

## BIOLOGICAL OBSERVATIONS ON THE BLACK TORPEDO, *TORPEDO NOBILIANA* BONAPARTE 1835 (CHONDRICHTHYES: TORPEDINIDAE), FROM TWO MEDITERRANEAN AREAS

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### ABSTRACT

Reproduction of the black torpedo *Torpedo nobiliana* is presented in this article on the basis of specimens captured off Tunisia (Central Mediterranean) and off the coast of Languedoc (southern France, northern Mediterranean). The smallest adult male and adult female were 550 mm and 900 mm total length (TL), respectively, and weighed 3,120 and 9,850 g, respectively. The largest male and the largest female were 770 and 1,200 mm TL and weighed 4,890 g and 25,500 g, respectively. The total mass versus total length relationships showed significant differences between males and females. Birth probably occurred at a mean TL of 185 mm  $\pm$  12.8 and a mean mass of 167.5 g  $\pm$  17.6. Both ovaries and both uteri were functional. The diameter of twenty-two yolky oocytes ready to be ovulated ranged between 32 and 38 mm (mean: 35.0  $\pm$  2.1), and their mass between 8.7 and 10.5 g (mean: 9.6 g  $\pm$  0.5). CBD based on mean dry masses calculated for *T. nobiliana* was # 8.7, and showed that it was probably an incipient histotrophic species. Gestation lasted for about a year, but oocyte growth is delayed during gestation. A biennial reproductive cycle remains a suitable hypothesis. Ovarian fecundity was related with female size. The juvenile males slightly outnumbered the female ones, and among the adults, females slightly outnumbered males. However, males and females were equally distributed in the total sample.

**Key words:** *Torpedinidae*, *Torpedo nobiliana*, reproductive biology, Tunisia, southern France, Mediterranean

## OSSERVAZIONI BIOLOGICHE SU TORPEDINE NERA, *TORPEDO NOBILIANA* BONAPARTE 1835 (CHONDRICHTHYES: TORPEDINIDAE), IN DUE AREE MEDITERRANEE

### SINTESI

L'articolo presenta alcuni dati inerenti la biologia riproduttiva di esemplari di torpedine nera, *Torpedo nobiliana*, catturati al largo della Tunisia (Mediterraneo centrale) e al largo della costa di Languedoc (Francia meridionale, Mediterraneo settentrionale). La lunghezza totale (TL) del maschio adulto più piccolo è risultata pari a 550 mm, per 3.120 g di peso. La femmina adulta più piccola misurava 900 mm, per 9.850 g di peso. Il maschio più grande misurava 770 mm, per 4.890 g. di peso. La femmina più grande era lunga 1.200 mm, per 25.500 g di peso. Il rapporto fra massa totale e lunghezza totale evidenzia differenze significative fra maschi e femmine. Le femmine raggiungono la maturità sessuale ad una lunghezza totale pari a 185 mm  $\pm$  12,8, con una massa media di 167.5 g  $\pm$  17,6. A tale stadio entrambe le ovaie e tutti e due gli uteri risultano funzionali. Il diametro di ventidue oociti vitellini, pronti per essere ovulati, è risultato compreso fra 32 e 38 mm (media: 35,0  $\pm$  2,1), per una massa compresa fra 8,7 e 10,5 g (media: 9,6 g  $\pm$  0,5). Il CBD, calcolato in base alla media delle masse secche, è risultato pari a # 8,7. La durata della gestazione è di circa un anno, ma la crescita degli oociti viene ritardata durante la gravidanza. Viene pertanto ipotizzato un ciclo riproduttivo biennale. La fertilità è stata messa in relazione alla grandezza della femmina. I giovani esemplari maschi superano di poco in numero le femmine; fra gli adulti sono leggermente più numerose le femmine. All'interno del campione però le femmine ed i maschi risultano uniformemente distribuiti.

**Parole chiave:** *Torpedinidae*, *Torpedo nobiliana*, biologia riproduttiva, Tunisia, Francia meridionale, Mediterraneo

## INTRODUCTION

According to Capapé (1989), five torpedinid species occur in the Mediterranean Sea: the Alexandrine torpedo *Torpedo alexandrinsis* Mazhar, 1987, the black-spotted torpedo *Torpedo fuscomaculata* Peters, 1855, the marbled torpedo *Torpedo marmorata* Risso, 1810, the black torpedo *Torpedo nobiliana* Bonaparte, 1835, and the common torpedo *Torpedo torpedo* (Linnaeus, 1758). However, the occurrence of *T. fuscomaculata* requires further observations, whereas the status of *T. alexandrinsis* as a valid species still needs to be confirmed (see Quignard & Tomasini, 2000).

*T. nobiliana* is rarely landed, although, it used to be widely distributed and reported on both sides of the Atlantic (Bigelow & Schroeder, 1953). Off the western Atlantic shore, Bigelow & Schroeder (1953) reported on the species from New Scotland to Cuba. Off the eastern Atlantic shore, *T. nobiliana* was reported by Muus & Dahlström (1964–1966), from the North Sea and around the British Isles by Wheeler (1969), southward from the Bay of Biscay by Bauchot & Pras (1980), while Quéro *et al.* (1976) suggested that two relative close species occurred in the area, although this opinion still needs further confirmation. Albuquerque (1954–1956) reported on the occurrence of *T. nobiliana* off Portugal. South of the Strait of Gibraltar, *T. nobiliana* was recorded off Morocco by Collignon & Aloncle (1972), southward its occurrence remained doubtful; according to Capapé & Desoutter (1980) and Capapé *et al.* (2001b), it was probably replaced by the ringed torpedo, *Torpedo mackayana* Metzelaar, 1919. In contrast, Smith & Heemstra (1986) reported on the species from off the South African coast.

In the Mediterranean, *T. nobiliana* occurred off the coasts of its western basin (Capapé & Desoutter, 1980), in its eastern basin off Greece (Economidis, 1973) and Turkey (Kabasakal, 2002), whereas the species' eastern-most border has been the Levantine basin (Golani, 1996, 2005).

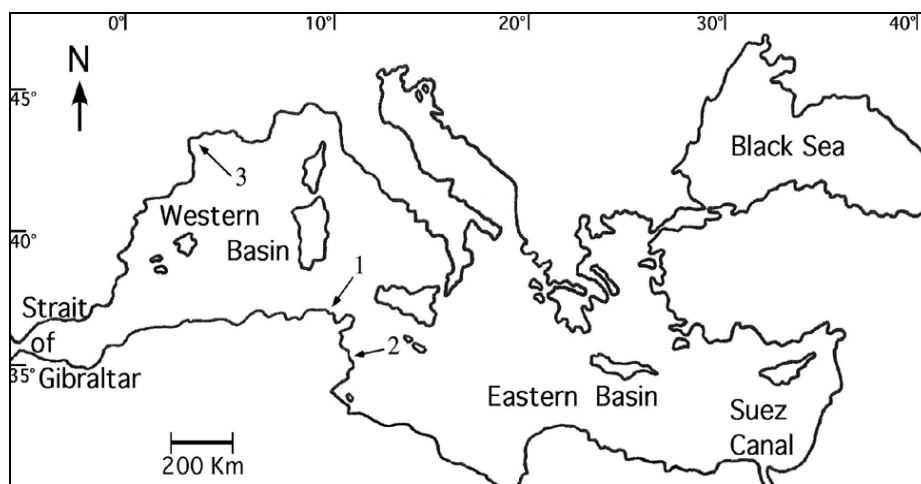
Capapé (1974) provided biological data and Capapé & Desoutter (1980) morphological description from the specimens collected off the northern coast of Tunisia. Additional records from this area and others from the coast of Languedoc (southern France) may increase the knowledge of this species with special regard to its reproductive biology.

## MATERIAL AND METHODS

The observed electric rays were collected in two Mediterranean areas: off the northern coast of Tunisia in the southern Mediterranean (Figs. 1 & 2), and off the coast of Languedoc, northern Mediterranean (Figs. 1 & 3).

In the first area, the investigations were conducted between 1970 and 1985: 72 specimens were captured off the northern coast of Tunisia by trawl at depths ranging from 50 to 400 m, down to 500 m at the level of the Bank of Esquerquis on sandy and muddy bottoms, while some among them were recorded on board the oceanographic trawlers 'Dauphin' and 'Hannoun'.

In the second area, the investigations were conducted between 1988 and 2005 off the coast of Languedoc: 8 specimens were collected at depths between 80 and 200 m on sandy and muddy bottoms by trawl. The monthly collection of all the observed specimens is presented in Table 1.



**Fig. 1:** Map of the Mediterranean Sea with the investigation areas: arrow 1 – northern coast of Tunisia, arrow 2 – southern coast of Tunisia, arrow 3 – coast of Languedoc.

**Sl. 1:** Zemljevid Sredozemskega morja z raziskanimi območji: puščica 1 – severno tunizijsko obrežje, puščica 2 – južno tunizijsko obrežje, puščica 3 – obrežje Languedoca.

The specimens were measured to the nearest millimetre for total length (TL) following Bass *et al.* (1973) and weighed to the nearest gram, when possible. Measurements comprised clasper length (CL, mm) according to Collenot (1969), and the diameter of yolky oocytes probably ready to be ovulated and developing oocytes. When possible, both categories of oocytes were removed from the ovaries and weighed to the nearest decigram.

The onset of sexual maturity was determined by the relationship between CL vs. TL. Bass *et al.* (1973) noted that claspers of juveniles were short and flexible, adding that males were adult when claspers were rigid, elongated and calcified. In addition, some aspects of the testes and the genital organs are described. Size of females at sexual maturity was determined from the condition of ovaries and the morphology of the reproductive tract. Two categories of specimens were distinguished for males and females: juvenile and adult.

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 mass of fertilized eggs and fully developed embryos. CBD can be computed as the mean dry mass

of near term embryos and/or neonates divided by the mean dry mass of yellow yolky oocytes or eggs. CBD is a tentative estimate.

In the size mass-total length relationship, comparisons of curves were made by ANCOVA. Tests for significance ( $p < 0.05$ ) were performed by using ANOVA t-test and chi-square test.

## RESULTS

### Size at sexual maturity

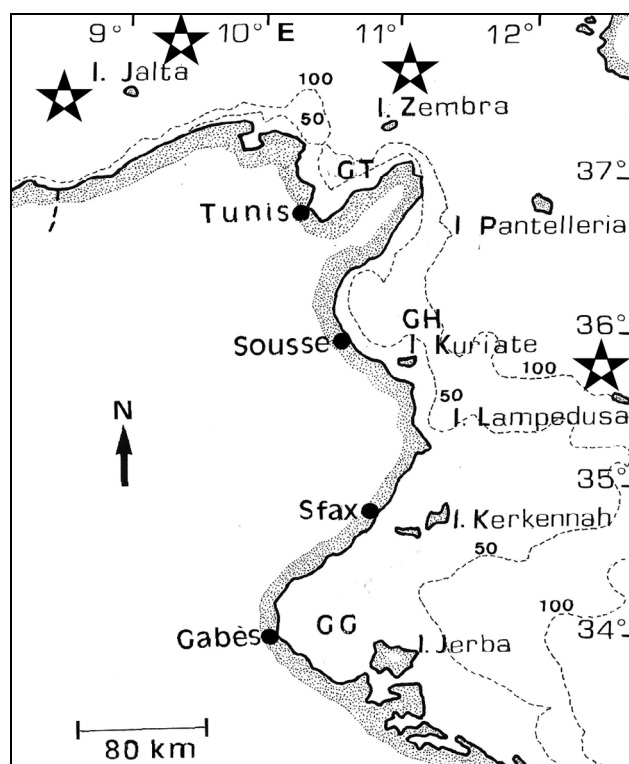
#### Males

During the juvenile stage, the males had short and flexible claspers and both testes and genital duct were membranous and undeveloped. This stage comprised 27 males, ranging between 170 and 770 mm TL. Among the juveniles, the 3 smallest specimens showed on dorsal surface an unhealed umbilical scar and a residual internal umbilical vesicle (remains of yolk absorbed and partially digested). They were probably neonates or aborted embryos, ranging from 170 to 220 mm TL and weighing between 150 and 246 g. Some specimens were caught throughout the year except in March, April and June, with a peak observed in January (Tab. 1).

During the adult stage, the claspers were rigid, elongated and calcified. The testes were developed, with spermatocyst externally visible. The genital duct was conspicuously developed and the vas deferens (*sensu* Hamlett *et al.* 1999; Jones *et al.*, 2005) clearly twisted. Sperm was generally present in the seminal vesicles. The adult stage comprised all the males over 550 mm TL. Fourteen specimens were observed. The largest adult male was 770 mm TL, weighing 4890 g. Mass of the heaviest specimen reached 5400 g and it measured 750 mm TL. Some specimens were captured in February, March, June, and slightly more in November and December (see Tab. 1, Fig. 4).

#### Females

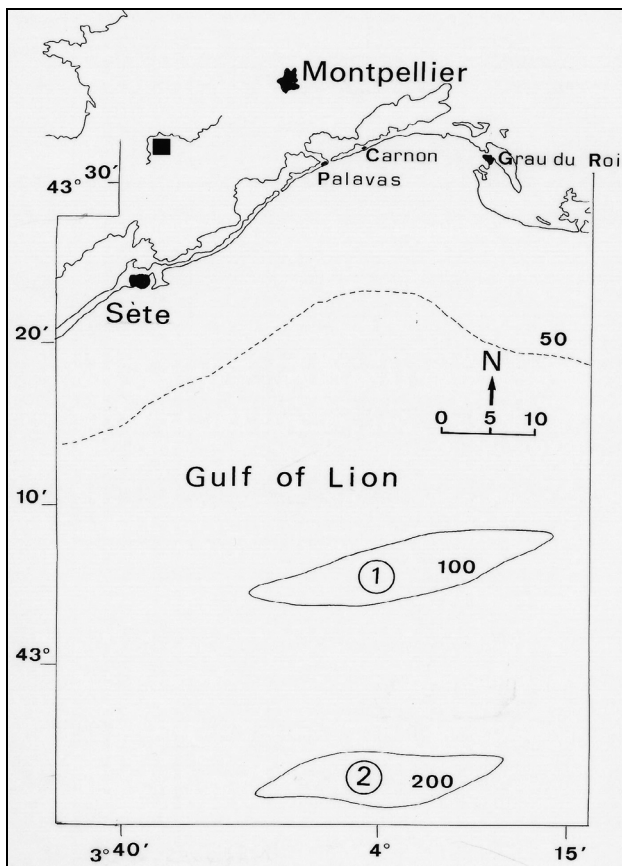
Twenty juvenile females were observed, ranging from 195 to 800 mm TL and weighing from 150 to 550 mm TL. The smallest juvenile could be considered as neonate or aborted (see males above). Juveniles had whitish ovaries with oocytes of microscopic size and indistinct oviducal glands. The genital duct was membranous, filiform and translucent. However, females between 650 and 800 mm TL exhibited translucent oocytes, a conspicuous oviducal gland and a differentiated genital duct. They probably entered a maturation stage at about 600 mm TL. Juvenile females were caught practically throughout the year, except in February, March and July, with a peak observed in November (Tab. 1).



**Fig. 2: Map of Tunisia, showing the investigation areas off both southern and northern coasts (black stars).  
Sl. 2: Zemljevid Tunizije z raziskanimi območji (črne zvezdice) ob njenem severnem in južnem obrežju.**

**Tab. 1: Monthly collection of the observed *T. nobiliana* for total sample.****Tab. 1: Mesečna zbirka opazovanih električnih skatov *T. nobiliana* v skupnem vzorcu.**

Sex	Category	Months												Total
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Males	Juveniles	9	1	–	–	4	3	–	1	1	4	2	2	27
	Adults	–	2	1	–	–	3	–	–	–	–	4	4	14
	Total	9	3	1	–	4	6	–	1	1	4	6	6	41
Females	Juveniles	1	–	–	2	5	2	–	1	1	1	7	–	20
	Adults	2	4	2	–	2	1	1	1	–	3	3	–	19
	Total	3	4	2	2	7	3	1	2	1	4	10	–	39
<b>Grand total</b>		<b>12</b>	<b>7</b>	<b>3</b>	<b>2</b>	<b>11</b>	<b>9</b>	<b>1</b>	<b>3</b>	<b>2</b>	<b>8</b>	<b>16</b>	<b>6</b>	<b>80</b>



**Fig. 3: Map of France pointing out the coast of Languedoc and the captures sites of *T. nobiliana* in the 'pits' from off Sète, where the small spotted catshark *Scyliorhinus canicula* ① and the blackmouth catshark *Galeus melastomus* ② are the dominant elasmobranch species.**

**Sl. 3: Zemljevid Francije z obrežjem Languedoca in lokacijami, kjer je bil v "votlinah" nedaleč od mesta Sète ujet električni skat *T. nobiliana*, kjer sta prevladujoči vrsti med morskimi psi in skati morski mački *Scyliorhinus canicula* ① in *Galeus melastomus* ②.**

In the adults, the genital apparatus was clearly developed and both ovaries exhibited batches of developing and fully yolky oocytes. The genital tract was enlarged, but no pregnant female was clearly observed; they were probably *post partum* females or females having aborted. Nineteen adult females were observed, ranging from 900 to 1200 mm TL and weighing between 9850 and 25500 g. Some adult females were captured monthly, except in September (Tab. 1).

#### Size and mass

Of the 5 smallest free-swimming specimens observed, 4 were males and a single female. Males ranged from 170 to 220 mm TL and weighed from 150 to 246 g, the female was 195 mm TL and weighed 180 g. Mean TL and mean mass calculated from these data were 185 mm  $\pm$  12.8 and 167.5 g  $\pm$  17.6, respectively. The diameter of 22 yolky oocytes ready to be ovulated ranged between 32 and 38 mm (mean: 35.0  $\pm$  2.1), and their mass between 8.7 and 10.5 g (mean: 9.6 g  $\pm$  0.5). CBD based on mean dry masses calculated for *Torpedo nobiliana* was about 8.7.

The total mass vs. total length relationships showed significant differences between males and females (Fig. 5). The latter did not bear embryos. The relationships for males were

$$\log TM = 2.39 \times \log TL - 3.11; r = 0.98; n = 40,$$

and for females

$$\log TM = 2.66 \times \log TL - 3.81; r = 0.98; n = 28; (F = 7.4; p = 0.008).$$

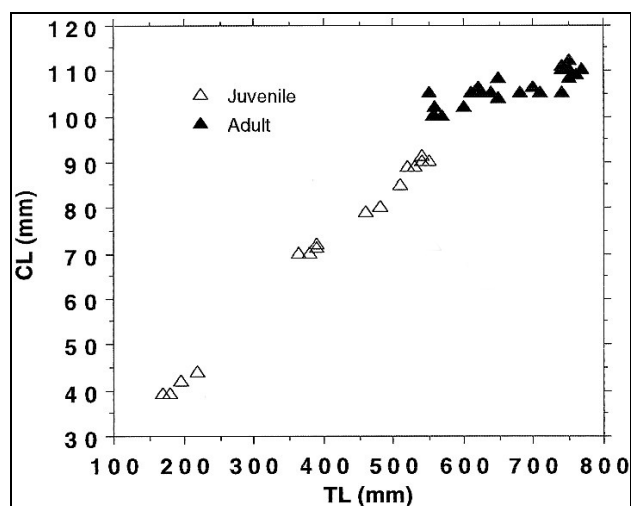
#### Reproductive status of females

Records obtained from adult females *T. nobiliana* are summarized in Table 2. No pregnant female was observed, however, records 10 to 13 show that uteri of females were distended when caught, and they were full of uterine fluid secreted by largely developed villi covering uterine walls, while their ovaries were in a resting phase. These females were probably *post partum* specimens. This suitable hypothesis is confirmed by the fact

**Tab. 2: Reproductive status of female *T. nobiliana*. Condition of ovary and uteri during gestation.**  
**Tab. 2: Reprodukcijski status samice *T. nobiliana*. Stanje jajčnika in maternic med brejostjo.**

Record	Month of catch	Female size (TL, mm)	Female mass (g)	Ovarian condition	Oocytes number	Oocytes diameter (mm)	Oocytes mass (g)	Uteri condition
1	Jan	980	?	Vitellogenesis	?	15–17	?	Resting
2	Jan	> 900	?	Vitellogenesis	?	?	?	Resting
3	Feb	# 1000	?	Vitellogenesis	?	> 15	?	Resting
4	Feb	1020	?	Vitellogenesis	?	?	?	Resting
5	Feb	> 900	?	Vitellogenesis	?	?	?	Resting
6	Feb	1000	?	Vitellogenesis	?	?	?	Resting
7	Mar	980	?	Vitellogenesis	15+15	>30	?	Resting
8	Mar	1000	?	Vitellogenesis	> 40	> 30	?	Resting
10	May	940	11000	Resting	–	–	–	Distended
11	May	950	12000	Resting	–	–	–	Distended
11	Jun	970	13500	Resting	–	–	–	Distended
12	Jul	960	12300	Vitellogenesis	–	–	–	Distended
13	Aug	985	17000	Vitellogenesis	–	–	–	Distended
14	Oct	980	13000	Vitellogenesis	8+8	11–12	1.2–1.5	Resting
15	Oct	1020	18900	Vitellogenesis	16+16	12–15	1.5–1.7	Resting
16	Oct	900	9850	Vitellogenesis	8+7	25–27	7.8–8.5	Resting
17	Nov	950	10000	Vitellogenesis	12+12	30–31	8.5–9.5	Resting
18	Nov	1110	20000	Vitellogenesis	36+35	29–30	7.9–9.4	Resting
19	Dec	1020	20000	Vitellogenesis	34–32	32–38	8.7–9.9	Resting

that the smallest specimens described above were concomitantly captured. The 16 other records show that females exhibited an obvious vitellogenic activity, while their uteri were in a resting phase, thick, not distended and with internal wall not covered by undeveloped villi. Records 1 to 8 and 14 to 19 show a regular increase of oocytes diameter.



**Fig. 4: Clasper length (CL) vs. disc width (TL) in male *T. nobiliana*.**

**Sl. 4: Dolžina spolnega organa (CL) proti širini telesne plošče (TL) pri samcih električnega skata *T. nobiliana*.**

Furthermore, Table 2 shows that ovarian fecundity based on counts of yolky oocytes occurring in ovaries increases slightly with female size.

#### Sex ratio

Table 3 shows that among juveniles, males slightly outnumbered females, whereas among adults females slightly outnumbered males. However, these differences were not significant. In the total sample, males and females were equally distributed.

**Tab. 3: *T. nobiliana* sex ratio for each category of specimens and for the total sample.**

**Tab. 3: Razmerje med spoloma pri vrsti *T. nobiliana* za vsako kategorijo osebkov in skupni vzorec.**

Category	Males	Females	Males: Females
Juveniles	27	20	1.35: 1
Adults	14	19	1: 1.35
<b>General total</b>	<b>41</b>	<b>39</b>	<b>1.05: 1</b>

#### DISCUSSION

Although *Torpedo nobiliana* has a wide distribution, it was rarely recorded and its reproductive biology is poorly known. As other batoid species, such as rajids (see Hunter et al., 2005a, b), a decline of captures of *T.*

**Tab. 4: CBD values calculated in incipient histotrophic elasmobranch species.****Tab. 4: Vrednosti CBD, izračunane pri zametkovnih histotrofičnih vrstah morskih pssov in skatov.**

Species	CBD values	Areas	Authors
<i>Hexanchus griseus</i>	3.7	Mediterranean	Capapé <i>et al.</i> (2004)
<i>Galeorhinus galeus</i>	1.0	Maghreb	Capapé <i>et al.</i> (2005a)
<i>Oxynotus centrina</i>	1.36	Mediterranean	Capapé <i>et al.</i> (1999b)
<i>Rhinobatos cemiculus</i>	1.0	Gulf of Gabès	Capapé & Zaouali (1994)
<i>R. cemiculus</i>	1.85	Senegal	Seck <i>et al.</i> (2004)
<i>R. rhinobatos</i>	1.15	Gulf of Gabès	Capapé <i>et al.</i> (1997)
<i>R. rhinobatos</i>	1.43	Senegal	Capapé <i>et al.</i> (1999a)
<i>Torpedo mackayana</i>	1.20	Senegal	Capapé <i>et al.</i> (2001b)
<i>T. marmorata</i>	1.30	Senegal	Capapé <i>et al.</i> (2001a)
<i>T. torpedo</i>	1.58	Senegal	Capapé <i>et al.</i> (2000)
<i>Torpedo nobiliana</i>	8.7	Mediterranean	This study

*nobiliana* has been reported during the last decades according to our own observations. The last specimen was captured off the coast of Tunisia in 1980, while between 1980 and 1988 no electric ray was landed in Tunisian fishing sites to our knowledge. Bradaï *et al.* (2004) reported *T. nobiliana* among the species reported off the Tunisian coast referring to previous observations provided by Quignard & Capapé (1971) and Capapé (1975). Moreover, information provided by fishermen since 1985 confirmed that specimens were no longer reported off the Tunisian coast. Has the electric ray disappeared from the area? This phenomenon needs further investigations in order to confirm it. During our investigations in the area, the species was caught especially off the northern coast of Tunisia, and some specimens, including all four juveniles, in southern areas, such as off the Island of Lampedusa (see Fig. 2). In all, 8 specimens were caught off the Languedocian coast during the sixteen year period, with the last specimen observed caught in December 2002 (Tab. 2, record 19). Moreover, Golani (1996, 2005) noted the occurrence of *T. nobiliana* off the Mediterranean coast of Israel, where it had not been formerly reported by Ben-Tuvia (1966, 1971). Moreover, Golani (2005, *pers. comm.*) informed us that the only specimen caught off Israel was a female 265 mm TL, collected on 1<sup>st</sup> June 1993, by trawl at a depth of ca. 350 m.

Males matured at a smaller size than females and reached a smaller maximum size, confirming previous observations (Capapé & Desoutter, 1980) for specimens from the Tunisian coast and sexual dimorphism in size for other torpedinids species (Tab. 5). Bigelow & Schroeder (1953) noted that off the eastern coast of the United States, specimens up to 610 mm were probably mature. It seems that such observations concerned male *T. nobiliana*.

According to the data presented herein, size at birth was between 170 and 220 mm TL, which is in agreement with Bigelow & Schroeder (1953), who noted that

it was between 200 and 250 mm and recorded one embryo of 159 mm TL. Maximum sizes recorded off both Tunisian and Languedocian coast were similar, although smaller than those of other Mediterranean areas. Duméril (1865) reported 1600 mm TL from specimens caught off Italy, and Lozano Rey (1928) 1800 mm TL from those caught off the northern coast of Spain. The largest specimen reported by Bigelow & Schroeder (1953) off the eastern coast of the United States was 1700 mm TL, weighing ca. 90 kg.

Table 2 shows that vitellogenesis occurred throughout the year in some adult females that exhibited a regular development of oocytes, while no embryo was found in each uterus. Vitellogenesis does not proceed in parallel with gestation and similar patterns were observed in other torpedinid species previously studied (Mellinger, 1981, 1989). Our data did not allow us to state about the length of oocytes production. It is generally long in torpedinid species, from 6 to 8 months in the common torpedo *T. torpedo* according to Quignard & Capapé (1974) and Capapé *et al.* (2000), one-two years in the marbled torpedo *T. marmorata* according to Capapé (1979), Mellinger (1981) and Capapé *et al.* (2001a). So, a vitellogenic activity that probably lasts for at least a year remains a suitable hypothesis for *T. nobiliana*, which consequently could reproduce in alternate year.

The CBD about 8.7 for *T. nobiliana* showed that the role of the mother cannot be neglected and it seems that the uterine fluid found in mothers certainly provided a complement of nutriment, inorganic matters, and also protected the embryos throughout their development. However, *T. nobiliana* is close to those sharks, skates and rays considered incipient histotrophic species, *sensu* Hamlett *et al.* (2005), (see Tab. 4), mid-term between lecithotrophic species (CBD <1), such as squatinids (Capapé *et al.*, 2002, 2005b) and matrotrophic species (*sensu* Wourms, 1977, 1981; Wourms *et al.*, 1988), in which CBD reach high values, (c CBD > 30), such as

Tab. 5: Size at birth, size at maturity, maximum size (in mm) and fecundity in some torpedinids.

Tab. 5: Velikost osebkov ob rojstvu, velikost v času, ko postanejo spolni zreli, maksimalna velikost (v mm) in plodnost pri nekaterih vrstah iz družine Torpedinidae.

Species	Size at birth	Size at maturity		Maximal size		Ovarian fecundity	Litter size	Area	Authors
		Male	Female	Male	Female				
<i>Torpedo bauchotae</i>	?	?	?		590–790	16–24	?	Coast of Senegal	Capapé <i>et al.</i> (2001b)
<i>T. fuscomaculata</i>	?	?	?	?	?	?	5	Indian Ocean	Capapé and Farrugio (1986)
<i>T. mackayana</i>	92–96	315	350	382	500	10–18	6–15	Coast of Senegal	Capapé <i>et al.</i> (2001a)
<i>T. marmorata</i>	?	290	390	395	580	3–15	2–13	Coast of Tunisia	Capapé (1979)
<i>T. marmorata</i>	112–145	270	380	380	560	6–19	8–20	Coast of Senegal	Capapé <i>et al.</i> (2001a)
<i>T. torpedo</i>	80–97	190	190	390	410	1–15	1–9	Coast of Tunisia	Quignard and Capapé (1974)
<i>T. torpedo</i>	102–125	300	310	445	550	10–28	5–20	Coast of Senegal	Capapé <i>et al.</i> (2000)
<i>T. nobiliana</i>	170–220	550	900	750	1200	15–71	?	Mediterranean	This study

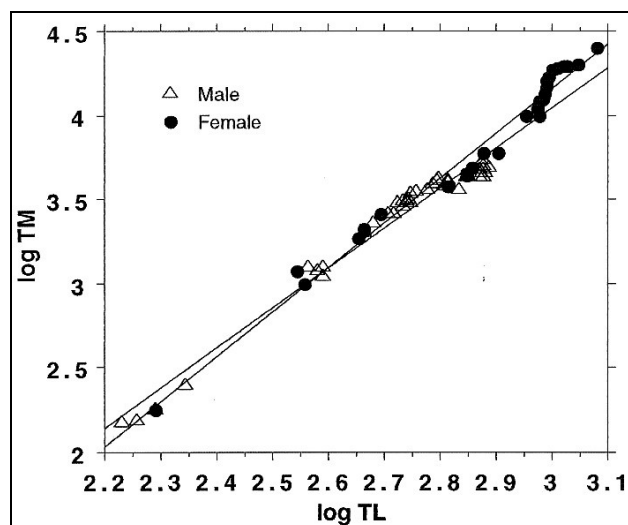


Fig. 5: Total mass (TM) vs. disc width (TL) relationship expressed in logarithmic co-ordinates for male and female *T. nobiliana*. TL was measured to the nearest mm and TM to the nearest gram.

Sl. 5: Razmerje med skupno maso (TM) in širino telesne plošče (TL), izraženo v logaritmičnih koordinatah za samce in samice vrste *T. nobiliana*. TL je bila izmerjena do najbližjega mm, TM pa do najbližjega g.

carcharinids (Capapé *et al.*, 2003; Saïdi *et al.*, 2005) and dasyatids (Capapé *et al.*, 1992; Capapé & Zaouali, 1995).

*T. nobiliana* is not a prolific species. Its fecundity was rather low, although higher than in other torpedinid species, and it seems that this phenomenon depends on torpedinid species size (see Table 5).

The slight changes of sex ratio were due to sampling; however, captures of possible *post partum* adult females showed that they probably approach the coast in order to expel their brood in the best environmental conditions.

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## REPRODUKTIVNA BIOLOGIJA ELEKTRIČNEGA SKATA *TORPEDO NOBILIANA* BONAPARTE 1835 (CHONDRICHTHYES: TORPEDINIDAE) IZ DVEH LOČENIH OBMOČIJ SREDOZEMSKEGA MORJA

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### POVZETEK

Pričujoči članek obravnava reproduktivno biologijo električnega skata *Torpedo nobiliana*, in sicer na osnovi oseb-  
kov, ujetih v bližini Tunizije in nedaleč od Languedoca v južni Franciji. Skupna dolžina (TL) najmanjšega odraslega  
samca je merila 550 mm, TL najmanjše odrasle samice pa 900 mm. Samec je tehtal 3.120 g, samica 9.850 g. Naj-  
večji samec je bil dolg 770 mm in težak 4.890 g, največja samica pa dolga 1.200 mm in težka 25.000 g. Razmerje  
med skupno maso in celotno TL je pokazalo na očitne razlike med samci in samicami te vrste. Samice so verjetno  
rojevale pri srednji TL  $185 \text{ mm} \pm 12,8$  in srednji masi  $167,5 \text{ g} \pm 17,6$ . Funkcionalna sta bila oba jajčnika in obe ma-  
ternici. Premier 22 rumenjastih oocitov, pripravljenih na ovulacijo, se je gibal med 32 in 38 mm (srednja vrednost  
 $35,0 \pm 2,1$  mm), njihova masa pa med 8,7 in 10,5 g (srednja vrednost  $9,6 \pm 0,5$  g). CBD, izračunan za električnega  
skata *T. nobiliana* na osnovi srednjih mas, je bil # 8,7, hkrati pa je pokazal, da gre bržkone za zametkovno histotro-  
fično vrsto. Brejost je trajala približno leto dni, vendar je rast oocitov med nosečnostjo zamujala. Avtorji zato dom-  
nevajo, da gre pri tej vrsti za bienalni razmnoževalni cikel. Sicer pa je bila plodnost povezana z velikostjo samic.  
Mladostni samci so za malenkost številčno prekašali mladostne samice, kar zadeve odrasle osebkke, pa so bile samice  
malce številčneje od samcev. Toda v skupnem vzorcu so bili samci in samice razporejeni v enakem razmerju.

**Ključne besede:** Torpedinidae, *Torpedo nobiliana*, reproduktivna biologija, Tunizija, južna Francija, Sredozemsko morje

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