females
January, 1983	0.1542	0.5007
February	0.3296	0.6906
March	0.5111	0.8535
April	0.5222	1.0350
May	0.5201	2.5128
June	0.5009	3.6475
July	0.4816	3.6241
August	0.3630	3.6228
September	0.3112	2.1653
October	0.2304	1.4833
November	0.2120	0.9838
December	0.1942	0.6838

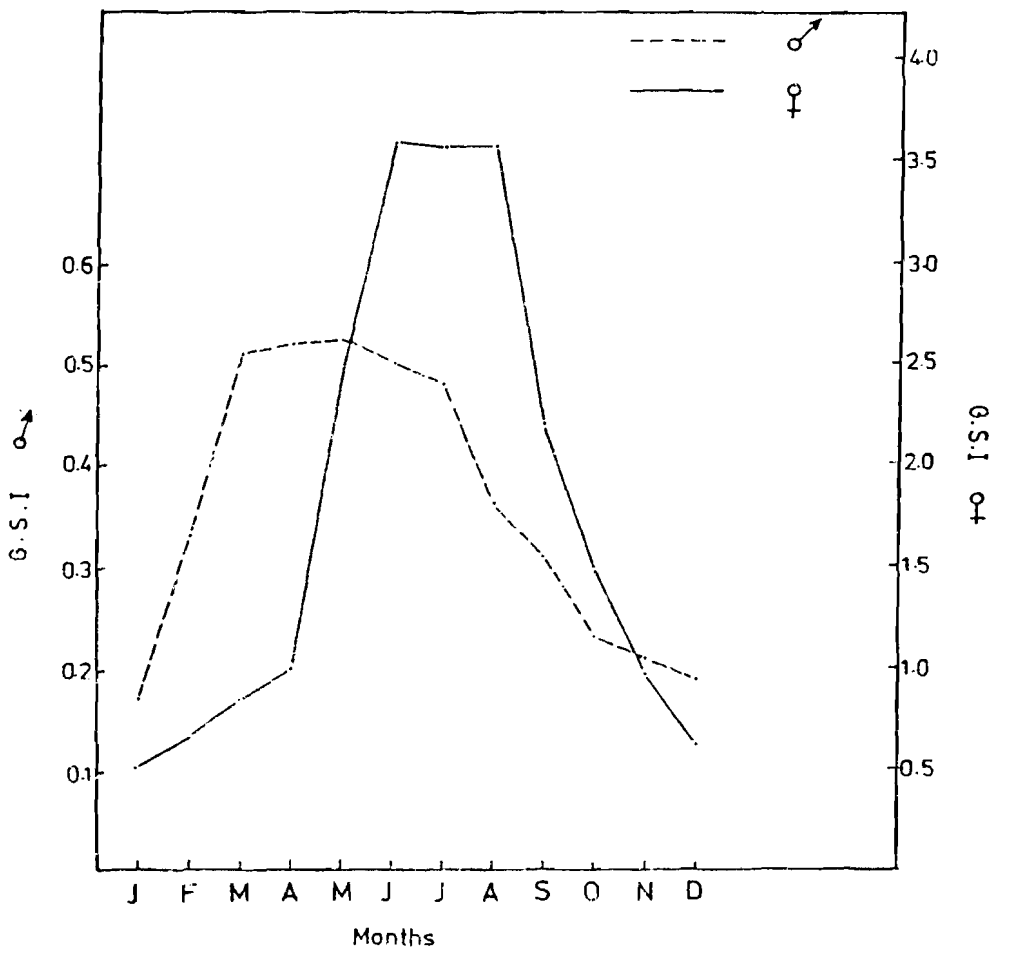

Fig. (2)
Monthly variation of gonado - somatic index (G.S.I.)
of female and males R. miraletus off Alexandria, 1983.

November) represented the period of high percentages of gravid females. It should be noted that no gravid females were observed in the months from January to April.

During the present investigation, we have never seen more than one ovum in a single uterus. The maximum size of ova present in the ovary of a gravid female measured not more than 1.6 cm.

TABLE (3)

Monthly distribution of maturity stages in females
R. miraletus (1983).

Months	Females without vitellogenic activity (Juvenile) No. (%)	Females with vitellogenic activity (mature) No. (%)	Gravid females No. (%)
January, 1983	20(80.00)	5(20.00)	0
February	13(72.22)	5(27.78)	0
March	12(70.59)	5(29.41)	0
April	12(60.00)	8(40.00)	0
May	6(30.00)	12(60.00)	2(10.00)
June	5(15.15)	25(75.76)	3(9.09)
July	6(14.29)	30(71.43)	6(14.29)
August	3(11.54)	13(50.00)	10(38.46)
September	2(9.09)	8(36.36)	12(54.55)
October	5(20.83)	5(20.83)	14(58.33)
November	6(30.00)	6(30.00)	8(40.00)
December	10(47.62)	4(19.05)	7(33.33)

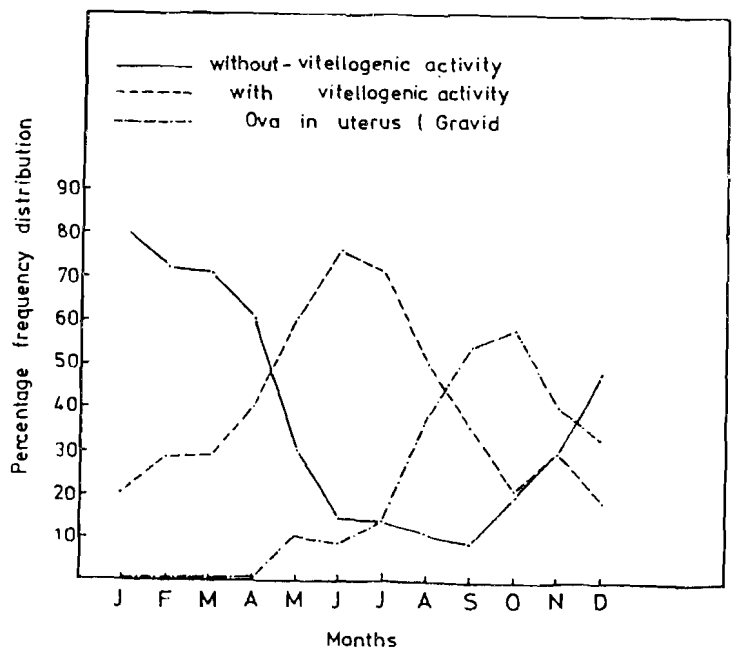

Fig. (3)
Monthly distribution of maturity stages in female
R. miraletus, 1983.

Table (4) and Fig. (4) showed the percentage frequency of ova diameter in female ovaries with vitellogenic activity. This reveales that, in female with low vitellogenic activity (G.S.I = 0.85, April), there was no sharp separation between the maturing yellow ova and the main eggs tock (white), i.e. no separation between ova with respect to their diameter. One group of eggs (0.2 - 1.2 cm) was evident. On the other hand, in an ovary of a female with active vitellogenesis (G.S.I. = 2.2 , 3.2 June) we could distinguish between two types of ova :

1 - Advanced ova with diameter more than 1.6 cm.
2 - Ova with lesser diameters.

TABLE (4)

Percentage frequency distribution of ova diameter in female ovaries with vitellogenic activity.

Egg diameter in cm	Ovary with low vitellogenic activity G.S.I. 0.85 T.L = 31 cm		Ovary with active vitellogenesis G.S.I. 22.2 T.L = 38 cm		Ovary with active vitellogenesis G.S.I. = 3.2 T.L = 45 cm	
	No	%	NO	%	No	%
0.2	7	23.33	7	23.26	12	30.30
0.4	9	30.00	9	30.00	8	21.21
0.6	5	16.67	4	13.95	5	12.12
0.8	4	13.33	3	10.00	3	9.09
1.0	3	10.00	2	6.98	3	9.09
1.2	2	6.67	2	6.98	2	6.06
1.4	-	-	-	-	-	-
1.6	-	-	1	2.33	1	3.03
1.8	-	-	-	-	1	3.03
2.0	-	-	1	2.33	-	-
2.2	-	-	-	-	1	3.03
2.4	-	-	-	-	-	-
2.6	-	-	1	2.33	1	3.03

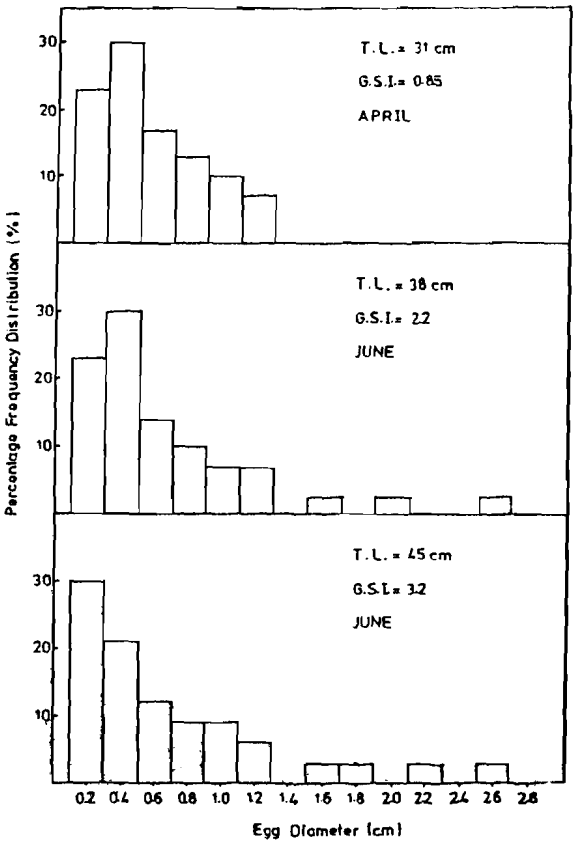

Fig. (4)
Percentage frequency distribution of ova diameter in female ovaries with vitellogenic activity.

It should be noted that the ripe ova pass to maturity one after the other (not all at once). Thus when an ovum passes to the uterus, the one after it needs a time to reach the size to be laid out. From the above we can say that after the ovum reaches ripeness (diameter above 2.5cm) it passes to the uterus and the female becomes gravid.

Fecundity :

The ovaries of mature **Raja miraletus** contain two types of eggs, one is white protoplasmic and the other yellow trophoplasmic. Counts were made of all the yellow yolked eggs (Table 5). Average egg number was done on one ovary (the right ovary). No significant differences in the

Table (5)
Relation between number of yellow ovarian eggs in right ovary and total length of **R. miraletus.**

Length group (cm)	34	36	38	40	42	44	46	48	50
Number of fish	2	5	6	4	4	3	5	2	1
Number of yeloow ovarian eggs	16	19	20	23	28	33	38	41	45

number or maturity of ova, between the two ovaries were observed. The annual egg production of **Raja miraletus** as calculated for one ovary was found to vary between 16 and 45 (i.e. 32 and 90 ova for both ovaries).

The regression of total number of yellow ovarian eggs on total material length for ripe females was represented in Fig. (5). From this figure, a linear relationship existed between the number of yolked ovarian eggs

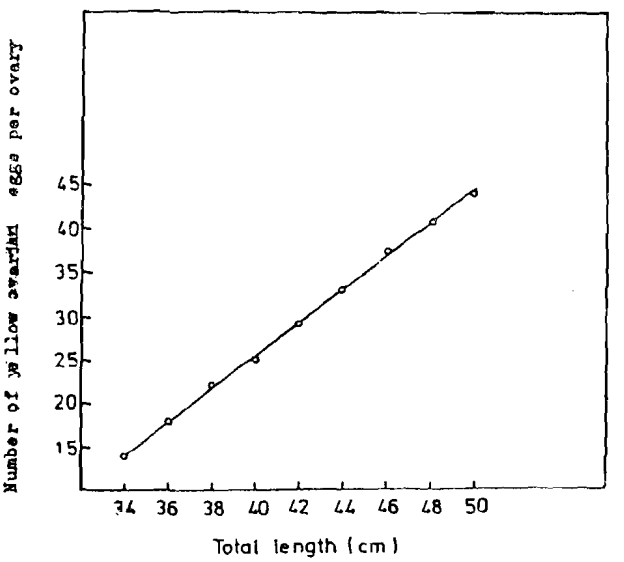

Fig. (5)
Relation between number of yellow ovarian eggs and total length of **R. miraletus** off Alexandria, 1983.

and total length of **R. miraletus**. Such relationship was found to be represented by the following equation

$$Y = 12.033 + 1.521\ x$$

where, Y = Number of yellow ovarian eggs per ovary,
X = Total fish length in cm.

DISCUSSION

In the majority of fish species various morphological variations take place by the approach of sexual maturity (Nikolsky, 1963). In cartilagenous fishes various authors have shown the presence of a logaritnmic relationship between length of pterygopods and that of body in the males (Borcea, 1905; Zupanovic, 1961; Collenot, 1969; Capape, 1076, b, 1977 and Ryland and Ajayi 1984). The present study shows the presence of 3 stages in the course of development of the claspers (pterygopods) in **Raja miraletus,** namely a period of slow growth (juvenile phase) followed by a phase of rapid growth (maturation phase) and a third phase where growth ceases (adult phase). This phenomenon has been mentioned before by Capape 1974 b, in the same species and in other ray species by the same author (**Raja clavata, Raja alba, Raja melitensis**).

The present results show that sexual maturity in **Raja miraletus** is reached in the males at smaller sizes than the females. Therefore for **R. miraletus** maximum length of female might be bigger than that of males, this phenomenon have been noted before for the same species in Tunisian waters by Capape and Quignard, 1974. The same was found to be true for **R. radula** (Capape, 1974 a) and **R. clavata** (Capape, 1976 a).

In fishes, various authors proved that the gonads whether ovaries or testes vary in size in different months of the year in function of sexual maturity of the fish (Rounsefell and Everhart, 1953; Lagler 1956). Gonadosomatic index is an indication of the ovarian and testicular maturation. As the gonad matures its inclusions increase up to the degree of full ripeness. Study of variation of G.S.I. in **R. miraletus** revealed the presence of a peak of G.S.I. values during the months of June, July and August for females and from March to July in males i.e. a long season of reproduction.

Capape (1977, 1979); studied the monthly variation in G.S.I. of **R. radula** and **R. miraletus** and made a comprehensive study on the relation between monhly fluctuations in G.S.I., H.S.I. and condition factor for the two species. The author demenstrated the presence of a long spawing season for both species i.e. a peroid of active vitellogenesis followed by a period of "sexual repose".

Ryland and Ajayi (1984) gave six stages of sexual maturition based on the variations of the values of gonado-somatic index, hepatosomatic index,

condition factor and the ratio of clasper length / total length for **R. microocellate.**

Brander and Palmer (1985) determined the spawning season of **R. clavata** from March to September, with a peak in June, using the variations in the values of G.S.I.

Clark (1922), Holden (1975), Holden et al. (1971) and Ryland and Ajayi (1984) found a characteristic prolonged breeding season as was the case in **Raja miraletus.** This might necessitate the storage of spermatozoa in mated females noted by Holden (1975), especially in the light of discontinuous mating consequent upon the resorption of clasper cartilages.

The present study on maturity stages in females, shows that vitellogenic activity is very low in winter months and increases in spring and summer whence it reaches its maximum degree. Gravid females appear in the catch from May. This is in accordance with the results of Capape and Quignard (1974) for the same species.

Study of percentage frequency distribution of ova diameter shows that the ova mature one at a time i.e. when a single ovum ripens it passes to the oviduct. The next ovum needs another time to reach its ripness during which the ovum existing in uterus is shed. This is in accordance with what Capape have dimonstrated in 1976 a,b. According to his dimonstration the ova mature in batches and there is alternative periods of rest and activity between the ovary and the uterus (In **R. clavata**). According to Capape (1976a), vitellogenic activity is increased by temperature for this species, that is why it is very low in winter. This phenomenon was observed for **R. clavata** by Holden et al. (1971), who showed that the rate of egg laying and onset of spawning is temperature dependent.

The evaluation of fecundity present a certain number of difficulties that renders the methods used very approximate. It seems that only the exact determination of spawning rythm and also the throwing out of ovarian capsules that permits a satisfactory approach of the problem.

The method of Holden (1975) based on the rythem of egg laying in aquarium and on the monthly percentage of females with ovisacs in uterus is not directly applicable to the study of fecundity in **R. miraletus.**

The fecundity of **R. miraletus** in the present study is based on the method of Capape and Quignard (1975) which depends on the determination of maximum annual vitellogenic activity of the species.

In **Raja miraletus eggs** on the ovaries were always at the same stage of maturity as reported by Holden (1975) and Ryland and Ajayi (1984) in contrast to **R. garmani** in which the right egg is shed in advance of the left (McEachran, 1970). Thus the annual egg production of **R. miraletus** as calculated for one ovary was found to vary between 16 and 45 (i.e. 32

and 90 ova for both ovaries). Capape (1975) reported a value between 40 and 72, for the same species in Tunisian waters, which shows a little difference from the present estimation.

The relationship between annual egg production and total maternal length in this fish was found to be linear as was reported by Capape (1974 a) in **R. radula** and (1976 a1954 in **R. clavata,** and by Capape and Quignard (1974) in **R. miraletus** and by Holden (1975) in **R. clavata.** A linear relationship between numbers of embryo and maternal length has been reported by Ripley (1942) for the soup-fin shark **Galeorhinus zyopterus** and by Olsen (1954) for the Australian school shark **G. australis.** Holden and Meadows (1964) described a cubic relationship between fecundity and maternal length for spiny dog fish **Squalus acanthias**

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