Reproductive biology of the common torpedo, *Torpedo torpedo* (Linnaeus, 1758) (Pisces, Torpedinidae) from the coast of Senegal (Eastern Tropical Atlantic)

C. Capapé, A. A. Seck & Y. Diatta

Capapé, C., Seck, A. A. & Diatta, Y., 2000. Reproductive biology of the common torpedo, *Torpedo torpedo* (Linnaeus, 1758) (Pisces, Torpedinidae) from the coast of Senegal (Eastern Tropical Atlantic). *Misc. Zool.*, 23.1: 9-21.

Reproductive biology of the common torpedo, Torpedo torpedo *(Linnaeus, 1758) (Pisces, Torpedinidae) from the coast of Senegal (Eastern Tropical Atlantic).*– Among the five species of genus *Torpedo* recorded from the coast of Senegal, the common torpedo, *Torpedo torpedo* is that most commonly caught in the area. Adult males and females studied were over 300 mm and 310 mm total length (TL), respectively, with the largest male and the largest female recorded being 445 mm and 550 mm TL respectively. Size at birth was between 102 and 125 mm TL (mean 112.12 mm; s.e.m. 5.58). Weight of eggs ranged from 6.2 to 8.0 g (mean: 7.07; s.e.m. 0.5). Gestation lasts longer, from 6 to 8 months, than in the Mediterranean specimens. A calculated chemical balance of development based on mean dry weights of the fully developed fetuses and ripe oocytes was 1.58 for *T. torpedo*. This value shows that this torpedinid is not a pure lecithotrophic species, and the role of the mother during gestation is not negligible. The fecundity (s.l.) of *T. torpedo* ranges from 5 to 28 in Senegalese specimens as compared to 1 to 9 in Mediterranean specimens. Male embryos and fully developed fetuses are more numerous than females. Among the free-living specimens, number of males and females is practically the same. The common torpedos from the coast of Senegal are larger and the eggs are heavier than Mediterranean specimens.

Key words: Pisces, Torpedinidae, *Torpedo torpedo*, Reproductive biology, Senegal, Eastern Tropical Atlantic.

(Rebut: 28 XII 99; Acceptació condicional: 27 III 00; Acc. definitiva: 20 VI 00)

Christian Capapé, Laboratoire d'Ichtyologie, Université Montpellier II, Sciences et Techniques du Languedoc, 34095 Montpellier cedex 05, France (France).- A. A. Seck, Institut fondamental d'Afrique noire Cheikh Anta Diop, Musée de la Mer, Gorée, Sénégal (Senegal).- Y. Diatta, Département de Biologie animale, Faculté des Sciences et Techniques, Université Cheikh Anta Diop, BP 5005, Dakar, Sénégal (Senegal).

ISSN: 0211-6529

Introduction

According to Cadenat (1950) and Capapé & Desoutter (1990), five species of genus *Torpedo* have been recorded from the coast of Senegal (eastern tropical Atlantic): the common torpedo, *Torpedo torpedo*; the marbled torpedo, *T. marmorata*; the Bauchot's torpedo ray *T. bauchotae*; the electric ray, *T. nobiliana* and the McKay's torpedo ray *T. mackayana*.

Among these species, *T. torpedo* is currently caught in this marine locality but little is known about its reproductive biology. Only scarce information was summarized by Capapé et al. (1995). New records of specimens in the marine area allow us to expand these previous data. In this paper, we also give details on size at sexual maturity, size at birth, reproduction, fecundity and sex-ratio of the common torpedo. These data are compared and contrasted with other data previously provided by Quignard (1973) and Quignard & Capapé (1974) from specimens caught off the Tunisian coasts (Central Mediterranean).

Material and methods

The torpedinids were caught off the Cape Verde Peninsula in commercial gill-nets from 1994 to 1998. A total of 183 specimens were observed, including 91 males and 92 females. The specimens were generally captured by demersal gill-nets and by anglers, in the shallow coastal waters at a depth of 80 m to a maximum, on sandy and/or muddy bottoms, but rarely among macroalgae. They were landed at the fishing site of Ouakam, 5 km from Dakar, where they were examined (fig. 1).

The month of collection, the sex and condition of the observed specimens are described in table 1. In addition, 152 embryos and 81 fetuses were studied. Embryos still had an umbilical stalk and a yolk stalk. These features were completely reabsorbed in fully developed fetuses, and a scar marked the site of the umbilical stalk.

T. torpedo is caught all year round, but adult individuals of both sexes are most frequently captured from March to October.

The specimens were measured to the nearest millimetre for total length (TL). Specimens from the observed sample were weighed to the nearest gram. Measurements also included clasper length (CL, mm) from the forward rim of the pelvic girdle to the tip of the claspers according to Collenot (1969), and diameter or length and weight to the nearest decigram for oocytes, eggs, embryos and fetuses. Developing oocytes were measured while they were still in the ovaries, whilst ripe oocytes were removed from the ovaries and undevelopped eggs, embryos and fetuses were removed from the uteri, then counted, measured and weighed. Fetuses and also embryos were sexed whenever possible.

The onset of sexual maturity was determined when possible by the relationship between clasper length and total length. The linear regression was expressed in decimal logarithmic coordinates. Correlations were assessed by least-squares regression. According to Bass et al. (1975) and Stevens & Lyle (1989), the claspers of juvenile males are short and flexible. Males are considered to be mature when the claspers are elongated and calcified. These features were verified in torpedinids to avoid underestimation of size at maturity.

Size of females at sexual maturity was determined from the condition of the ovaries and the morphology of the reproductive tract. Three categories of females were considered: juveniles, having small whitish ovaries with oocytes of microscopic size, membranous oviducts and inconspicuous nidamental glands; subadults with ovaries showing translucent oocytes and a differentiated genital duct; and adults having functional ovaries with yellow-yolked oocytes and a fully developed genital duct.

To investigate the embryonic development and the role of the mother during gestation, a chemical balance of development (CBD) was considered. CBD is based on the mean dry weight of fertilized eggs and fully developed fetuses. CBD can be computed as the mean dry weight of fully developed fetuses divided by the mean dry weight of fertilized eggs. Water content of 50% in ova and 75% in fully developped fetuses can be taken as standard values, based on chemical analyses of the small-spotted catshark, *Scyliorhinus canicula*, by Mellinger & Wrisez (1989). CBD is a tentative estimate.

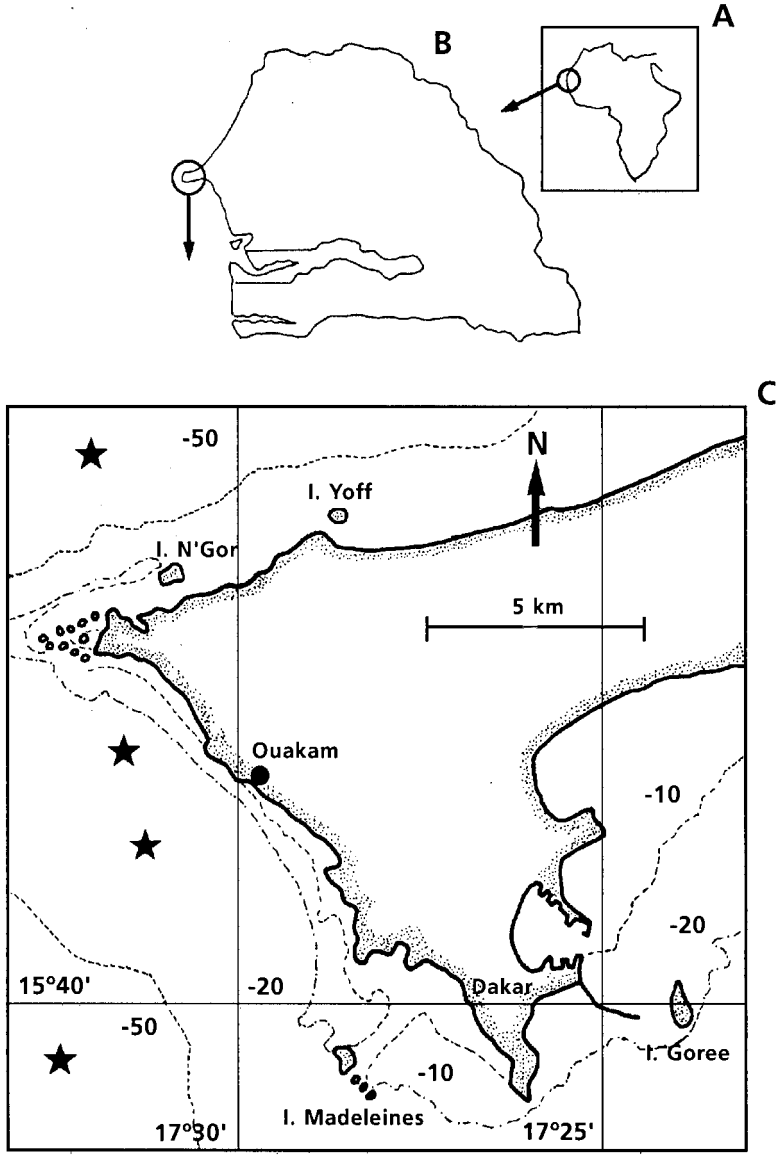

Fig. 1. A. Map of Africa marking Senegal; B. Map of Senegal pointing out the Cape Verde peninsula; C. Western part of the Cape Verde peninsula (redrawn from Sourie, 1954) showing the fishing site of Ouakam and the fishing areas of the three torpedinids (black stars).

A. Mapa de África indicando Senegal. B. Mapa de Senegal con la península de Cabo Verde señalada; C. Parte oeste de la península de Cabo Verde (obtenido en Sourie, 1954) mostrando Ouakam, lugar de pesca y las áreas de pesca de los tres torpedínidos (estrellas negras).

Table 1. Monthly collection of *Torpedo torpedo* caught off the coast of Senegal. *Recolección mensual de* Torpedo torpedo *capturados frente a la costa de Senegal.*

	Months												
	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
Males													
Newborn	-	-	-	-	-	-	-	-	6	10	-	-	16
Juvenile	2	3	6	-	1	4	6	2	-	2	-	-	26
Subadult	-	3	3	2	1	1	1	2	-	-	-	-	13
Adult	-	3	9	7	8	3	2	3	1	-	-	-	36
Total	2	9	18	9	10	8	9	7	7	12	-	-	91
Females													
Newborn	-	-	-	-	-	-	-	-	2	8	-	-	10
Juvenile	2	2	3	4	6	2	1	-	-	-	-	-	20
Subadult	2	1	3	6	5	-	1	-	-	-	-	-	18
Adult	2	2	3	12	5	3	4	3	3	2	1	4	44
Total	6	5	9	22	16	5	6	3	5	10	1	4	92
	8	14	27	31	26	13	15	10	12	22	1	4	183

Results

Onset of sexual maturity

Males

The CL to TL relationship (fig. 2) shows two inflexions indicating the three stages of sexual development in males. The first stage includes the juveniles and the relationship is:

$$\log [CL] = 0.764 \log TL - 0.143$$
$$n = 26,\ r = 0.899$$

The second stage concerns the subadults with:

$$\log [CL] = 2.049 \log TL - 3.169$$
$$n = 13,\ r = 0.982$$

The third phase concerns the adults, with:

$$\log [CL] = 0.625 \log TL + 0.067$$
$$n = 19,\ r = 0.968$$

According to these relations, the claspers grew fastest during the second stage. Juveniles and adults had short, uncalcified flexible claspers. Those of adults were elongated, calcified, rigid and functional. The third relation shows that they grew allometrically throughout life. All the males having over 300 mm TL were adult. The largest male was 445 mm TL and weighed 1,400 g.

Females

The smallest mature female which also was the smallest gravid female was 310 mm in length. Among the adults, 19 were non-gravid and 25 were gravid. Among the former, 11 had developing oocytes in their ovari, 7 had ripe oocytes, and one specimen, which was probably in a quiescent phase, did not exhibit any vitellogenetic activity. Of the 25 gravid females, 10 possessed fertilized eggs or ova in their uteri, 10 had early-stage embryos and 5 presented fully developed fetuses. Females over 500 mm TL were often captured. The largest female was 550 mm TL and weighed 2,305 g.

Reproduction

The common torpedo is an aplacental viviparous species. The two ovaries and the

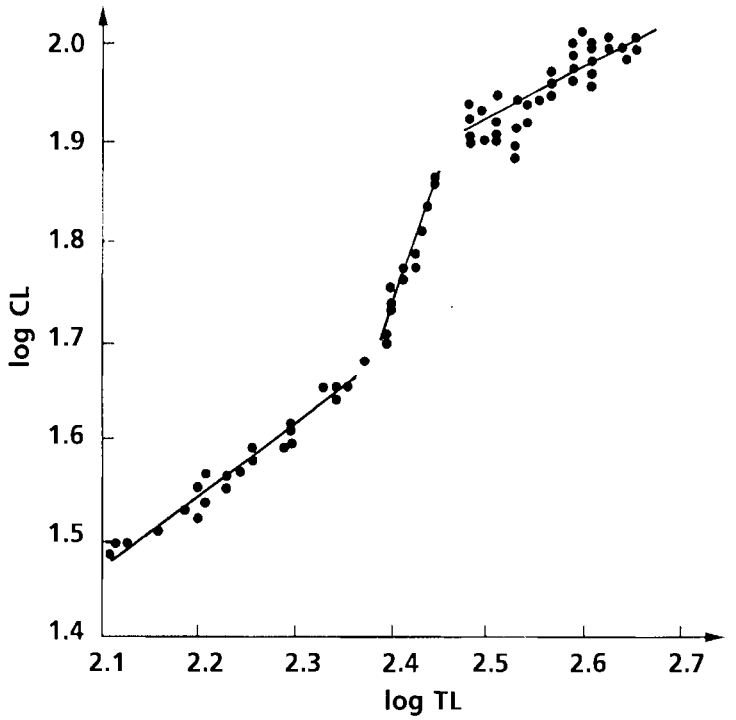

Fig. 2. Clasper length (CL) versus total length (TL) in male *Torpedo torpedo* expressed in decimal logarithmic co-ordinates.

Longitud de los apéndices copuladores en relación con la longitud total (TL) en un macho de Torpedo torpedo *expresado en coordenadas de logaritmo decimal.*

two uteri are both functional. The ovaries produced cohorts of oocytes similar in size and in weight. One of these cohorts developed into ripe oocytes, the other oocytes degenerated. The diameter and the weight of ripe oocytes ready to be ovulated increased as the size of the female grew (table 2). However, these oocytes features reduced as the number of oocytes increased. This was also the case for fertilized eggs found in the uteri (table 3).

Table 4 reveals that all the pregnant females were caught from April to October. Females with oocytes and with fertilized eggs in their uteri were captured in April and in May and females with fully developed fetuses in September and in October. These observations suggest that gestation begins in spring and ends in late summer and early autumn. Gestation probably lasts from a minimum of 6 months to a maximum of 8 months.

During gestation the ovaries were in a resting phase. In contrast, 14 adult females exhibited a phase of active vitellogenic activity with developing or ripe oocytes in their ovaries, whilst their uteri were in a resting phase. Vitellogenetic activity lasted approximatively six months and the complete reproductive cycle did not exceed one year.

Developing and ripe oocytes were slightly more numerous in the left ovary than in the right. The opposite was observed for eggs, embryos or fetuses. In a single specimen,

Table 2. Oocytes features according to total length (TL, mm) in adult female *Torpedo torpedo* from the coast of Senegal.

Características de los oocitos en función de la longitud total (TL, mm) en hembras adultas de Torpedo torpedo *de la costa de Senegal.*

		Diameter (mm)			Weight (g)		
TL	N	Range	Mean	s.e.m.	Range	Mean	s.e.m.
350	15	23-25	24.13	0.99	4.1-4.6	4.26	0.14
395	16	24-27	24.75	0.77	4.8-5.1	4.92	0.13
400	14	25-28	26.35	1.50	5.5-5.8	5.64	0.12
440	14	26-28	27.14	0.53	5.4-6.1	5.70	0.27
450	14	26-28	26.42	0.75	5.6-5.8	5.70	0.07
450	18	24-26	24.94	0.80	5.3-5.5	5.40	0.08
460	20	24-26	25.00	0.72	5.2-5.5	5.28	0.08

Table 3. Weight and number of eggs versus total length (TL, mm) in adult female *Torpedo torpedo* from the coast of Senegal.

Peso y número de huevos en función de la longitud total (TL, mm) en hembras adultas de Torpedo torpedo *de la costa de Senegal.*

		Weight (g)		
TL	N	Range	Mean	s.e.m.
310	5	3.4-3.6	3.44	0.15
330	10	3.2-4.1	3.84	0.32
350	7	4.3-4.8	4.47	0.14
360	12	3.7-4.5	4.21	0.29
390	12	4.4-5.4	4.78	0.35
400	14	4.9-5.3	5.13	0.15
410	11	7.9-9.4	8.57	0.43
460	15	5.5-6.4	5.99	0.30
480	15	5.7-6.3	6.16	0.22
510	17	6.2-8.0	7.07	0.53

these features were equally distributed in each uterus. In all cases, the weight of fully developed fetuses was significantly higher that the weight of the fertilized ovum (t-test, $P < 0.05$).

Eggs, embryos and fetuses were not encapsulated but were free in the uteri. Throughout gestation, the uterine contents were protected by a jelly-like structure.

Size at birth

The total length of 76 fully developed fetuses ranged from 100 mm to 125 mm ($\bar{x}$ = 112.13 mm; s.e.m. 5.58). Twenty-six individuals, 16 males and 10 females were collected by scuba divers in shore waters between 5 and 10 m depth, during September and October. They exhibited an unhealed scar on their ventral face and a conspicuous internal vitelline vesicle. These specimens were probably the young of the year. The smallest free living specimens observed ranged from 102 mm to 118 mm.

Chemical balance of development

Fresh weights of the 17 largest ova ranged from 6.2 g to 8.0 g ($\bar{x}$ = 7.07, s.e.m. 0.53) and of 81 fully developed fetuses from

Table 4. Reproductive cycle of female *Torpedo torpedo*, condition of ovaries and uteri during gestation: M. Month of capture; N. Number of females; F. Size range of females (TL, mm); Ova. Ovarian activity; Ooc. Oocyte condition; Ood. Oocyte diameter range (mm); Uc. Uteri content; Ucl. Uteri content lenght range (TL, mm).

Ciclo reproductor de la hembra de Torpedo torpedo, *estado de los ovarios y útero durante la gestación: M. Mes de captura; N. Número de hembras; F. Variación de la talla de las hembras (TL, mm); Ova. Actividad ovárica; Ooc. Desarrollo de los oocitos; Ood. Variación del diámetro de los oocitos (mm); Uc. Contenido del útero; Ucl. Variación de la longitud del contenido del útero (TL, mm).*

M	N	F	Ova	Ooc	Ood	Uc	Ucl
January	2	345-455	vitellogenesis	developing	15-18	resting	-
February	2	325-335	vitellogenesis	developing	17-20	resting	-
March	3	420-450	vitellogenesis	developing	20-21	resting	-
April	7	350-360	vitellogenesis	ripe	23-28	resting	-
	5	310-410	resting	-	-	eggs	-
May	5	310-410	resting	-	-	eggs	-
June	3	390-550	resting	-	-	embryos	21-27
July	4	340-505	resting	-	-	embryos	35-44
August	2	480-500	resting	-	-	embryos	55-63
	1	460	resting	-	-	embryos	75-80
September	3	415-460	resting	-	-	fetuses	102-115
October	2	510-525	resting	-	-	fetuses	105-115
November	1	420	resting	-	-	-	-
December	4	500-535	vitellogenesis	developing	5-9	resting	-

20.5 g to 25.5 g ($\bar{x}$ = 22.23, s.e.m. 0.87). CBD, based on mean dry weights calculated for *Torpedo torpedo*, is 1.58.

Fecundity

Ovarian fecundity (OF) was based on the number of ripe oocytes counted in 19 females, their TL ranging from 325 to 535 mm. OF ranged from 10 to 28 ($\bar{x}$ =16.84, s.e.m. 4.71). The relationship between OF and female TL was:

OF = 0.058TL - 8.395, n = 19, r = 0.053

However, uterine fecundity (UF) based on the number of fertilized eggs, embryos or fully developed fetuses was counted in 25 specimens, their TL ranging from 310 mm to 550 mm. UF ranged from 5 to 20 ($\bar{x}$ = 3.88, s.e.m. 3.53). The relationship between UF and TL is:

UF = 0.035 TL - 1.252, n = 24, r = 0.741

These two types of fecundity are correlated with females TL and they slowly increase with females size (fig. 3).

Sex ratio

Table 5 shows that among the embryos and the fully developed fetuses, males were more abundant than females. This was also true for juveniles, but was not the case for subadults and adults. The sex ratio of the uterine contents in individual females was similar to the mean sex ratio for uterine

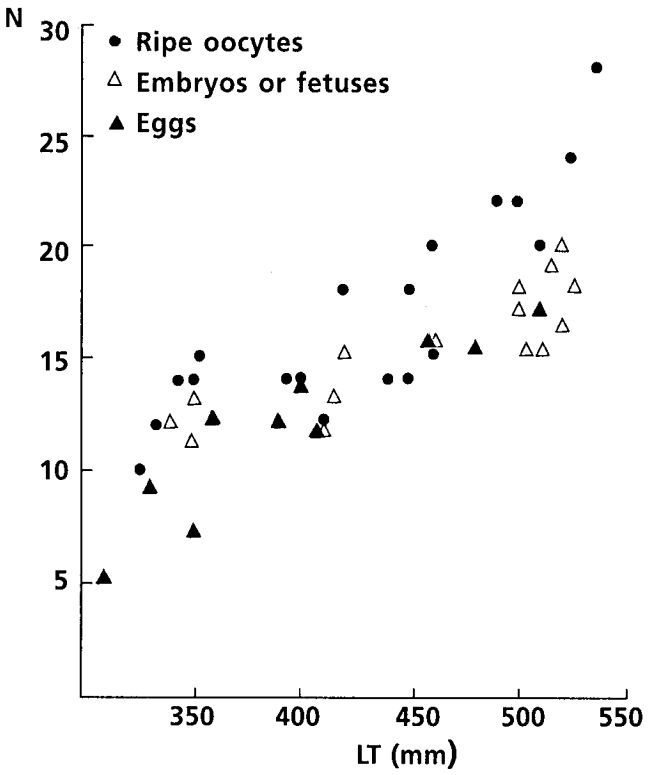

Fig. 3. Number of ripe oocytes, eggs, embryos and/or fetuses versus total length (TL, mm) in female *Torpedo torpedo*.
Número de oocitos maduros, embriones y/o fetos en relación a la longitud total (TL, mm) en hembras de Torpedo torpedo.

contents of all gravid females. Among the free-living specimens, the numbers of females and males was practically the same. In the total sample of 363 specimens, the males were significantly more abundant than the females (χ^2, $P < 0.05$) and the pooled ratio was 1.10 (♀:♂).

Discussion

The common torpedo is an Atlanto-Mediterranean species that generally prefers warm-temperate and subtropical waters. In this area, *T. torpedo* is one of the rare elasmobranch species which enters and reproduces in both hypohaline and hyperhaline lagoons and estuaries (Ben Brahim et al, 1998; Pandare et al., 1997).

Off Senegal, size at first sexual maturity was closely related in both sexes. However, the females were generally larger and heavier than the males. Off Naples, Lo Bianco (1899) noted that the smallest gravid female was 230 mm TL and the largest female was 450 mm TL. In Tunisian waters, specimens of both sexes were adults over 190 mm TL (Quignard, 1973; Quignard & Capapé, 1974). The largest male was 390 mm TL and weighed 848 g, the largest female was 410 mm TL and weighed 1,005 g, but the heaviest female weighed 1,254 g and was 390 mm in TL.

Table 5. *Torpedo torpedo* sex ratio for each category of specimens and for the total sample: N♀. Number of females; N♂. Number of males; R. Ratio (♀:♂).

Porcentaje de sexos de Torpedo torpedo *para cada categoría de individuos y para el total de la muestra: N♀. Número de hembras; N♂. Número de machos; R. Ratio (♀:♂).*

Category	N♀	N♂	R
Uterine content			
Embryos	45	58	1:1.29
Fetuses	37	44	1:1.19
Total	82	102	1:1.24
Free living specimens			
Newborns	10	16	1.1.60
Juveniles	20	26	1:1.33
Subadults	18	13	1.38:1
Adults	44	36	1.22:1
Total	92	91	1.01:1
Grand total	174	193	1:1.10

Our observations show that birth occurred when term pups were between 102 and 125 mm and weight at birth was between 20.5 and 25.5 g. Off Naples, size at birth ranged from 80 mm (Lo Bianco, 1899) to 88 mm (Ranzi, 1932). This author added that average weight at birth was 13.37 g. In Tunisian waters, Quignard & Capapé (1974) found that size at birth was between 80 and 97 mm and weight at birth between 9 and 16 g.

The intraspecific geographic variations of size and weight at birth as a function of the marine area are probably related to ova weight which in turn is subject to variation according to the marine locality (table 6).

Off Senegal, the ova weight ranged from 6.2 to 8.0 g ($\bar{x}$ = 7.07 g). Off Naples, Ranzi (1932) noted that this parameter ranged from 5.02 to 6.53 g ($\bar{x}$ = 6.34 g). In Tunisian waters, Quignard & Capapé (1974) noted that it ranged from 2 to 7 g ($\bar{x}$ = 4.182). These differences could also explain why the common torpedos from the Senegalese coast are larger than those of the Mediterranean (s.l.). That ova of heavier weight could produce specimens of greater weight and size may be concluded. These observations show that the common torpedos from Senegalese waters are on the whole larger and heavier than the Mediterranean specimens.

These intraspecific variations in size were also observed among oviparous elasmobranch species, such as the small-spotted catshark *S. canicula*. The Mediterranean specimens appear to be smaller than those of the Atlantic because they mature at a smaller size (Leloup & Olivereau, 1951; Mellinger, 1966, 1989; Collenot, 1969). Leloup & Olivereau (1951) stated that these intraspecific variations are related to environmental influences, especially light and temperature, on growth. On the contrary, Dodd (1983) emphasized that nothing is known about environmental influences on reproduction in viviparous species. It is therefore interesting to note that in a closely related torpedinid, *T. marmorata* there are no intraspecific variations in size between specimens from the Bay of Biscay (Mellinger, 1971), specimens from the Tunisian coasts (Capapé, 1979) and specimens captured off the coast of Senegal (unpublished data).

In *T. torpedo* from the Senegalese coast, as in all torpedinid species studied to date, oocytes and/or eggs, embryos, and fully developed fetuses were more numerous on the left side than on the right. Mellinger (1974) and Quignard & Capapé (1974) pointed out in *T. marmorata* and in *T. torpedo* respectively that an asymmetry of abdominal viscera exists. This morphological character is due to the fact that the right genital tract is more developed than the left.

A 6-8 months gestation period in the common torpedo off the Senegalese coast could be considered a possible hypothesis. This period was longer than that of the Mediterranean specimens which generally did not exceed four months (Lo Bianco, 1888, 1899; Ranzi, 1932; Quignard & Capapé, 1974). According to these authors, females produced their brood at the end of August in these areas. The parturition occurred during September and October off the Senegalese coast.

Table 6. Aspects of the reproductive biology of *Torpedo torpedo*. Comparison between the populations of the Tunisian coasts (QUIGNARD & CAPAPÉ, 1974) and the coasts of Senegal (this paper).

Aspectos de la biologia reproductiva de Torpedo torpedo. *Comparación entre las poblaciones de las costas de Túnez (QUIGNARD & CAPAPÉ, 1974) y las de la costa de Senegal (este trabajo).*

	Tunisian coasts		Coasts of Senegal	
Sex	males	females	males	females
Size at maturity (mm)	190	190	300	310
Maximal size (mm)	390	410	445	550
Size at birth (mm)	range	mean	range	mean
	80-97	-	102-125	112.13
Eggs weight (g)	range	mean	range	mean
	2-7	4.18	6.2-8.0	7.07
Gestation	4 months		6-8 months	
Ovarian fecuntity	range	mean	range	mean
	1-15	4.32	10-28	16.84
Uterine fecundity	range	mean	range	mean
	1-9	3.38	5-20	13.88

Vitellogenesis does not proceed in parallel with gestation. Moreover, the females exhibit a block to oocyte growth during gestation. Egg capsules are lacking. These phenomena are the rule in torpedinids according to MELLINGER (1981, 1989). They were also observed in other elasmobranch species, generally those belonging to the family Squalidae such as *Centroscymnus* spp. (YANO & TANAKA, 1988) and *Centrophorus granulosus* (CAPAPÉ, 1985) and to family Oxynotidae as *Oxynotus centrina* (CAPAPÉ et al., 1999). Consequently, the duration of the reproductive cycle remains particularly long in torpedinids whatever the species and whatever the area. The common torpedo achieves an annual reproductive cycle in both Tunisian and Senegalese waters. MELLINGER (1971) stated that the reproductive cycle of the marbled electric ray from the Bay of Biscay lasted two years at a minimum, CAPAPÉ (1979) emphasized that it probably lasted three years for the specimens from the Tunissian coasts.

CAPAPÉ et al. (1990) calculated a CBD value of 0.5 for two squatinids from the Tunisian coasts. They concluded that *Squatina* is a purely lecithrotrophic genus where the role of the mother during gestation is not important. On the other hand, the CBD of the spiny butterfly ray, *Gymnura altavela* from the same marine area, 30.6, is the highest value ever computed in elasmobranchs (CAPAPÉ et al., 1992). It is a consequence of trophonemata activity during gestation and embryonic nutrition. It gives an estimate of mother-derived organic molecules to embryonic growth. It is a case of matrotrophy according to the definitions of WOURMS (1977, 1981) and WOURMS et al. (1988). The computed CBD of the common torpedo is 1.58 according to the theoretical values given by MELLINGER & WRISEZ (1989). However, if using the data of RANZI (1932), i.e. 43% water in ova and 83% in newborns of this species, CBD should be 0.8 for specimens from Naples and 1.10 for those from Senegal. These CBD values were closely related whatever the marine locality. Both values show that *T. torpedo* is not a

pure lecithotrophic species and the role of the mother during gestation is not negligible.

Ovarian fecundity is a little higher than uterine fecundity. This phenomenon is due to the fact that some ripe oocytes were not ovulated and were degenerated. Moreover, some gravid females lost their brood when caught. Off Naples, Lo Bianco (1888) stated that common torpedos bore from 3 to 6 embryos. Moreover, in 1899, he pointed out a relation between female size and fecundity. According to Quignard & Capapé (1974), in the *T. torpedo* from the Tunisian coasts, ovarian fecundity ranged from 1 to 15 (mean 4.32) and the uterine fecundity from 1 to 9 (mean 3.38). Both types of fecundity were lower in the common torpedo from the Mediterranean than in specimens from the Senegalese coast. This is probably related to the size difference observed from specimens of these two marine localities (table 6).

The sex-ratio changes of specimens from the coast of Senegal agree with the observations of Quignard & Capapé (1974). Males embryos, fully developed fetuses and juveniles are more numerous than females. The opposite however is seen in subadults and adults. These changes in sex-ratio are not due to a higher rate of mortality in males than in the females but rather to the segregation of the sexes at different depths during certain stages of the reproductive cycle. During the breeding period, the adult females generally approach the coastal waters: numerous gravid specimens were observed in our sample, some of which were practically at the end of gestation. This phenomenon seems to be the rule among elasmobranch species (Castro, 1993; Capapé et al, 1995).

Resumen

Biología reproductiva del torpedo común Torpedo torpedo *(Linnaeus, 1758) (Pisces, Torpedinidae) de la costa de Senegal (Atlántico tropical oriental)*

Entre las cinco especies del género *Torpedo* recolectadas en las costas del Senegal, el torpedo común, *Torpedo torpedo* es el torpedínido más recolectado en esta área (fig. 1, tabla 1). Los machos (fig. 2) y hembras adultos recolectados tenían una longitud total (TL) superior a 300 mm y 310 mm respectivamente, la longitud total del macho y la hembra más largos recolectados fue de 445 mm y 550 mm respectivamente. El tamaño al nacer era entre 102 y 125 mm TL ($\bar{x}$ = 112,12 mm; s.e.m. 5,58). El peso de los huevos variaba de 6,2 a 8,0 g ($\bar{x}$ = 7,07; s.e.m. 0,5) (tablas 2, 3). La gestación dura más, de 6 a 8 meses, que en los individuos del Mediterráneo (tabla 4). Un balance químico calculado de desarrollo basado en la media del peso seco de todos los fetos completamente desarrollados y los oocitos maduros fue de 1,58 en *T. torpedo*. Este valor indica que este torpedínido no es una especie lecitotrófica pura, y que el papel de la madre durante la gestación no es negligible. La fecundidad (s.l.) de *T. torpedo* variaba entre 5 y 28 en los invididuos senegaleses y de 1 a 9 en los mediterráneos (fig. 3). Los embriones masculinos y fetos completamente desarrollados son más numerosos que los femeninos. Entre los individuos que viven libres, el número de machos y hembras es prácticamente el mismo (tabla 5). Los torpedo común de la costa del Senegal son más largos y sus huevos pesan más que en los del Mediterráneo (tabla 6).

Acknowledgements

The authors wish to thank the fishermen from the fishing site of Ouakam (Cape Verde peninsula, Senegal) who provided the material, and the two referees for their useful and helpful comments on the manuscript.

References

Bass A. J., D'Aubrey J. D. & Kistnasamy, N., 1975. Sharks of the east coast of southern Africa. III. The families Carcharhinidae (excluding *Mustelus* and *Carcharhinus*) and Sphyrnidae. *Invest! Rep. (S. Afr. Ass. mar. Biol. Res.)*, 38: 1-100.

Ben Brahim, R., Seck, A. A. & Capapé, C., 1998. Albinisme chez la torpille ocellée, *Torpedo (Torpedo) torpedo* (Linnaeus, 1758). *Cybium*, 22: 83-86.

Capapé, C., 1979. La torpille marbrée, *Torpedo marmorata* Risso, 1810 (Pisces, Rajiformes) des côtes tunisiennes: nouvelles données

sur l'Écologie et la biologie de la reproduction de l'espéce, avec une comparaison entre les populations méditerranéennes et atlantiques. *Annal. Sci. nat., Zoologie, Paris*, 13éme série, 1: 79-97.

- 1985. Nouvelle description de *Centrophorus granulosus* (Schneider, 1801) (Pisces, Squalidae). Données sur la biologie et le régime alimentaire des spécimens des côtes tunisiennes. *Bull. Inst. natn. sci. techn. Océanogr. Pêche, Salammbô*, 12: 97-141.

Capapé, C. & Desoutter, M., 1990. Torpedinidae. In: *Check-list of the Fishes of the Eastern Tropical Atlantic*, vol. 1: 55-58 (J. C. Quéro, J. C. Hureau, C. Karrer, A. Post & L. Saldanha, Eds.). UNESCO, Paris.

Capapé, C., N'Dao M., & Diop, M, 1995. Observations sur la biologie de la reproduction de quatorze espéces de Sélaciens batoïdes capturés dans la région marine de Dakar-Ouakam (Sénégal, Atlantique tropical oriental). *Bull. Ins. fond. Afr. noire Cheikh Anta Diop, Dakar, série A*, 48: 89-102.

Capapé, C., Quignard, J. P. & Mellinger, J., 1990. Reproduction and development of two angel sharks, *Squatina squatina* and *S. oculata* (Pisces: Squatinidae), off Tunisian coasts: semi-delayed vitellogenesis, lack of egg capsule and lecithotrophy. *J. Fish Biol.*, 37: 347-56.

Capapé, C., Seck, A. A. & Quignard, J. P., 1999. Aspects of the reproductive biology of the angular rough shark, *Oxynotus centrina* (Oxynotidae). *Cybium*, 23(3): 259-271.

Capapé, C., Zaouali, J., Tomasini, J. A. & Bouchereau, J. L., 1992. Reproductive biology of the spiny butterfly ray, *Gymnura altavela* (Linnaeus, 1758) (Pisces: Squatinidae) from off the Tunisian coasts. *Sci. mar.*, 56(4): 347-355.

Castro, J. I., 1993. The shark nursery of Bulls Bay, South Carolina, with a review of the shark nurseries of the southeastern coast of the United States. *Env. Biol. Fish.*, 38: 37-48.

Collenot, G., 1969. Etude biométrique de la croissance relative des ptérygopodes chez la roussette *Scyliorhinus canicula* L. *Cah. Biol. mar.*, 10: 309-29.

Dodd, J. M., 1983. Reproduction. In: *Fish Physiology, vol 1*: 31-95 (W. S. Hoar, D. J. Randall & E. M. Donaldson, Eds.). Acad. Press, New-York.

Leloup, J. & Olivereau, M., 1951. Données biométriques comparatives sur la Roussette (*Scyllium canicula* L.) de la Manche et de la Méditerranée. *Vie et Milieu*, 2: 182-206.

Lo Bianco, S., 1888. Notizie biologiche riguardante specialmente il periodo di maturità sessuale degli animali del golfo di Napoli. *Mitt. Zool. Stn. Neapel*, 8: 385-440.

- 1889. Notizie biologiche riguardante specialmente il periodo di maturitê sessuale degli animali del golfo di Napoli. *Mitt. Zool. Stn. Neapel*, 13: 448-572.

Mellinger, J., 1966. Etude biométrique et histophysiologique des relations entre les gonades, le foie et la thyroïde chez *Scyliorhinus caniculus* (L.). Contribution à l'étude des caracteres sexuels secondaires des Chondrichthyens. *Cah. Biol. mar.*, 7: 107-137.

- 1971. Croissance et reproduction de la torpille (*Torpedo marmorata*). I. Introduction. Ecologie. Croissance générale et dimorphisme sexuel. Cycle. Fecondité. *Bull. Biol. Fr. Belgique*, 105: 165-218.
- 1974. Croissance et reproduction de la torpille (*Torpedo marmorata*). III. L'appareil génital femelle. *Bull. Biol. Fr. Belgique*, 108: 107-50.
- 1981. Biologie et physiologie du développement, de la croissance et de la reproduction des torpilles: un aperçu des recherches depuis 1965. *Arch. Inst. Pasteur Tunis*, 58: 441-463.
- 1989. Reproduction et développement des Chondrichthyens. *Océanis*, 15: 283-303.

Mellinger, J. & Wrisez, J., 1989. Biologie et physiologie comparées de deux Sélaciens ovipares, les Roussettes *Scyliorhinus canicula* et *Scyliorhinus stellaris*. Evolution de la matière sèche, de l'eau et des ions (Cl^-, Na^+, K^+) dans le vitellus de *S. canicula* au cours du développement. *Bull. Soc. zool. France*, 114: 51-62.

Pandaré, D., Niang, S., Diadhiou, H. & Capdeville, B., 1997. Ichtyofauna du fleuve casamance: reproduction et distribution en fonction du gradient de salinité. *Bull. inst. fond. Afr. noire Cheikh Anta Diop., Dakar, sér. A*, 49: 167-190.

Quignard, J. P., 1973. Recherches sur la biologie d'u sélacien du golfe de Tunis, *Torpedo torpedo* (Linné, 1758) (Croissance relative, croissance absolue, coefficient de condition).

Ann. Inst. Michel Pacha, 6: 72-110.

QUIGNARD, J. P. & CAPAPÉ, C., 1974. Recherches sur la biologie d'un Sélacien du golfe de Tunis, *Torpedo torpedo* Linné, 1758 (Ecologie, sexualité, reproduction). *Bull. Inst. natn. sci. tech. Océanogr. et Péche, Salammbô*, 3: 99-129.

RANZI, S., 1932. Le basi fisio-morfologiche dello sviluppo embrionale dei Selaci. Parte I. *Pubbl. Staz. Zool. Napoli*, 12: 209-39.

SOURIE, R., 1954. Contribution à l'étude écologique des côtes rocheuses du Sénégal. *Mém. Inst. fr. Afr. noire*, 38: 1-342.

STEVENS, J. D. & LYLE, J. M., 1989. Biology of three hammerhead sharks *(Eusphyra blochii, Sphyrna mokarran* and *S. lewini)* from northern Australia. *Aust. J. Mar. Fresh. Res.*, 40: 129-146.

WOURMS J. P., 1977. Reproduction and development in chondrichthyan fishes. *Am. Zool.*, 17: 379-410.

- 1981. Viviparity: the maternal-fetal relationship in fishes. *Am. Zool*, 21: 473-515.

WOURMS J. P., GROOVE J. P. & J. LOMBARDI, J., 1988. The maternal-emrelationship in viviparous fishes. In: *Fish Physiology*, vol 1: 1-134 (W. S. Hoar, D. J. Randall & E. M. Donaldson, Eds.). Acad. Press, New York.

YANO, K. & TANAKA, S. 1988. Size at maturity, reproduction cycle, fecundity and depth segregation of the deep sea squaloid sharks *Centroscymnus owstoni* and *C. coelolepis*. *Nippon Suisan Gakkaishi*, 54: 167-174.