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The reproductive biology of the school shark, *Galeorhinus galeus* Linnaeus 1758 (Chondrichthyes: Triakidae), from the Maghreb shore (southern Mediterranean)

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The school shark, Galeorhinus galeus*, is commonly captured off the Maghreb shore along the Algerian and Tunisian coasts of the southern Mediterranean. Of 517 specimens collected during more than twenty years, the smallest adult male was 1225 mm total length (TL) and weighed 11 580 g, the largest adult male was 1580 mm and weighed 18 000 g, and the heaviest male was 1570 mm and weighed 19 900 g. All males above 1260 mm TL were adult. Adult females were 1400-1900 mm TL. The smallest pregnant female was 1400 mm TL and carried developing embryos. The largest female was 1990 mm TL and weighed 27 900 g. Females were generally heavier than males, but there was no significant difference between males and females in mass versus total length relationship. Two ovulation and two pupping seasons occurred in winter and in spring. Gestation was estimated at twelve months, with most females appearing to reproduce in alternate years. The diameter of the largest yolky oocytes ranged 43-47 mm (mean 44.7±1.8) and the mass ranged 45-52 g (mean 47.9±2.2). Both uteri were compartmentalized into chambers and a single embryo developed in each chamber. Length and weight at birth, based on near-term embryos, were estimated at 240-320 mm TL and 88-109 g. The chemical balance of development, based on the mean dry mass of the largest yolky oocytes and of near-term fetuses, was about 1, showing that* G. galeus *can be considered as an incipient histotrophic species. Ovarian fecundity was higher than uterine fecundity. Litter sizes ranged 8-41. Males generally outnumbered females, especially among free-swimming adult specimens.*

Key words: Chondrichthyes, Triakidae, *Galeorhinus galeus*, reproductive biology, Maghreb shore

INTRODUCTION

The school shark, *Galeorhinus galeus*, is widely distributed in cold to warm temperate continental seas (COMPAGNO, 1984). The species is an important component of the southern Australian shark fishery (PUNT & WALKER, 1998) and other marine areas off New Zealand (FRANCIS, 1998), Argentina (CHIARAMONTE, 1998), and South Africa (KROESE & SAUER, 1998). Along the eastern Atlantic, *G. galeus* has been reported off Scandinavia, the Faroe Islands, Iceland (MUUS & DAHLSTRÖM, 1964-1966), the British Isles and southward from the coast of France to southern Morocco (MAURIN & BONNET, 1970; CADENAT & BLACHE, 1981). The species is doubtful off Mauritania and no information exists about populations in this area (FISCHER *et al.*, 1981). Nor has *G. galeus* been reported off the coast of Senegal (CADENAT, 1950; CADENAT & BLACHE, 1981; SÉRET & OPIC, 1990; CAPAPÉ *et al.*, 1994).

In the Mediterranean, captures of the species are rather rare and landings are constantly declining along the French coast (EUZET, 1960; QUIGNARD *et al.*, 1962; CAPAPÉ *et al.*, 2000b) and in the Italian Seas (NOTARBARTOLO DI SCIARA & BIANCHI, 1998). *Galeorhinus galeus* is more often reported in the western basin than in the eastern, the Aegean Sea probably being its eastern limit (ECONOMIDIS, 1973; KABASAKAL, 2003). It has not been recorded in the Sea of Marmara (KABASAKAL, 2003), the Black Sea (BRANSTETTER, 1984), the eastern Levant of the Mediterranean (GOLANI, 1996), or the Red Sea (GOLANI, 1997).

Investigations since 1996 along the Algerian shore show a qualitative and quantitative increase of shark captures (HEMIDA, 1998; HEMIDA & LABIDI, 2001; HEMIDA & CAPAPÉ, 2002, 2003; HEMIDA *et al.*, 2002; CAPAPÉ *et al.*, 2003a, 2004b), probably as a consequence of increased traditional prospection, the use of newer techniques for exploring inaccessible habitats, and migrations from the Atlantic through the Strait of Gibraltar and from the Red Sea through the Suez Canal (GOLANI, 1996; GOLANI & SONIN, 1996; QUIGNARD & TOMASINI, 2000).

Of all shark species presently recorded off the Algerian coast, the school shark, *G. galeus*, is the most abundantly and regularly landed, although it was not formerly reported as common to the area (DIEUZEIDE *et al.*, 1953). *Galeorhinus galeus* has been captured in northern areas off the Tunisian coast (QUIGNARD & CAPAPÉ, 1971; CAPAPÉ & MELLINGER, 1988) and occasionally in southeastern areas such as the Gabès Gulf (CAPAPÉ, 1989; BRADAÏ *et al.*, 2002, 2004). CAPAPÉ (1974) and CAPAPÉ & MELLINGER (1988) provided data on the reproductive biology of tope sharks from the Tunisian coast, comparing data with specimens from other areas. New and additional data on *G. galeus* from the Maghreb shore (both the Algerian and the Tunisian coasts) offer the opportunity to expand and review its reproductive biology.

MATERIALS AND METHODS

The studied sample comprised 517 *G. galeus*, 342 males and 175 females, collected off the Maghreb shore in 1970-2000 (Fig. 1). Specimens were caught by commercial trawlers, gill-netters, and bottom and pelagic long line vessels. Data provided by CAPAPÉ & MELLINGER (1988) are included in the sample.

Total length (TL) of the specimens was measured to the nearest millimeter following BASS *et al.* (1973) and CASTRO (1996). Mass was measured to the nearest gram, when possible. Clasper-length (CL; mm) was measured from the forward rim of the pelvic girdle to the tip of the clasper, following COLLENOT (1969). The diameters of developing and fully-yolked oocytes and the total lengths of developing and near-term embryos were measured to the nearest millimeter. Oocytes and embryos were weighed to the nearest gram and embryos were sexed when possible.

Specimens were classified into three categories: juveniles, sub-adults, and adults. In males, size at sexual maturity was determined by the condition and length of claspers following BASS *et al.* (1973), STEVENS & MCLOUGHLIN (1991), and WATSON & SMALE (1998). The claspers of

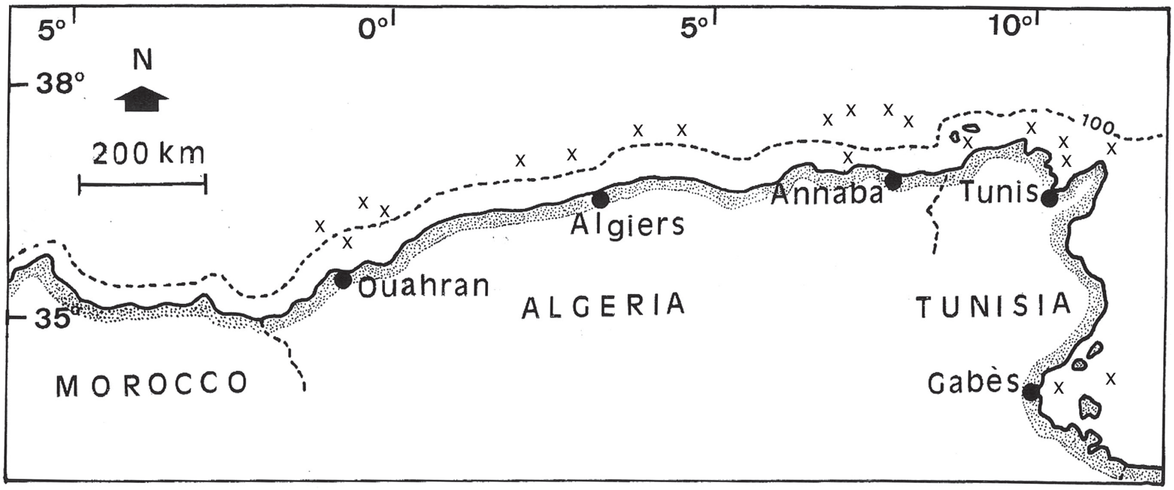

Fig. 1. Capture sites (X) of Galeorhinus galeus *off the Maghreb shore (along the Algerian and Tunisian coasts)*

juveniles are shorter than the pelvic fin length, flexible, and slightly calcified, while those of sub-adults are slightly longer than pelvic fin length, flexible, and slightly calcified. In adults, the claspers are obviously elongated, longer than pelvic fin length, rigid, and calcified. Aspects of the testes and other reproductive organs are given following CAPAPÉ *et al.* (1990, 2002) and BRIDGE *et al.* (1998). In females, size at sexual maturity was determined from the condition of the ovaries and the morphology of the reproductive tract (CAPAPÉ *et al.*, 1990). Ovarian fecundity was estimated by counting ripe oocytes while uterine fecundity was determined by counting embryos in pregnant females.

A chemical balance of development (CBD) was used to evaluate embryonic development and the role of nourishment by the mother during gestation. The CBD was calculated as the mean dry mass of fully-developed embryos divided by the mean dry mass of fully-yolked oocytes or eggs. Standard water content values were 50% for ripe oocytes and 75% for fully-developed embryos, based on chemical analyses of the small spotted catshark, *Scyliorhinus canicula*, by MELLINGER & WRISEZ (1989). The CBD is a tentative estimate.

Tests for significance (p<0.05) were performed using ANOVA, STUDENT's t test, and the chi-square test. Linear regression was performed following log transformation of data. Correlations were assessed by least-squares regression. In the relationship between mass and total length, curves were compared by ANCOVA.

RESULTS

Number of specimens

Table 1 shows the 524 specimens caught off the Maghreb coast. Males outnumbered females in all categories except in juveniles. However, the differences were significant in adults only (see Table 1).

Males

Sixteen juveniles were caught from January to June. They ranged 500-810 mm TL and 320-4200 g, their claspers were short and flexible, and their testes and genital ducts were slightly developed and membranous. Nineteen sub-adults, caught almost throughout year, ranged 870-1260 mm TL and 4980-13 000 g. Their testes were developed but no spermatocysts were externally visible and there was no sperm in the seminal vesicles. Their genital ducts were conspicuously visible and the *ductus deferens* (HAMLETT *et al.*, 1999) was slightly convoluted. The claspers were slightly calcified and rapidly elongated. They grew fastest during the sub-adult stage (Fig. 2). Three hundred and seven

Table 1. Collection of Galeorhinus galeus *off the Maghreb shore*

		Month												
Sex	Category	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
Males														
	Juveniles	2	6	4	2	3	1	-	-	1	-	-	-	19
	Sub-adults	1	2	-	-	4	1	1	1	1	4	4	-	19
	Adults	16	30	4	2	5	45	2	73	3	7	48	72	307
	Total males	19	38	8	4	12	47	3	74	5	11	52	72	345
Females														
	Juveniles	2	5	5	-	1	1	-	1	-	3	-	2	20
	Sub-adults	1	-	1	-	1	1	-	2	3	2	2	2	15
	Adults	5	2	-	7	8	64	6	25	4	4	1	18	144
	Total females	8	7	6	7	10	66	6	28	7	9	3	22	179
Grand total		**27**	**45**	**14**	**11**	**22**	**113**	**9**	**102**	**12**	**20**	**55**	**94**	**524**

adults were collected. The smallest was 1225 mm TL and 11 580 g and the largest was 1580 and 18 000 g. All males above 1260 mm TL were adult. Their claspers were elongated, rigid, calcified, clearly longer than the pelvic fin, and continued to grow rapidly. Spermatocysts were externally visible and there was sperm in the seminal vesicles. Total mass for 38 adults was calculated: the heaviest specimen weighed 19 900 g and was 1570 mm TL.

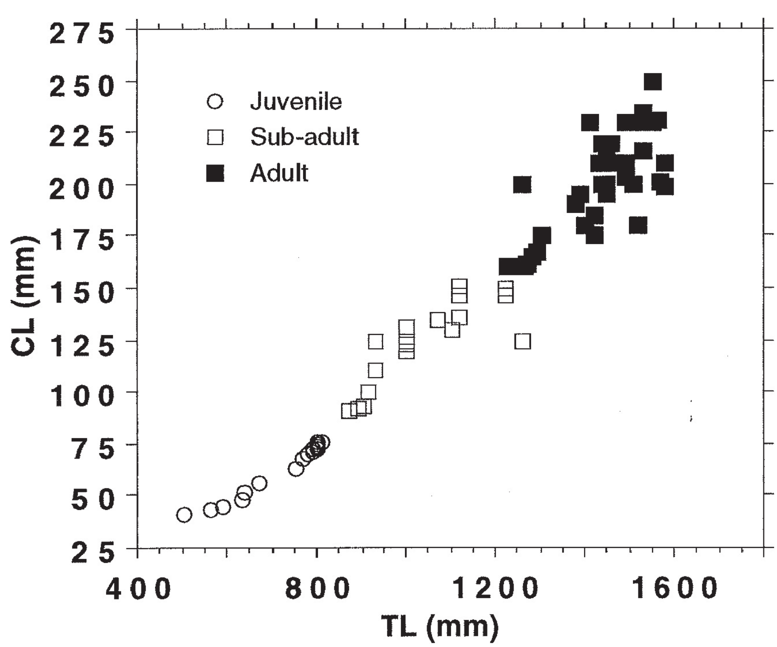

Fig. 2. Clasper length (CL) vs total length (TL) in male Galeorhinus galeus

Females

Sixteen juvenile females, captured mainly in winter, ranged 590-900 mm TL and 700-5600 g. They had membranous ovaries, membrane-like oviducts, and inconspicuous oviducal glands. Fifteen sub-adults were captured, most between August and December. They ranged 980-1370 mm TL and 7900-12 500 g. Sub-adults had ovaries with translucent oocytes, well-differentiated genital ducts, and slightly rounded oviducal glands. One hundred and forty-four adult females, caught mostly in June, August, and December, ranged 1400-1990 mm TL. The total mass of 22 specimens was calculated at 15 500-27 900 g. The smallest pregnant female was 1400 mm TL and had developing embryos.

Reproductive status of females

Galeorhinus galeus is an aplacental viviparous elasmobranch species. Juvenile females had two ovaries. Morphological differences between the ovaries developed as the specimens grew and reached sexual maturity. The right ovary increased in length and mass and became functional while the left became rudimentary and non-functional. The right ovary produced oocyte batches similar in size and mass, but only one batch developed into yolky oocytes and the others became atretic. In contrast, both uteri were functional in adult females. Of the 34 adult females examined, 14 were pregnant with embryos or eggs (Table 2). Of the pregnant females, two specimens, caught in April, had eggs; four, caught in January and November, had developing embryos (3, 4, 7, 33); and eight had near-term embryos. The ovary was resting in females with developing embryos but, among females with near-term embryos, four (18, 22-24) had vitellogenic activity together with the embryonic development. Of 25 yolky oocytes removed from a female during ovulation (record 12), 17 were measured and weighed; the diameters ranged 43-47 mm (mean 44.7±1.8) and the mass 45-52 g (mean 47.9±2.2). Of the 20 non-pregnant females, the ovary of 15 specimens had vitellogenic activity and five were in a complete rest phase (9-11, 30, 31).

Table 2. Reproductive status of 34 female Galeorhinus galeus *caught off Maghreb coast*

Record no.	Month of catch	Capture area	Total length of female (mm)	Ovarian activity	Oocyte diameter (mm)	Number of oocytes	Uterine content	Embryo size (mm)	Embryo mass (g)	Number of embryos or eggs
01	Jan.	Tunisian coast	?	Resting	-	-	Embryos	240-250	?	20
02	Jan.	Algerian coast	1450	Resting	-	-	Embryos	240-250	?	15
03	Jan.	Algerian coast	1520	Resting	-	-	Embryos	110-120	?	30
04	Jan.	Algerian coast	1600	Resting	-	-	Embryos	110-120	?	30
05	Feb.	Algerian coast	?	Vitellogenesis	42-45	?	-	-	-	-
06	Feb.	Algerian coast	1600	Vitellogenesis	43-45	?	-	-	-	-
07	Feb.	Algerian coast	1540	Resting	-	-	Embryos	110-120	?	?
08	Feb.	Algerian coast	1650	Resting	-	-	Embryos	250-260	-	8
09	Mar.	Algerian coast	1410	Resting	-	-	-	-	-	-

Table 2. Cont'd

10	Mar.	Tunisian coast	1420	Resting	-	-	-	-	-	-
11	Mar.	Tunisian coast	1480	Resting	-	-	-	-	-	-
12	Apr.	Tunisian coast	1410	Vitellogenesis	42-45	15	-	-	-	-
13	Apr.	Algerian coast	1420	Vitellogenesis	42-45	19	-	-	-	-
14	Apr.	Algerian coast	1480	Vitellogenesis	?	20	-	-	-	-
15	Apr.	Algerian coast	1500	Vitellogenesis	43-47	25	-	-	-	-
16	Apr.	Algerian coast	1500	-	-	-	Eggs	-	-	15
17	Apr.	Algerian coast	1810	-	-	-	Eggs	-	-	35
18	May	Tunisian coast	1580	Vitellogenesis	33-35	35	Embryos	265-290	98-109	10
19	Jun	Algerian coast	1440	Vitellogenesis	25-28	25	-	-	-	-
20	Jun.	Algerian coast	1490	Vitellogenesis	43-45	-	-	-	-	-
21	Jun.	Algerian coast	1500	Vitellogenesis	43-48	20	-	-	-	-
22	Jun.	Tunisian coast	1690	Vitellogenesis	43-47	28	Embryos	280-320	?	28
23	Jun.	Tunisian coast	1740	Vitellogenesis	35-39	42	Embryos	285-310	?	31
24	Jun.	Tunisian coast	1990	Vitellogenesis	42-45	51	Embryos	290-320	?	41
25	Aug.	Tunisian coast	1410	Vitellogenesis	<25	24	-	-	-	-
26	Aug.	Tunisian coast	1430	Vitellogenesis	?	?	?	?	?	?
27	Aug.	Tunisian coast	1430	Vitellogenesis	?	?	?	?	?	?
28	Aug.	Tunisian coast	1600	Vitellogenesis	?	?	?	?	?	?
29	Aug.	Tunisian coast	1420	Vitellogenesis	42-45	19	-	-	-	-
30	Sep.	Algerian coast	1510	Resting	-	-	-	-	-	-
31	Sep.	Algerian coast	1560	Resting	-	-	-	-	-	-
32	Nov.	Algerian coast	1600	Vitellogenesis	?	?	?	?	?	?
33	Nov.	Algerian coast	1480	Resting	-	-	Embryos	>120	?	25
34	Dec.	Algerian coast	1500	Resting	-	-	Embryos	240-250	?	28

Fertilized eggs were enveloped in a diaphanous capsule ending with a large brownish filament at both sides (Fig. 3). Capsules were fragile and eggs rapidly spilled during handling; they were sometimes difficult to observe. Uteri of pregnant females were compartmentalized into chambers. A single embryo developed in each chamber (Fig. 4), observed in embryos of about 120 mm TL. During early gestation, embryos had a large yolk sac and nutrients were transferred from the yolk sac to the embryo through the umbilical stalk.

Near-term embryos ranging 240-320 mm TL (mean 280.5±26.8) were examined, 40 were weighed, and the total mass (TM) ranged 88-109 g (mean 97.2±10.1). The relationship between TL and TM did not significantly differ between males and females ($F = 1.6$; $p = 0.2$). The relationships were log TM = 2.82 log TL – 4.73; r = 0.93; n = 78 for the males and log TM = 2.56 log TL – 3.99; r = 0.93; n = 49 for the females (Fig. 5). The CBD for the 25 yolky oocytes and the 45 near-term fetuses was about 1.

Fig.3. Encapsuled eggs removed from an adult female Galeorhinus galeus (photo F. HEMIDA)

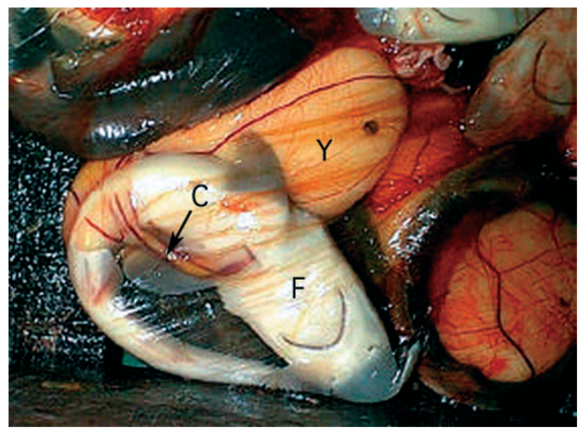

Fig. 4. Developing embryo in a chamber removed from a pregnant female Galeorhinus galeus *(photo F. HEMIDA). C: umbilical cord. F: developing embryo. Y: yolk sac*

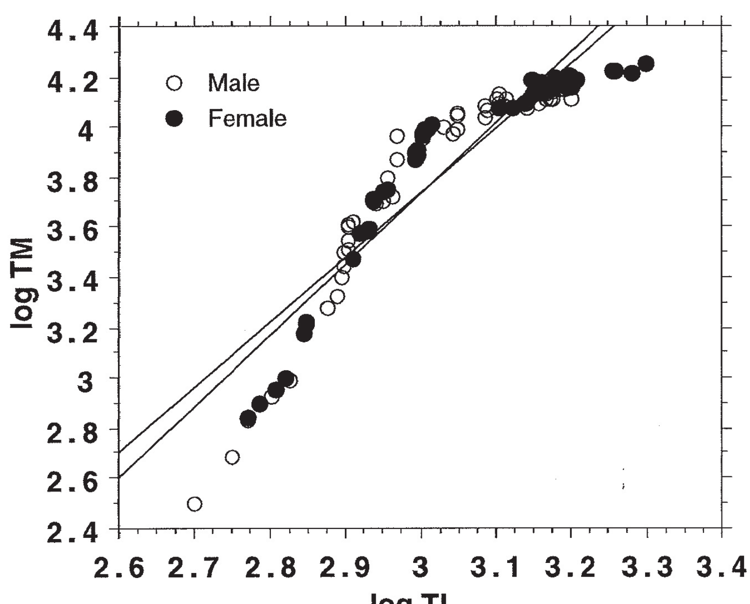

Fig. 5. Relationship of total mass (TM) to total length (TL), expressed in logarithmic co-ordinates for male and female Galeorhinus galeus

There was a positive relationship between number of oocytes and total length: number of oocytes = 0.61 TL (mm) – 66.48 ; r = 0.93. Litter sizes ranged 8-41 (mean 26.6±9.6) in eleven pregnant females with a slightly positive relationship between number of embryos/eggs and total length: litter size = 0.42 TL (mm) – 40.99; r = 0.73. Among full-term embryos, 65 were male and 55 female.

DISCUSSION

Our sample shows the relative abundance of *G. galeus* off the Maghreb shore where it had been considered rare (DIEUZEIDE *et al*., 1953; QUIGNARD & CAPAPÉ, 1971) except in the Gulf of Tunis where a sustainable population was successfully established (CAPAPÉ & MELLINGER, 1988).

The captures of *G. galeus* confirm the qualitative and quantitative abundance of elasmobranch species in the area (HEMIDA, 1998; HEMIDA & LABIDI, 2001; HEMIDA & CAPAPÉ, 2002, 2003; BRADAÏ *et al*., 2002; HEMIDA *et al*., 2002) suggesting that, despite fishing pressure, the use of newer techniques allows exploration of previously inaccessible habitats and findings of species that were previously poorly known in the area. Sharks are of economic interest in the Maghreb for local consumption and export, especially of fins. They are seasonally targeted, which could explain the relatively abundant captures in January, June, August, November, and December. However, the abundance of both male and female adults in June and August also suggests that these months might be the mating period. Similar patterns were observed by OLSEN (1984) in southern Australia, PERES & VOOREN (1991) in southern Brazil, and LUCIFORA *et al.* (2004) in Argentina.

Galeorhinus galeus is prone to large migratory movements. Specimens tagged off England and Ireland have been recaptured as far away as north of Iceland (2641 km) and near the Canary Islands (2526 km), and Azores (HOLDEN & HARROD, 1979; STEVENS, 1990). Recent migrations of *G. galeus*, similar to those of other shark species (HEMIDA *et al*., 2002; HEMIDA & CAPAPÉ, 2003), from the eastern Atlantic into the Mediterranean Sea cannot be excluded; such migrations increase available fishery stocks.

Males matured at a smaller size than females and reached a smaller maximum size, confirming observations of CAPAPÉ & MELLINGER (1988) for specimens from the Gulf of Tunis and sexual dimorphism in size for other shark species (MELLINGER, 1989). Similar patterns were reported for *G. galeus* from other areas, although geographic intraspecific size variations are apparent (Table 3). This phenomenon was previously reported in migratory species such as carcharhinids (CAPAPÉ *et al*., 2003b, 2004b; SAÏDI *et al*. 2005). In contrast, geographic intraspecific variations are not evident regarding size at birth. RANZI (1932, 1934) reported approximately 102 g as the mass of specimens at birth in the Bay of Naples, southern Italy, while PERES & VOOREN (1991) reported an average mass of 92.9 g, findings that did not differ from those in Tunisian *G. galeus*.

Table 3. Comparison of total length (TL) and biological parameters in Galeorhinus galeus *from different areas*

Area	Size at birth (TL, mm)	Size at maturity (TL, mm)		Maximum size (TL, mm)		Oocyte diameter (mm)	Litter size	Author
		Males	Females	Males	Females			
California	350-370	1350-1400	1700	1550	1950	40-60	16-54	RIPLEY (1946)
Southern Australia	310	1200-1320	1550	1550	1740	40-50	17-41	OLSEN (1984)
Southern Brazil	303	1070-1170	1180-1280	1480	1545	46-55	4-41	PERES & VOOREN (1991)
Argentina	310*	1080-1190	1250	1528	1532	42-57.5	25	LUCIFORA e*t al.* (2004)
Maghreb shore	240-320	1225-1260	1400	1580	1990	42-48	8-41	This study

* Estimated (LUCIFORA, 2005, pers. comm.)

Two ovulation periods occurred: one in February (records 5, 6) and one in April-June (records 12-21). Consequently, two breeding periods occurred: in winter (December-February; records 1, 2, 7, 8, 31) and April-June (records 16-18, 22-24). Similar patterns were reported for aplacental viviparous species, sharks such as the longnose spurdog, *Squalus blainvillei*, the bluntnose sixgill shark, *Hexanchus griseus*, and some rays (CAPAPÉ, 1974, 1993; CAPAPÉ *et al*., 1992, 2003a; CAPAPÉ & ZAOUALI, 1995). Observations in Tunisian waters showed that the length of gestation and reproductive cycle could not be clearly delineated, probably due to the fact that different populations inhabit the same areas.

CAPAPÉ & MELLINGER (1988) stated that the reproductive cycle lasts approximately one year due to fact that vitellogenesis proceeds in parallel with gestation in pregnant females and yolky oocytes are ready to be ovulated during parturition. Our observations showed that some pregnant females did not develop oocytes during embryonic development and, moreover, some were in a complete resting phase, suggesting that female *G. galeus* may reproduce in alternate years but that a 3-year reproductive cycle remains a suitable hypothesis. Similar patterns were reported for carcharhinid species (BRANSTETTER, 1981; CAPAPÉ, 1984; SCHWARTZ, 1984; HAMLETT *et al*., 1993; HAZIN *et al*., 2002; DRIGGERS *et al*., 2004; CAPAPÉ *et al*., 2003b, 2004b; SAÏDI *et al*., 2005). RIPLEY (1946) reported an annual reproductive cycle for *G. galeus* off California. OLSEN (1984) suggested a biennial cycle for specimens from southern Australia, but more recent evidence indicates that it is triennial (WALKER, 2005). PERES & VOOREN (1991) and LUCIFORA *et al.* (2004) proposed a 3-year reproductive cycle for female tope shark from Brazil and northern Argentina. LUCIFORA *et al.* (2004) suggested that inter-regional variations might be due to population differences.

Our study shows a complex population structure in *G. galeus* with mature females aggregating in warm waters at certain times of year, in agreement with PERES & VOOREN (1991) and WALKER (1999, 2005). At present, our data is insufficient to state whether the Maghreb shore is a specialized nursery area for sharks (CASTRO, 1993) such as Australian areas (RIPLEY, 1946; OLSEN, 1954), however this hypothesis should not be excluded.

Based on observations carried out in shark species such as *Carcharhinus fitzroyensis* and *C. melanopterus* (LYLE, 1987) and *Furgaleus macki* (SIMPFENDORFER & UNSWORTH, 1998), CAPAPÉ (2004b) suggested that the length of the reproductive cycle depends on whether the female is energetically capable of producing both a litter and yolky oocytes within a 12-month period. Data reported by CAPAPÉ & MELLINGER (1988) concerned only specimens from the Gulf of Tunis where a sustainable tope shark population is established. They were sedentary specimens, which could explain why some females were able to undergo vitellogenesis and gestation concomitantly. Other pregnant females come from open areas such as the Algerian coast and southern Tunisia and probably underwent longer migrations. Further, some specimens may have been recent migrants from the eastern Atlantic, entering the Mediterranean through the Strait of Gibraltar.

Females in our sample were longer and heavier than males, corroborating data of RIPLEY (1946), OLSEN (1984), and WALKER (2005). No differences in mass were found in near-term embryos of both sexes. The CBD was about 1, showing that the role of the mother in *G. galeus* is minimal and that the uterine fluid provides a full complement of nutriments and inorganic matter and protects the embryos throughout development. *Galeorhinus galeus* is close to sharks, skates, and rays that are considered incipient histotrophic species (HAMLETT *et al*., 2005), midway between lecithotrophic species (CBD<1) such as squatinids (CAPAPÉ *et al*., 2002, 2005) and matrotrophic species (WOURMS, 1977, 1981; WOURMS *et al*., 1988; (CBD>30) such as carcharhinids (CAPAPÉ *et al*., 2003b, 2004b; SAÏDI *et al*., 2005) and dasyatids (CAPAPÉ *et al*., 1992; CAPAPÉ & ZAOUALI, 1995), (see Table 4).

Ovarian fecundity was higher than uterine fecundity as a consequence of unovulated yolky oocytes that entered atresia. Abortions during capture and handling cannot be excluded, as observed at fish markets. However, a single

Table 4. Chemical balance of development (CBD) values calculated in incipient histotrophic elasmobranch species

Species	CBD	Area	Author
Hexanchus griseus	3.7	Mediterranean	CAPAPÉ *et al.* (2004a)
Galeorhinus galeus	1.0	Maghreb	This study
Oxynotus centrina	1.36	Mediterranean	CAPAPÉ *et al.* (1999b)
Rhinobatos cemiculus	1.0	Gulf of Gabès	CAPAPÉ & ZAOUALI (1994)
R. cemiculus	1.85	Senegal	SECK *et al.* (2004)
R. rhinobatos	1.15	Gulf of Gabès	CAPAPÉ *et al.* (1997)
R. rhinobatos	1.43	Senegal	CAPAPÉ *et al.* (1999a)
Torpedo mackayana	1.20	Senegal	CAPAPÉ *et al.* (2001b)
T. marmorata	1.30	Senegal	CAPAPÉ *et al.* (2001a)
T. torpedo	1.58	Senegal	CAPAPÉ *et al.* (2000a)

embryo was included in a single chamber where it was protected by the uterine fluid and abortions naturally decreased as pregnancy advanced. LUCIFORA *et al.* (2004) noted that larger females lose a smaller proportion of their fecundity than do smaller females. Both categories of fecundity increased with the size of the females, corroborating data reported by CAPAPÉ & MELLINGER (1988) from the Gulf of Tunis and other marine areas.

In our sample, males outnumbered females in near-term embryos and all categories of specimens except juveniles, in agreement with OLSEN (1984) for *G. galeus* from southern Australia. In contrast, PERES & VOOREN (1991) and LUCIFORA *et al.* (2004) noted than females largely outnumbered males in their samples from southern Brazil and Argentina, respectively. Except for the Gulf of Tunis, the specimens included in our sample originated from open marine areas, where males generally outnumber females. This could be the result of females approaching the shore in search of nursery areas to expel their embryos (CASTRO, 1993). No neonates were observed in our sample, as in those of PERES & VOOREN (1991) and LUCIFORA *et al.* (2004), probably due to gear selectivity. *Galeorhinus galeus* near-term embryos are clearly smaller than those of other shark species in the area, and competition between neonate shark species cannot be excluded.

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REFERENCES

BASS, A.J., JD. D'AUBREY & N. KISTNASAMY. 1973. Sharks of the east coast of southern Africa. III. The genus *Carcharhinus* (Carcharhinidae). Invest. Rep. Ocean. Res. Inst., 33: 1-168.

BRADAÏ, M.N., B. SAÏDI, M. GHORBEL, A. BOUAÏN, O. GUÉLORGET & C. CAPAPÉ. 2002. Observations sur les requins du golfe de Gabès (Tunisie méridionale, Méditerranée centrale) (Observations on sharks from the Gulf of Gabès (Southern Tunisia, Central Mediterranean). Mésogée, 60: 61-77.

BRADAÏ, M.N., J.P. QUIGNARD, A. BOUAÏN, O. JARBOUI, A. OUANNES-GHORBEL, L. BEN ABDALLAH, J. ZAOUALI & S. BEN SALEM. 2004. Ichtyofaune autochtone et exotique des côtes tunisiennes: recensement et biogéographie (Autochtonous and exotic fish species of the Tunisian coasts: Inventory and biogeography). Cybium, 28 (4): 315-328.

BRANSTETTER, S. 1981. Biological notes on the sharks of the north central Gulf of Mexico. Contrib. Mar. Sci., 24: 13-34.

BRANSTETTER, S. 1984. Triakidae. In: J.P. Whitehead, M.L. Bauchot, J.C. Hureau, J. Nielsen and E. Tortonese (Editors). Fishes of the north-western Atlantic and the Mediterranean. Vol. I, UNESCO, Paris. pp. 117-121.

BRIDGE, N.F., D. MC KAY & G. NEWTON. 1998. Biology of the ornate angel shark (*Squatina tergocellata*) from the Great Australian Bight. Mar. Freshwater Res., 49: 679-686.

CADENAT, J. 1950. Poissons de mer du Sénégal (Fishes of the Senegal Sea). Init. Afr., 3: 1-345.

CADENAT, J. & J. BLACHE. 1981. Requins de Méditerranée et d'Atlantique (plus particulièrement de la côte occidentale d'Afrique) (Sharks from the Mediterranean and Atlantic (especially from the western coast of Africa). Faune trop., ORSTOM, 21: 1-330.

CAPAPÉ, C. 1974. Observations sur la sexualité, la reproduction et la fécondité de 16 sélaciens pleurotrêmes vivipares aplacentaires des côtes tunisiennes (Observations on sexuality, reproductive biology and fecundity of 16 viviparous aplacental pleurotremata selachians from the Tunisian coasts). Arch. Inst. Pasteur, Tunis, 51 (3): 229-256.

CAPAPÉ, C. 1984. Nouvelles données sur la morphologie et la biologie de la reproduction de *Carcharhinus plumbeus* (Nardo, 1827) (Pisces, Carcharhinidae) des côtes tunisiennes (New data of morphology and reproductive biology of *Carcharhinus plumbeus* (Nardo, 1827) (Pisces, Carcharhinidae) from the Tunisian coasts). Inv. Pesq., 48: 115-137.

CAPAPÉ, C. 1989. Les sélaciens des côtes Méditerranéennes: aspects généraux de leur écologie et exemples de peuplements (The Selachians from the Mediterranean coasts: General characters of their ecology and examples of populations). Océanis, 15: 309-331.

CAPAPÉ, C. 1993. New data on the reproductive biology of the thorny stingray, *Dasyatis centroura* (Pisces: Dasyatidae) in Tunisian waters. Environ. Biol. Fishes, 38: 73-80.

CAPAPÉ, C. & J. MELLINGER. 1988. Nouvelles données sur la biologie de la reproduction du milandre, *Galeorhinus galeus* (Linné, 1758) (Pisces, Triakidae) des côtes tunisiennes (New data on the reproductive biology of the school shark *Galeorhinus galeus* (Linné, 1758) (Pisces, Triakidae) from the Tunisian coasts). Cah. Biol. Mar., 29: 135-146.

CAPAPÉ, C. & J. ZAOUALI. 1994. Distribution and reproductive biology of the blackchin guitarfish, *Rhinobatos cemiculus* (Pisces: Rhinobatidae) in the Tunisian waters. Aust. J. Mar. Freshwater Res., 45: 551-561.

CAPAPÉ, C. & J. ZAOUALI. 1995. Reproductive biology of the marbled stingray, *Dasyatis marmorata* (Steindachner, 1892) (Pisces: Dasyatidae) in Tunisian waters (Central Mediterranean). J. Aquat. Sci., 7: 108-19.

CAPAPÉ, C., J.P. QUIGNARD & J. MELLINGER. 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: 347-356.

CAPAPÉ, C., J. ZAOUALI, J.P. TOMASINI & J.L. BOUCHEREAU. 1992. Reproductive biology of the spiny butterfly ray, *Gymnura altavela* (Linnaeus, 1758) (Pisces: Gymnuridae) from off the Tunisian coasts. Sci. Mar., 56: 347-355.

CAPAPÉ, C., M. DIOP & M. N'DAO. 1994. Observations sur la biologie de la reproduction de dix-sept espèces de sélaciens d'intérêt économique capturés dans la région marine de Dakar-Ouakam (Sénégal, Atlantique oriental tropical) (Observations on reproductive biology of seventeen selachian species captured in the marine area of Dakar-Ouakam (Senegal, eastern tropical Atlantic). Bull. Inst. Fond. Afr. Noire Cheikh Anta Diop, Dakar, Sér. A, 47: 87-102.

CAPAPÉ, C., J. ZAOUALI & R. BEN BRAHIM. 1997. Aspects de la biologie de la reproduction de la guitare commune, *Rhinobatos rhinobatos* L., 1758 (Rhinobatidae) des eaux tunisiennes (Méditerranée centrale) (Aspects of the reproductive biology of the common guitarfish, *Rhinobatos rhinobatos* L., 1758 (Rhinobatidae) from Tunisian waters (Central Mediterranean)). Icthyophysiol. Acta, 20: 113-127.

CAPAPÉ, C., A.A. SECK & A. GUEYE-NDIAYE. 1999a. Observations sur la biologie de la reproduction de la guitare commune, *Rhinobatos rhinobatos* (L., 1758) (Rhinobatidae) de la péninsule du cap Vert (Sénégal, Atlantique oriental tropical) (Aspects of the reproductive biology of the common guitarfish, *Rhinobatos rhinobatos* L., 1758 (Rhinobatidae) from Cape Verde Peninsula (Senegal, eastern tropical Atlantic)). Ichtyophysiol. Acta , 22: 87-101.

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

CAPAPÉ, C., A.A. SECK. & Y. DIATTA. 2000a. Reproductive biology of the common torpedo, *Torpedo torpedo* (Linnaeus, 1758) from the coast of Senegal. Miscel. Zool., 23 (1): 9-21.

CAPAPÉ, C., J.A. TOMASINI & J.P. QUIGNARD. 2000b. Les élasmobranches pleurotrêmes de la côte du Languedoc (France méridionale): observations biologiques et démographiques (Elasmobranchii Pleurotremata from the coast of Languedoc (southern France): biological and demographic observations). Vie Milieu, 50: 123-133.

CAPAPÉ, C., A. GUEYE-NDIAYE, Y. DIATTA, M. DIOP & A.A. SECK. 2001a. Observations on six elasmobranch species recorded from off the coast of Senegal (eastern tropical Atlantic). Acta Adriat., 42(1): 89-102.

CAPAPÉ, C., A.A. SECK, Y. DIATTA & M. DIOP. 2001b. Observations on the reproductive biology of *Torpedo (Tetronarce) mackayana* from off the coast of Senegal (eastern tropical Atlantic). Cybium, 25(1): 95-99.

CAPAPÉ, C., A.A. SECK., A. GUEYE-NDIAYE, Y. DIATTA & M. DIOP. 2002. Reproductive biology of the smooth angelshark, *Squatina oculata* (Elasmobranchii: Squatinidae), from the coast of Senegal (eastern tropical Atlantic). J. Mar. Biol. Assoc. U.K., 82: 635-640.

CAPAPÉ, C., O. GUÉLORGET, J. BARRULL, I. MATE, F. HEMIDA, R. SERIDJI, J. BENSACI & M.N. BRADAÏ. 2003a. Records of the bluntnose six-gill shark, *Hexanchus griseus* (Bonnaterre, 1788) (Chondrichthyes: Hexanchidae) in the Mediterranean Sea: a historical survey. Annales, Ser. Hist. Nat., 13(2): 99-108.

CAPAPÉ, C., F. HEMIDA, A.A. SECK, Y. DIATTA, O. GUÉLORGET & J. ZAOUALI. 2003b. Distribution and reproductive biology of the spinner shark, *Carcharhinus brevipinna* (Müller and Henle, 1841) (Chondrichthyes: Carcharhinidae). Isr. J. Zool., 49 (3): 269-286.

CAPAPÉ, C., F. HEMIDA, O. GUÉLORGET, J. BARRULL, I. MATE, J. BEN SOUISSI & M.N. BRADAÏ. 2004a. Reproductive biology of the bluntnose sixgill shark *Hexanchus griseus* (Bonnaterre, 1788) (Chondrichthyes, Hexanchidae) from the Mediterranean Sea: a survey. Acta Adriat., 45(1): 95-106.

CAPAPÉ, C., A.A. SECK, Y. DIATTA, C. REYNAUD, F. HEMIDA & J. ZAOUALI. 2004b. Reproductive biology of the blacktip shark, *Carcharhinus limbatus* (Chondrichthyes: Carcharhinidae) off west and north African coasts. Cybium, 28 (4): 275-284.

CAPAPÉ, C., Y. DIATTA, A.A SECK, O. GUÉLORGET, J. BEN SOUISSI & J. ZAOUALI. 2005. Reproduction of the sawback angelshark *Squatina aculeata* (Chondrichthyes: Squatinidae) off Senegal and Tunisia. Cybium, 29 (2): 147-157.

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

CASTRO, J.I. 1996. Biology of the blacktip shark, *Carcharhinus limbatus*, off the southeastern United States. Bull. Mar. Sci., 59 (3): 508-522.

CHIARAMONTE, G.E. 1998. Shark fisheries in Argentina. Mar. Freshwater Res., 49: 579-591.

COLLENOT, G. 1969. Etude biométrique de la croissance relative des ptérygopodes chez la petite roussette *Scyliorhinus canicula* L. (Biometrical study of clasper growth in the small spotted catshark *Scyliorhinus canicula* L.). Cah. Biol. Mar., 10: 309-323.

COMPAGNO, L.V.J. 1984. FAO species catalogue. Vol. 4. Sharks of the world. An annotated and illustrated catalogue of shark species known to date. Part 2. Carcharhiniformes. FAO Fish. Syn. (125): 251-655.

DIEUZEIDE, R., M. NOVELLA & J. ROLAND. 1953. Catalogue des poissons des côtes algériennes. Bull. Stn. Aquic. Pêch (Catalogue of fishes from the Algerian coasts). Castiglione (n.s.), 4, 1952 [1953]: 1-135.

DRIGGERS, W.B., D.A. OAKLEYS, G. ULRICH, J.K. CARLSON, B.J. CULLUM & J.M. DEAN. 2004. Reproductive biology of *Carcharhinus acronotus* in the coastal waters of South Carolina. J. Fish Biol., 64 (6): 1540-1551.

ECONOMIDIS, P.S. 1973. Catalogue des poissons de la Grèce (Catalogue of fishes of Greece). Hell. Oceanol. Limnol., 11: 421-600.

EUZET, L. 1960. Recherche sur les cestodes tétraphyllides des sélaciens des côtes de France (Researches on tetraphyllid cestods from the coasts of France). Nat. Monspel., Série Zool., 3: 7-263.

FISCHER, W., G. BIANCHI & W.B. SCOTT. 1981. Fiches FAO d'identification des espèces pour les besoins de la pêche. Atlantique centre-est; zones de pêche 34, 47 (en partie). Canada Fond de Dépôt. Ottawa, Ministère des Pêcheries et Océans du Canada, en accord avec l'organisation des Nations-Unies pour l'Alimentation et l'Agriculture, Vol. 165. Pag. var. (FAO species identification sheets for fishery purpose; fishing area 34, 47 (in part). Canada Fund of Deposit, Ministry of Fisheries and Oceans of Canada, with special authorization of Food and Agriculture Organization of the United Nations, Vol. 165. Var. pag.)

FRANCIS, M.P. 1998. New Zealand shark fisheries: development, size and management. Mar. Freshwater Res., 49: 579-591.

GOLANI, D. 1996. The marine ichtyofauna of the eastern Levant. History, inventory and characterization. Isr. J. Zool., 42: 15-55.

GOLANI, D. 1997. Handbook of the fishes of Israel (in Hebrew). Keter Publ. House: Jerusalem. 269 pp.

GOLANI, D. & O. SONIN. 1996. The occurrence of the tropical west African marine fishes *Acanthurus monroviae* (Acanthuridae) and *Arius parkii* (Ariidae) in the Levant. J. Ichthyol. Aquat. Biol., 2 (1): 1-3.

HAMLETT, W.C., A.M. EULITT, R.J. JARRELL & M.A. KELLY. 1993. Uterogestation and placentation in elasmobranchs. J. Exp. Zool., 266: 347-367.

HAMLETT, W.C., M.K. HYSELL, T. ROZYCKI, N. BRUNETTE, K. TUMILTY, A. HENDERSON. & J. DUNNE. 1999. Sperm aggregation and spermatozeugma formation in the male genital ducts in the clearnose skate, *Raja eglanteria*. Proc. 5th Indo-Pac. Fish Conf. Nouméa, 3-8 Nov. 1997. Soc. Fr. Ichthyol. & ORSTOM: Paris. pp. 281-291.

HAMLETT, W.C., G. KORMANIK, M. STORRIE, B. STEVENS & T.I. STEVENS. 2005. Chondrichthyan parity, lecithotrophy and matrotrophy. In: W.C. Hamlett (Editor). Reproductive biology and phylogeny of Chondrichthyes: sharksb batoids and chimaeras. Sci. Publ., Inc.: Enfield, NH, USA. pp.395-434.

HAZIN, F.B.H., P.G. OLIVEIRA & M.K BROADHURST. 2002. Reproduction of the blacknose shark (*Carcharhinus acronotus*) in coastal waters off northeastern Brazil. Fish. Bull., 100: 143-148.

HEMIDA, F. 1998. The shark and skate fishery in the Algerian basin: biological and technological aspect. Shark News, 12: 14.

HEMIDA, F. & C. CAPAPÉ. 2002. Observations on a female bramble shark, *Echinorhinus brucus* (Bonnaterre, 1788) (Chondrichthyes: Echinorhinidae), caught off the Algerian coast (southern Mediterranean). Acta Adriat., 43 (1): 103-108.

HEMIDA, F. & C. CAPAPÉ. 2003. Observations on blue sharks, *Prionace glauca* (L., 1758) (Chondrichthyes: Carcharhinidae), from the Algerian coast (southern Mediterranean). J. Mar. Biol. Assoc. U.K., 83 (4): 873-874.

HEMIDA, F. & N. LABIDI. 2001. Nouvelle liste commentée des requins de la côte algérienne (New annotated list of sharks from the Algerian coast). Rapp. Comm. Int. Mer Médit., 36: 273.

HEMIDA, F., R. SERIDJI, N. LABIDI, J. BENSACI & C. CAPAPÉ. 2002. New data on *Carcharhinus* spp (Chondrichthyes: Carcharhinidae) from off the Algerian coast (southern Mediterranean). Acta Adriat., 43 (2): 83-93.

HOLDEN, M.J. & R.G. HAROLD. 1979. The migrations of the tope, *Galeorhinus galeus* (L.), in the eastern North Atlantic as determined by tagging. J. Cons. Inter. Explor. Mer, 38: 314-317.

KABASAKAL, H. 2003. Historical and contemporary records of sharks from the Sea of Marmara, Turkey. Annales, Ser. Hist. Nat., 13(1): 1-12.

KROESE, M. & W.H.H. SAUER. 1998. Elasmobranch exploitation in Africa. Mar. Freshwater Res., 49: 573-578.

LUCIFORA, L.O., R.C. MENNI & A.H. ESCALANTE. 2004. Reproductive biology of the school shark, *Galeorhinus galeus*, off Argentina: support for a single southwestern Atlantic population with synchronized migratory movements. Environ. Biol. Fishes, 71: 199-209.

LYLE, J.M. 1987. Observations on the biology of *Carcharhinus cautus* (Whitley), *C. melanopterus* (Quoy & Gaimard) and *C. fitzroyensis* (Whitley) from northern Australia. Aust. J. Mar. Freshwater Res., 38: 701-710.

MAURIN, C. & M. BONNET. 1970. Poissons des côtes nord-ouest Africaines (campagnes de la Thalassa), (1962 et 1968) (Fishes of northwestern coasts of Africa). Rev. Trav. Inst. Sci. Tech. Pêch. Marit., 34: 125-170.

MELLINGER, J. 1989. Reproduction et développement des Chondrichthyens (Reproduction and development of Chondrichthyan fishes). Océanis, 15: 283-303.

MELLINGER, J. & J. WRISEZ. 1989. Biologie et physiologie comparée 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 (Compared biology and physiology of two oviparous selachians, the spotted catsharks *Scyliorhinus canicula* et *Scyliorhinus stellaris*. Dry matter, water and ions (Cl -, Na+, K+) during development). Bull. Soc. Zool. France, 114: 51-62.

MUUS, B.J. & P.B. DAHLSTRÖM. 1964-1966. Guide des poissons de mer et pêche (Guide of marine and commercial fishes). Delachaux & Niestlé: Lausanne. 244 pp.

NOTARBARTOLO DI SCIARA, G. & I. BIANCHI. 1998. Guida degli squali e delle razze del Mediterraneo (Guide of sharks and rays from the Mediterranean). Franco Muzzio, Padova. 388 pp.

OLSEN, A.M. 1954. The biology, migration, and growth rate of the school shark, (*Galeorhinus australis* (Macleay) (Carcharhinidae) in south-eastern Australian waters. Aust. J. Mar. Freshwater Res., 5: 353-410.

OLSEN, A.M. 1984. Synopsis of biological data on the school shark *Galeorhinus australis* (Macleay 1881). FAO Fish. Synop., 139: 1-42.

PERES, M.B. & C.M. VOOREN. 1991. Sexual development, reproductive biology and fecundity of the school shark *Galeorhinus galeus* off southern Brazil. Fish. Bull., 89: 655-667.

PUNT, A.E. & T.I. WALKER. 1998. Stock assessment and risk analysis for the school shark (*Galeorhinus galeus*) off southern Australia. Mar. Freshwater Res., 49: 719-731.

QUIGNARD, J.P. & C. CAPAPÉ. 1971. Liste commentée des sélaciens de Tunisie (Annotated list of Selachians from Tunisia). Bull. Inst. Natl. Sci. Tech. Océanogr. Pêche, Salammbô, 2 (2): 131-141.

QUIGNARD, J.P. & J.A. TOMASINI. 2000. Mediterranean fish biodiversity. Biol. Mar. Medit., 7 (3): 1-66.

QUIGNARD, J.P., A. RAIBAUT & J.P. TRILLES. 1962. Contribution à la faune ichtyologique sétoise (Contribution to the knowledge of ichthyofauna from off Sète). Nat. Monspel., Série Zool., 4: 61-85.

RANZI, S. 1932. Le basi fisio-morfologiche dello sviluppo embrionale dei Selaci (Physio-morphological basis of embryonic development of Selachians). I. Pubbl. staz. zool. Napoli, 12 (2): 256-60.

RANZI, S. 1934. Le basi fisio-morfologiche dello sviluppo embrionale dei Selaci (Physio-morphological basis of embryonic development of Selachians). II. Pubbl. staz. zool. Napoli, 14 (3): 331-437.

RIPLEY, W.E., 1946. The soup fin shark and the fishery. Fish. Bull. Fish Wild Serv. U.S., 61: 1-38.

SAÏDI, B., M.N. BRADAÏ, A. BOUAÏN, O. GUÉLORGET & C. CAPAPÉ. 2005. Reproductive biology of the sandbar shark, *Carcharhinus plumbeus* (Chondrichthyes: Carcharhinidae) from the Gulf of Gabès (southern Tunisia, Central Mediterranean). Acta. Adriat., 46 (1): 47-62.

SCHWARTZ, F.J. 1984. Occurrence, abundance, and biology of the blacknose shark, *Carcharhinus acronotus* in North Carolina. Northeast Gulf Sci., 7 (1): 29-47.

SECK, A.A., Y. DIATTA, M. DIOP, O. GUÉLORGET, C. REYNAUD & C. CAPAPÉ. 2004. Observations on the reproductive biology of the blackchin guitarfish, *Rhinobatos cemiculus* E. Geoffroy Saint-Hilaire, 1817 (Chondrichtyes, Rhinobatidae) from the coast of Senegal (eastern tropical Atlantic). *Sci. Gerud.,* 27: 19-30.

SÉRET, B. & P. OPIC. 1990. Poissons de mer de l'ouest Africain tropical (Marine fishes of western tropical Africa). Init.-Doc., 49. ORSTOM: Paris. 416 pp.

SIMPFENDORFER, C.A. & P. UNSWORTH. 1998. Reproductive biology of the whiskery shark, *Furgaleus macki*, off south-western Australia. Mar. Freshwater Res., 49: 687-693.

STEVENS, J.D. 1990. Further results from a tagging study of pelagic sharks in the north-east Atlantic. J. Mar. Biol. Assoc. U.K., 70: 707-720.

STEVENS, J.D. & K.J. MCLOUGHLIN. 1991. Distribution, size and sex composition, reproductive biology and diet of sharks from northern Australia. Aust. J. Mar. Freshwater Res., 42: 151-199.

WALKER, T.I. 1999. *Galeorhinus galeus* fisheries of the world. In: Case studies of management of elasmobranchs fisheries. FAO Fish. Tech. Paper, 378/2: 728-773.

WALKER, T.I. 2005. Reproduction in fisheries science. In: W.C. Hamlett (Editor). Reproductive biology and phylogeny of Chondrichthyes: sharks, bgatoids and chimaeras. Sci. Publ., Inc.: Enfield, NH, USA. pp. 728-773.

WATSON, G. & M.J. SMALE. 1998. Reproductive biology of shortnose spiny dogfish, *Squalus megalops*, from the Agulhas Bank, South Africa. Mar. Freshwater Res., 49: 695-703.

WOURMS, J.P. 1977. Reproduction and gestation in Chondrichthyans fishes. Am. Zool., 17: 379-410.

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

WOURMS, J.P., J.P. GROOVE & J. LOMBARDI. 1988. The maternal-embryonic relationship in viviparous fishes. In: W.S. Hoar., D. J. Randall & E. M. Donaldson (Editors). Fish physiology Vol. 1. Academic Press: New York. 134 pp.

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Biologija reprodukcije psa butora, *Galeorhinus galeus* Linnaeus 1758 (Chondrichthyes: Triakidae), s obale Magreba (južni Mediteran)

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SAŽETAK

Pas butor, *Galeorhinus galeus* uobičajeno se lovi u južnom Mediteranu izvan obale Magreba, uzduž alžirske i tuniske obale. Od 517 primjeraka, sabranih kroz više od 20 godina, najmanji adultni mužjak bio je dug 1225 mm (TL) i težio je 11580 g, a najveći je imao dužinu od 1580 mm i težinu od 19900 g. Svi mužjaci, dužine veće od 1260 mm TL, bili su odrasli. Odrasle ženke imale su 1400 – 1900 TL. Najmanja ženka s embrijima u razvitku imala je 1400 mm TL. Najveća ženka imala je TL 1990 mm i težila je 27900 g. Uobičajeno su ženke bile teže od mužjaka, iako nije postojala signifikantna razlika između mužjaka i ženki s obzirom na odnos mase i ukupne dužine. Postoje 2 ovulacije i dva razvoja mladih – zimi i u proljeće. Procijenjeno je da trudnoća traje 12 mjeseci. Glavnina ženki se razmnožava u naizmjeničnim godinama. Promjer najveće oocite sa žumanjcem iznosio je 43-47 mm (prosjek 44,7±2,2). Oba uterusa bila su podijeljena u komorice i u svakoj od komorica se razvijao po jedan embrij. Dužina i težina kod rođenja, mjerena na embrijima vrlo bliskog datuma, procijenjene su na 240 –320 mm TL i 88 – 109 g. Kemijska ravnoteža razvoja, bazirana na prosječnoj suhoj težini najvećih oocita sa žumanjcem i embrijima bliskog vremenskog razdoblja, bila je oko 1, što znači da se *G. galeus* može smatrati semi-lecitotrofnom vrstom. Ovarijska plodnost bila je veća od uterine plodnosti. Veličine izlegnutih mladih bile su od 8 do 41. Općenito je bilo više mužjaka nego ženki, naročito među slobodno plivajućim odraslim primjercima.

Ključne riječi: Chondrichthyes, Triakidae, *Galeorhinus galeus,* reproduktivna biologija, obala Magreba