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Aspects of the reproductive biology of the brown ray *Raja miraletus* (Chondrichthyes: Rajidae) from the coast of Senegal (Eastern Tropical Atlantic)

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Abstract: The brown ray, *Raja miraletus* is commonly landed at the fishing sites of the Senegalese coast. Adult males and females are mostly captured in spring and summer. The smallest sexually mature male and female were 270 mm and 310 mm disc width, respectively. The largest male and the largest female adults were 380 mm and 415 mm disc width, respectively, and weighed 1205 g and 1336 g, respectively. They were the largest *R. miraletus* reported to date for both males and females. There was no significant relationship total mass *versus* disc width between males and females. Diameter of the largest yolky oocytes ranged from 18 to 23 mm (mean ± standard deviation: 19.9 mm ± 1.4), and weighed from 1.8 to 2.3 g (mean: 2.1 g ± 0.1). Vitellogenic activity practically occurred throughout the year, especially in spring and summer with a peak in April-May. Females carrying egg cases were found from November to June. Egg cases had 88-97 mm in length with horns (mean: 92.1 mm ± 2.9), and 48-52 mm without horns (mean: 50.4 mm ± 1.1), their width were 28-32 mm (mean: 30.3 mm ± 1.1) and they weighed 8.7-9.9 g (mean: 9.3 g ± 0.4). An estimation of the fecundity based on the occurrence of egg cases during one year and number of yellow oocytes counted in adult females allows us to consider it from 71 to 178.

Résumé : *Aspects de la biologie de la reproduction de la raie miroir* Raja miraletus *(Chondrichthyes: Rajidae) de la côte du Sénégal (Atlantique oriental tropical).* La raie miroir *Raja miraletus* est débarquée en relative abondance sur les sites de pêche de la côte du Sénégal. Mâles et femelles adultes sont le plus souvent capturés au printemps et en été. Le plus petit mâle et la plus petite femelle matures avaient 270 mm et 310 mm de largeur discale, respectivement. Le plus grand mâle et la plus grande femelle adultes avaient 380 mm et de 415 mm de largeur discale et pesaient 1205 g et 1336 g, respectivement. Ce sont les plus grands spécimens mâles et femelles de *R. miraletus* signalés à ce jour. Il n'y a pas de relation significative entre la masse totale et la largeur discale entre mâles et femelles. Le diamètre des plus grands ovocytes riches en vitellus se situait entre 18 et 23 mm (moyenne ± écart-type: 19,9 mm ± 1,4), et ils pesaient entre 1,8-2,8 g (moyenne: 2,1 g ± 0,1). L'activité vitellogénétique avait lieu pratiquement toute l'année, et plus particulièrement au printemps et en été avec un pic en avril-juin. Les femelles portant des œufs encapsulés sont capturées de septembre à juin. Les capsules

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ovifères avaient une longueur avec cornes entre 88-97 mm (moyenne: 92,1 mm ± 2,9), sans cornes entre 48-52 mm (moyenne: 50,4 mm ± 1,1), leur largeur était entre 28-32 mm (30.3 mm ± 1,1) et ils pesaient incluant les ovocytes fécondés entre 8,7-9,9 g (moyenne: 9,3 g ± 0,4). Une estimation de la fécondité fondée sur la présence d'œufs encapsulés et d'ovocytes jaunes au cours de l'année chez les femelles adultes, nous amène à la considérer comprise entre 71 et 178.

Keywords: Chondrichthyes ● Rajidae ● *Raja miraletus* ● Reproductive Biology ● Senegal ● Eastern Tropical Atlantic

Introduction

The brown ray, *Raja miraletus* (Linnaeus, 1758), occurs in the Mediterranean, where it is commonly caught off the southern shore and in the eastern basin (Capapé & Quignard, 1974; Golani, 1996). North of the Strait of Gibraltar, the species is reported off Portugal, southward from Morocco to South Africa (Séret & Opic, 1990). Off Senegal, *R. miraletus* is abundantly captured throughout the year in shallow coastal waters. The species is not locally used for human consumption as fresh or dried and has not economical interest, so specimens are generally discarded at sea by fishermen when caught. Consequently, little information is dealt on the reproductive biology of *R. miraletus* from off Senegal (Capapé et al., 1995).

Catches of *R. miraletus* off the coast of Senegal provided additional data, increasing our knowledge of the species in the area, and allowed us to evaluate whether there are differences in traits, such as size at sexual maturity, reproductive cycle and fecundity between the local population and those of other areas, especially the Tunisian coast (Capapé & Quignard, 1974 & 1975).

Material and Methods

The observed specimens were collected off the coast of Senegal between 1994 and 2002. Most of them were landed at the fishing site of Ouakam, Cape Verde Peninsula (Fig. 1). The observed specimens were captured by gill-netters at depths between 20 to 80 m, on sandy and muddy bottoms.

Disc width of the specimens was measured to nearest millimetre following Clark (1926) and mass was recorded to the nearest gram. Liver, gonads and oviducal glands were weighed to the nearest decigram. Developing and yolky oocytes, egg cases were measured to the nearest millimetre and their masses were recorded to the nearest decigram, when possible. Clasper length was measured from the forward rim of the pelvic girdle to tip of the clasper following Collenot (1969). In both males and females, specimens were divided in three categories: juveniles, sub-adults and adults.

The claspers of juveniles were not calcified and smaller than the length of the pelvic fin; those of sub-adults were longer than the length of the pelvic fin, but soft and flexible. In adults, claspers were rigid, calcified, elongated and became much longer than the pelvic fins length. Some aspects of the testes and other reproductive organs were described following Capapé et al. (1990), Hamlett et al. (1999) and Henderson et al. (2006). Size at sexual maturity was determined in females by analysing the condition of ovaries, the morphology of the reproductive tract and the mass of the oviducal glands following Capapé & Quignard (1974), Callard et al. (2005) and Henderson et al. (2006).

As other oviparous elasmobranch species, the fecundity in *Raja miraletus* cannot be directly determined as in viviparous elasmobranch species. Fecundity estimation was assessed by using the method of Holden (1975), based on estimation of the average number of eggs laid by adult females and by the method of Capapé & Quignard (1975) based on maximal number of oocytes counted in both ovaries in adult females. Holden et al. (1971) noted that rate of egg case laying by the thornback ray *Raja clavata* (Linnaeus, 1758) in aquaria was one egg case every 24 hours and this rate was maintained during 26 days. Holden (1975) considered that the month in which this production was at a maximum could be taken as corresponding to a rate of one egg capsule laid per day; then the rate for any other month will be proportional to the occurrence of egg cases in that month multiplied by the number of days in each month. Capapé & Quignard (1975) took into consideration the total of yellow oocytes produced per year in order to assess fecundity of both *R. miraletus* and *R. radula* (Delaroche, 1809) from the Tunisian coast. They counted the maximum of yellow oocytes produced in the sample per month. Similar counts were carried out for the present sample.

Tests for significance ($p < 0.05$) were performed by using ANOVA, Student *t*-test and the chi-square test. The linear regression was expressed in decimal logarithmic coordinates. Correlations were assessed by least-squares regression. In the relationship total mass *versus* total length and liver mass *versus* total length, comparisons of curves were carried out by ANCOVA.

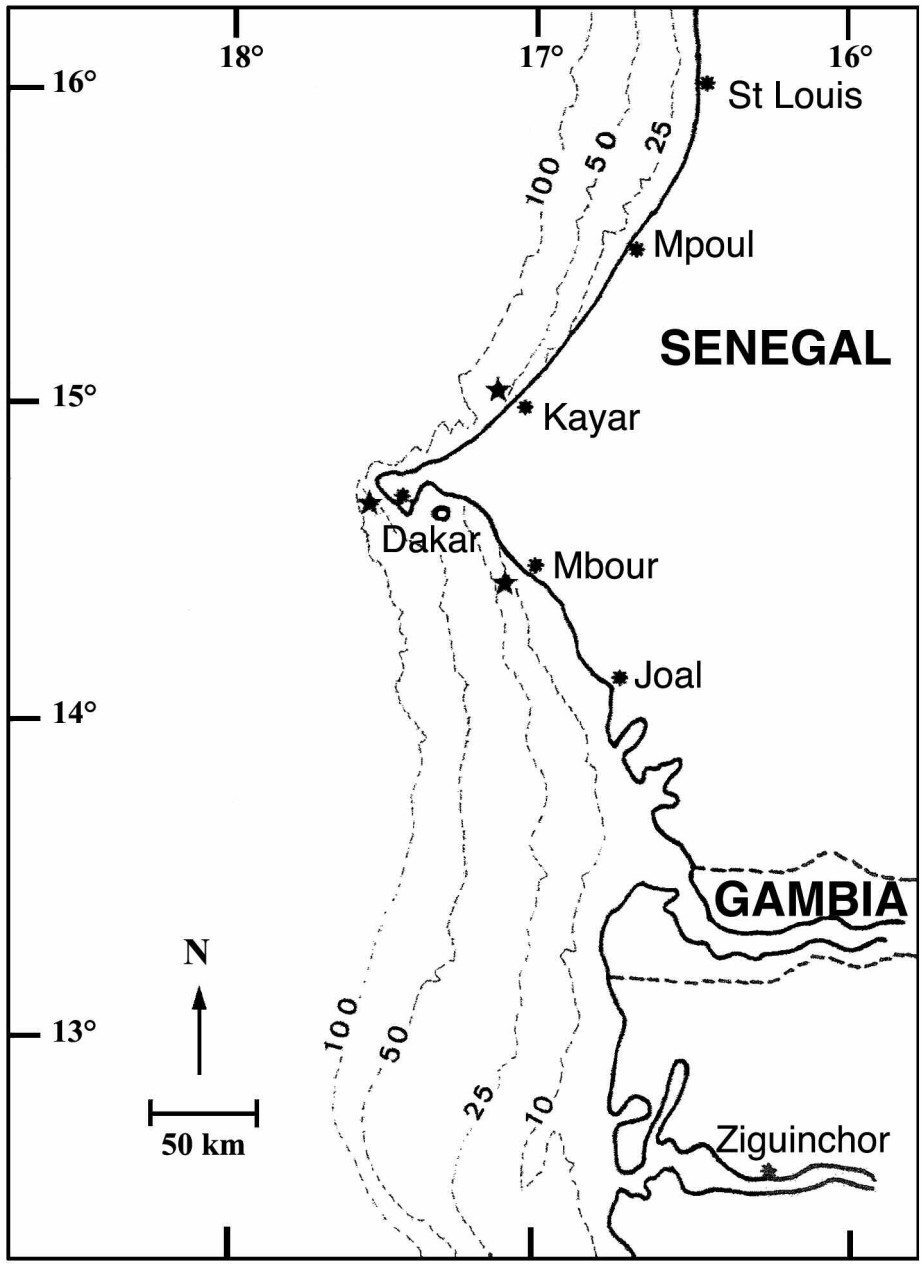

Figure 1. *Raja miraletus*. Map of Senegal showing the landing sites and captures sites (black stars) (redrawn from Kébé & Le Reste, 1993). Depth contour in metres.

Figure 1. *Raja miraletus*. Carte du Sénégal montrant les sites de débarquement et les sites de captures (étoiles noires) (redessiné d'après Kébé & Le Reste, 1993). Contour des profondeurs en mètres.

Results

Sample description

A total of 483 specimens, 236 males and 247 females, were examined. The monthly collection of observed specimens covering 8 years is presented in Table 1. Male and female juveniles were rather equally distributed in our sample. However, male sub-adults outnumbered the females' ones, and sex ratio for the three stages, and for total sample was quite 1: 1.05.

Males. Juveniles ranged between 220 and 280 mm DW and weighing between 151 and 505 g. Specimens had short flexible claspers (Fig. 2). Testes and genital ducts were

Table 1. *Raja miraletus*. Monthly collection observed in the sample.
Tableau 1. *Raja miraletus*. Récolte mensuelle observée dans l'échantillon.

Sex	Category	Months												Total
		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	
Males														
	Juveniles	4	5	4	6	1	4	4	1	2	1	10	6	48
	Sub-adults	1	3	-	-	3	4	3	3	5	4	3	4	33
	Adults	7	18	16	22	21	24	12	10	9	7	4	5	155
	Total	12	26	20	28	25	32	19	14	16	12	17	15	236
Females														
	Juveniles	5	6	6	5	2	2	4	4	3	1	9	5	52
	Sub-adults	3	1	2	2	5	4	5	5	3	6	5	5	46
	Adults	10	15	13	19	23	20	1	3	8	9	7	21	149
	Total	18	22	21	26	30	26	10	12	14	16	21	31	247
	Grand total	30	48	41	54	55	58	29	26	30	28	38	46	483

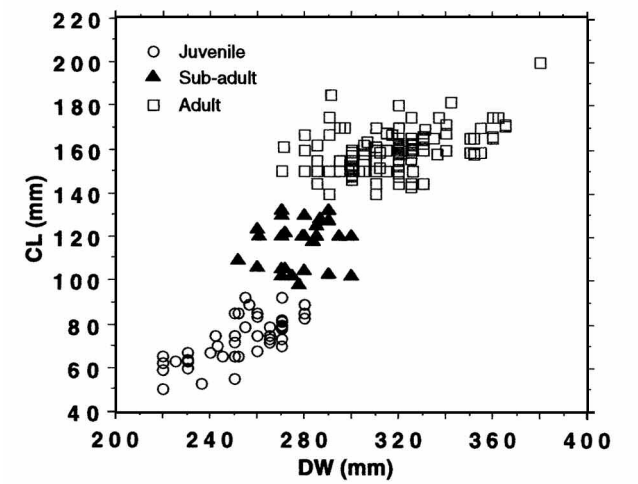

Figure 2. *Raja miraletus*. Clasper Length (CL) *vs* Disc Width (DW) in males.
Figure 2. *Raja miraletus*. Relation entre la longueur des ptérygopodes ou «claspers» (CL) et la largeur du disque (DW) chez les mâles.

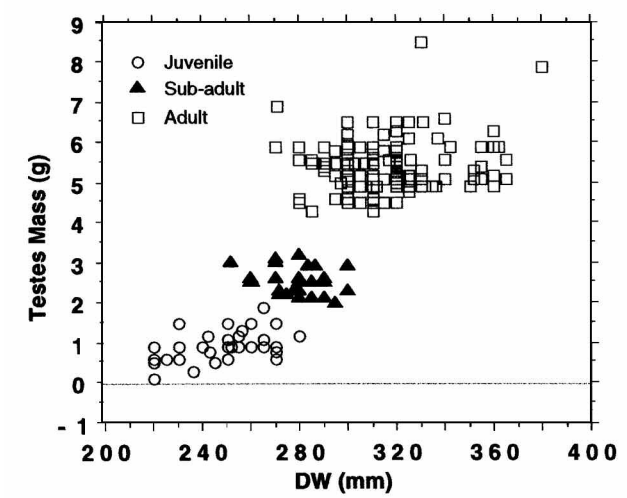

Figure 3. *Raja miraletus*. Testes Mass (TM) *vs* Disc Width (DW) in males.
Figure 3. *Raja miraletus*. Relation entre la masse des testicules (TM) et la largeur du disque (DW) chez les mâles.

inconspicuously developed and thread-like. Teeth were smooth on both jaws. Juveniles were mostly caught from November to April and a bit less in June and July (Table 1).

During the sub-adult stage, the claspers were developed and they were slightly longer than pelvic fins. The testes increased in mass (Fig. 3), but had not externally visible spermatocysts. The genital duct was slightly convoluted anteriorly. There were from one to three rows of alar and malar developing thorns on the dorsal surface of the disc. Median teeth were slightly sharped on both jaws. Disc width ranged from 252 to 300 mm, and mass between 342 and 596 g. Sub-adults were caught all year round except in March and April (Table 1).

During the adult stage, the claspers were elongated, calcified, and rigid. Testes were well-developed (Fig. 3) and exhibited spermatocysts externally visible. The genital duct was twisted and sperm occurred in seminal vesicles. Four to five developed and rigids rows alar and malar thorns appeared on the dorsal surface of the disc. The median rows of teeth were sharped in both rows. The smallest sexually mature male observed was 270 mm DW and weighed 550 g; the largest was 380 mm DW and weighed 1205 g. Moreover, all males above 300 mm DW were adult. The adults were collected all year round, mostly caught between February and June (Table 1).

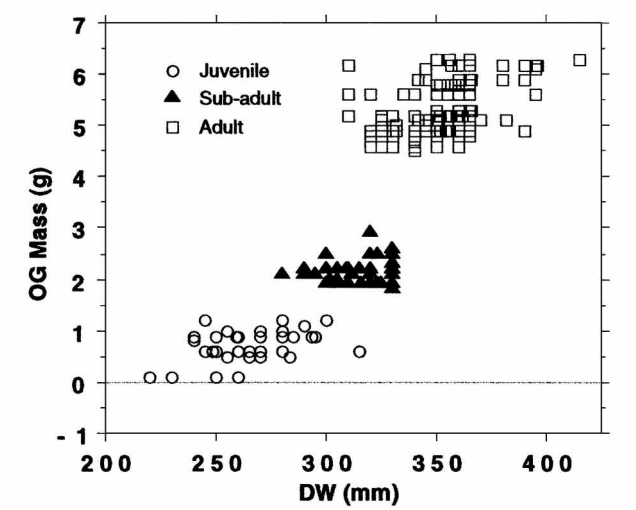

Figure 4. *Raja miraletus*. Oviducal Glands Mass (OG Mass) vs Disc Width (DW) in females.

Figure 4. *Raja miraletus*. Relation entre la masse des glandes nidamentaires (OG Mass) et la largeur du disque (DW) chez les femelles.

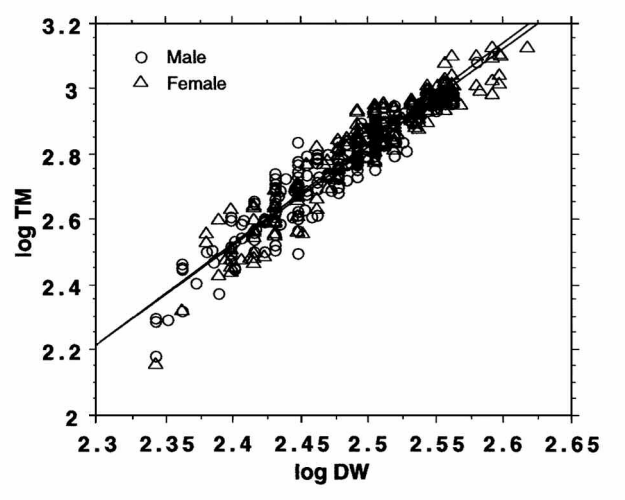

Figure 5. *Raja miraletus*. Relationships Total Mass (TM) *vs* Disc Width (DW) expressed in logarithmic co-ordinates for males and for females.

Figure 5. *Raja miraletus*. Relations entre la masse totale (TM) et la largeur du disque (DW) exprimée en coordonnées logarithmiques pour les mâles et les femelles.

Females. Juvenile females, ranged between 220 and 295 mm DW and weighed between 142 and 531 g, had whitish and undeveloped ovaries, thread-like oviducts and inconspicuous oviducal glands. Each month, some specimens were collected, a bit more in November (Table 1).

Sub-adults ranged between 280 and 330 mm and weighed between 514 and 682 g and exhibited primarily white translucent follicles and a well-differentiated genital duct. The oviducal glands were visible and slightly rounded. As for juveniles, each month, some specimens were caught, a bit less however in February, March and April (Table 1).

The analysed adults ranged from 310 to 415 mm DW and weighed from 696 to 1338 g, but the heaviest adult female recorded was 390 mm DW and weighed 1338 g. They had functional ovaries containing batches of yolky oocytes and fully developed genital ducts. The oviducal glands were conspicuously rounded and the mass consi-derably heavier than in the other stages (Fig. 4). Several adults contained one egg case in one or both oviducts. The smallest adult female collected contained egg cases had 310 mm DW. All females above 330 mm DW were adult. Adult females were especially captured from December to June, rarely from July to November (Table 1).

Size and mass relationships

The relationship between DW and TM (Fig. 5) did not significantly differ between sexes (F = 0.39, p = 0.59, d.f. = 1). The relationship was for males:

log TM = 3.07 log DW - 4. 85, r = 0.93, n = 236 (1)

and for females:

log TM = 3.02 log DW - 4.73, r = 0.94, n = 247 (2)

By contrast, the relationship between DW and LM (Fig. 6) significantly differed between sexes (F = 18.39, p < 0.001, d.f. = 1). The relationship was for males:

log LM = 2.45 log DW - 5. 06, r = 0.76, n = 236 (3)

and for females:

log LM = 3.28 log DW - 7.07, r = 0.84, n = 247 (4)

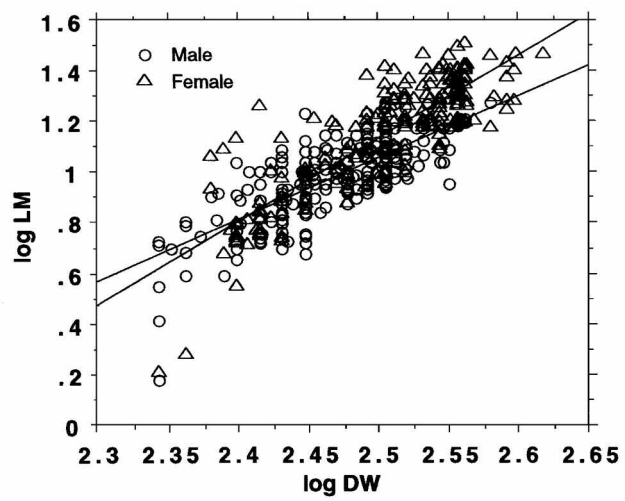

Figure 6. *Raja miraletus*. Relationships Liver Mass (LM) *vs* Disc Width (DW) expressed in logarithmic co-ordinates for male and for females.

Figure 6. *Raja miraletus*. Relations entre la masse du foie (LM) et la largeur du disque (DW) exprimée en coordonnées logarithmiques pour les mâles et les femelles.

Table 2. *Raja miraletus*. Monthly collection of the adult females observed in the sample.
Tableau 2. *Raja miraletus*. Récolte mensuelle des femelles adultes observées dans l'échantillon.

Category of adult females	Months												
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
Non egg-bearing													
With yolky and developing oocytes	5	4	5	4	11	14	1	3	7	8	2	17	81
With only developing oocytes	2	5	1	1	2	3	-	-	1	1	-	1	17
Total	7	9	6	5	13	17	1	3	8	9	2	18	98
Egg-bearing													
With yolky and developing oocytes	-	4	5	8	8	3	-	-	-	-	2	2	32
With only developing oocytes	3	2	2	6	2	-	-	-	-	-	3	1	19
Total	3	6	7	14	10	3	-	-	-	-	5	3	51
Grand total	10	15	13	19	23	20	1	3	8	9	7	21	149

Table 3. *Raja miraletus*. Measurements carried out on the three categories of oocytes from adult females from the sample.
Tableau 3. *Raja miraletus*. Mesures réalisées sur les trois catégories d'ovocytes des femelles adultes dans l'échantillon.

Category of oocytes	Diameter (mm)			Mass (g)	
	Number	Range	Mean	Range	Mean
Yolky oocytes	42	18-23	19.9 ± 1.4	1.8-2.3	2.1 ± 0.1
Larger developing oocytes	19	10-13	10.8 ± 0.9	0.9-1.2	1.1 ± 0.1
Smaller developing oocytes	16	6-8	6.8 ± 0.9	0.4-0.8	0.5 ± 0.1

Reproductive cycle of females

Adult female *R. miraletus* comprised two categories: egg-bearing and non egg-bearing (Table 2). In both categories, two categories of oocytes were observed: translucent oocytes and yellow oocytes. The former had small diameter, of up 3 mm. Three batches of yellow oocytes were distinguished: one batch of yolky oocytes, ready to be ovulated and two batches of developing oocytes: larger and small developing oocytes. For each batch, oocytes were similar in diameter and mass; measurements are detailed in Table 3, diameter and mass did not show significant differences related to females DW.

Number of yolky oocytes ranged from 1 to 8 in the first category of adult females, and between 1 and 6 in the second category of adult females. Seemingly, the first category of adult females contained more yolky oocytes than the second category (Table 4). This suggests that yolky oocytes were successively ovulated as oviducal glands produced egg cases until batch was completely consumed. After all egg cases were extruded, vitellogenesis started again and ovaries developed a batch of yolky oocytes by increasing of the previous larger developing oocytes, concomitantly with the previous smaller oocytes became larger and the translucent ones were charged by yolk. During vitellogenic activity, reproductive tract entered in a appearent rest phase.

Moreover, all year round, yolky oocytes were found in no egg case bearing females: this suggests that vitellogenesis could be permanent. Production of egg cases occurred from November to June. The absence of egg-bearing females in the remaining period (July to October) may be due to the low number of sample in that period, however a general rest phase for both reproductive duct and ovaries could be still considered.

Measurements carried out on egg cases removed from adult females *Raja miraletus* are given in Table 5. Production of oocytes and ovulation were quasi-permanent. Relationship between number of oocytes and disc width was not observed.

Table 4. *Raja miraletus*. Number of yolky oocytes counted in both categories of adult females.
Tableau 4. *Raja miraletus*. Nombre d'ovocytes chargés en vitellus comptés dans les deux catégories de femelles adultes.

Number of yolky oocytes	0	1	2	3	4	5	6	7	8	Total
Number of non egg-bearing specimens	17	2	21	16	14	11	15	-	1	97
Number of egg-bearing specimens	19	9	19	2	4	1	1	-	-	55
Total	36	11	40	18	18	12	16	-	1	152

Table 5. *Raja miraletus*. Measurements carried out on 28 egg cases removed from adult females from the coast of Senegal. A comparison is carried out with egg cases removed from adult females caught in the Gulf of Tunis (northern Tunisia).

Tableau 5. *Raja miraletus*. Mesures réalisées sur 28 œufs encapsulés retirés de femelles adultes de la côte du Sénégal. Une comparaison est réalisée avec des œufs encapsulés retirés de femelles adultes prises dans le golfe de Tunis (Tunisie septentrionale).

Measurements	Coast of Senegal		Gulf of Tunis	
	Range	Mean	Range	Mean
Length with horns (mm)	88-97	92.1 ± 2.9	-	-
Length without horns (mm)	48-52	50.4 ± 1.1	42-47	4.5 ± 1.1
Width (mm)	28-32	30.3 ± 1.1	27-32	3.02 ± 0.9
Mass (g)	8.7-9.9	9.3 ± 0.4	4.9-6.0	5.9 ± 0.4

Table 6. *Raja miraletus*. Estimation of the average number of egg cases laid by a mature female following the method of Holden (1975).

Tableau 6. *Raja miraletus*. Estimation du nombre moyen d'œufs encapsulés déposés par une femelle adulte d'après la méthode de Holden (1975).

Month	Egg capsule and rate of laying			
	Proportion with capsules	Relative proportion	Days	Number of eggs laid
Jan.	0.30	0.41	31	12.7
Feb.	0.40	0.54	28	15.1
Mar.	0.54	0.73	31	22.6
Apr.	0.74	1.00	30	30.0
May	0.43	0.58	31	18.0
Jun.	0.20	0.27	30	8.1
Jul.	0.00	0.00	31	0.00
Aug.	0.00	0.00	31	0.00
Sep.	0.00	0.00	30	0.00
Oct.	0.00	0.00	31	0.00
Nov.	0.71	0.96	30	28.8
Dec.	0.14	0.19	31	5.9
Total				141.2

Fecundity estimation

Production of egg cases was maximum in April (= 0.74, see Table 6), corresponding to a rate of one egg case laid per day, then the rate per month will be proportional to the occurrence of egg cases in each month relative to April, multiplied by the number of days in each month. This will give a total of 141 egg cases produced during one year by *R. miraletus* from the coast of Senegal. Capapé & Quignard (1975) suggested that one egg case was produced per day by *R. miraletus* from the Gulf of Tunis. If we considered that similar rate could be applied for Senegalese specimens, a total of 71 is produced during one year.

Monthly counts of maximum number of yellow oocytes counted per month according to size range ranged between 48 and 153 (Table 7). The mean counts per month were added and provided a fecundity maximum that could reach 178 (Table 7).

Discussion

Although specimens were generally discarded at sea by fishermen, our *Raja miraletus* samples were rather important in size and showed that the species practically occurred throughout the year in the area. Occurrence of egg-bearing females in spring and in early summer could explain that captures were relatively abundant in this period of the year. However, decreasing of captures in late summer and in early autumn could be also due to migration towards deeper areas until 150 m (Séret & Opic, 1990).

Off the coast of Senegal, male *R. miraletus* matured between 270 and 300 mm DW and females between 310 and 330 mm DW, consequently the former attained a smaller maximal size. This constitutes a new instance of sexual dimorphism in size in elasmobranch species (Mellinger, 1989; Capapé et al., 2004b). Similar patterns were observed for specimens from the Gulf of Tunis (northern Tunisia), the Bahiret El Biban (hyperhaline lagoon close to the Gulf of Gabès, in southern Tunisia) and the Adriatic Sea (see Table 8) and also, for other oviparous and viviparous elasmobranch species from different areas (Capapé et al., 2004b). In contrast, Braccini and Chiaramonte (2002) noted than male *Psammobatis extenta* (Garman, 1913) from off Argentina were slightly larger than females, moreover, Mellinger (1989) and Capapé et al. (2004b) reported similar data for scyliorhinid species.

R. miraletus from the coast of Senegal are larger than specimens from other Mediterranean areas, because they belong to different populations. Such phenomenon is related to fact that off Senegal, *R. miraletus* live in opened areas, more than in the Mediterranean; the smallest *R. miraletus* observed were from the Bahirat El Biban which is a very restricted area (Guélorget et al., 1982; Capapé et al., 2004a). Moreover, egg cases of Senegalese *R. miraletus* were larger than those recorded for Tunisian specimens. Mellinger et al. (1984) noted that the phenomenon could be due to fact that smaller specimens produced smaller egg cases.

Vitellogenic activity occurred throughout year, with a peak in spring from March to June, concomitant to production of egg cases. However, a second spawning period appeared in early autumn and winter, but this phenomenon is not supported by sufficient data. Capapé & Quignard (1974) delineated a permanent spawning period for

Table 7. *Raja miraletus*. Monthly estimation of maximum number of yolky oocytes counted in adult female per size range (disc width in mm).

Tableau 7. *Raja miraletus*. Estimation mensuelle du nombre maximum d'ovocytes chargés en vitellus comptés chez les femelles adultes par taille (largeur discale en mm).

Months	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
310-335	17	16	16	14	15	6	10	10	-	-	14	10	128
340-350	-	-	18	15	19	16	-	19	16	-	16	16	135
351-360	15	14	16	16	14	15	-	-	18	16	14	15	153
362-370	-	15	-	-	14	15	-	-	14	16	-	16	90
380-395	-	-	-	-	16	16	-	-	-	-	-	16	48
Mean	16	15	16.7	15	15.6	13.6	10	14.5	16	16	14.7	14.6	177.7

Table 8. *Raja miraletus*. Sizes at sexual maturity and maximal sizes observed from different marine areas.

Tableau 8. *Raja miraletus*. Taille de première maturité sexuelle et tailles maximales observées en différentes régions marines.

Size at sexual maturity (mm)		Maximal size (mm)		Area	Authors
Males	Females	Males	Females		
-	-	242	288	Malta, off Naples	Clark (1926)
-	-	250	280	North Adriatic	Zupanovic (1961)
220	220	240	240	Adriatic Sea	Jardas (1973)
220	240	320	330	Gulf of Tunis	Capapé and Quignard (1974)
220	240	-	-	Bahiret El Biban	Capapé et al. (2004a)
270-300	310	380	415	Coast of Senegal	Present study

Tunisian *R. miraletus*, which increased from March-April and attained a peak in summer. Similar patterns were noted for specimens from western African coast (Séret & Opic, 1990), Algeria (Dieuzeide et al., 1953) and Adriatic Sea (Zupanovic, 1961). Seasonal changes of vitellogenic activity in oviparous elasmobranchs were observed in several species such as scyliorhinids, *Scyliorhinus canicula* (Linnaeus, 1758) from the coast of Tunisia (Capapé, 1977a) and British Seas (Ellis & Shackley, 1997) and Tunisian *S. stellaris* (Linnaeus, 1758) (Capapé, 1977b) and rajids, *R. clavata* and *R. asterias* (Delaroche, 1809) from the coast of Tunisia (Capapé, 1976, 1977c) and *P. extenta* from off Argentina (Braccini & Chiaramonte, 2002).

Females were heavier than males as a consequence of gonad mass which generally developed a high vitellogenic activity and produced large and heavy yellow oocytes while oviducal glands produced egg cases (Fig. 6, Table 2). Moreover, relationship liver mass *vs* disc width showed significant differences between males and females, this suggests that liver play an important role in life cycle of the latter. However, Bone & Roberts (1969) and Baldridge (1970 & 1972) showed the role of liver in buoyancy for some elasmobranch species, especially for both deep sea and pelagic sharks. Braccini & Chiaramonte (2002) suggested "that bottom dwelling elasmobranchs required little static lift and hence the liver would not play such a very significant role in buyoancy". Liver accumulated hepatic lipids for metabolic functions such as gonadic products, this phenomenon is more evident in females during vitellogenesis and egg cases production.

R. miraletus is a serial spawner (*sensu* Holden, 1975), as other oviparous elasmobranch species, and a reproductive cycle could not be clearly estimated. Holden (1975) noted that rate of egg laying attained by the thornback ray, *R. clavata* kept in aquaria was one egg case per day and this rate was constant during 26 days. Capapé & Quignard (1975) noted the rate of egg cases produced by *R. miraletus* kept in aquaria was one egg case every two days, this rate was constant during 10 days, stopped during a week approximately and started again during some days then the specimen died. However, rate of egg cases for specimens in captivity and for those in wild environment are probably different. So, the two rates of egg cases production remained possible hypothesis. Moreover, egg cases production is related to oocytes production and vitellogenesis that were probably permanent, but submitted to changes all year round. A large range of fecundity estimation between 71 and 178 could be a suitable hypothesis.

Locally considered as by-catch species, the distribution of *R. miraletus* population structures could not be assessed, however similar proportions of males and females in each category of specimens and the relative high proportions of both adult males and females suggests that a sustainable population was probably established in the area.

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