



Biological observations on a rare deep-sea shark, *Dalatias licha* (Chondrichthyes: Dalatiidae), off the Maghreb coast (south-western Mediterranean)

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Abstract. Investigations conducted off the Maghreb coast allowed to capture 47 kitefin sharks *Dalatias licha* (Bonnaterre, 1788) and to state that the species is not completely extinct in the area. In the observed sample, males significantly outnumbered females ($df = 1$; $\chi^2 = 4.8$; $p > 0.05$), with sex-ratio F: M = 1: 2.1. All males over 740 mm TL were adult. A pregnant female carried 6 developing embryos, 3 males and 3 females, between 340 and 360 mm TL, which exhibited a conspicuous yolk sac. In the female, both ovaries were in a resting phase, suggesting that the vitellogenesis and embryonic development were not concomitant in *D. licha*. The species probably reproduces in alternate years. The breeding period occurs in the summer in the region. *D. licha* feeds mainly on fishes, occasionally on cephalopods.

Key words: reproductive biology, pregnant female, size at birth, diet.

Resumen: Observaciones biológicas sobre un raro tiburón de aguas profundas, *Dalatias licha* (Chondrichthyes: Dalatiidae), aguas afuera de la costa de Maghreb (Mediterráneo sudoccidental). Investigaciones conducidas aguas afuera de la costa de Maghreb permitieron capturar 47 carochos *Dalatias licha* (Bonnaterre, 1788) y establecer que la especie no está completamente extinta en esa área. En la muestra observada, el número de machos superó el número de hembras de forma significativa ($df = 1$; $\chi^2 = 4.8$; $p > 0.05$), siendo la razón sexual H: M = 1: 2.1. Todos los machos con tamaños mayores que 740 mm de longitud total eran adultos. Una hembra preñada contenía 6 embriones en desarrollo; 3 machos y 3 hembras con tamaños entre 340 y 360 mm de longitud total, exhibiendo un conspicuo saco vitelínico. En ésta hembra preñada, ambos ovarios se encontraban en fase de reposo, lo que sugiere que la vitelogénesis y el desarrollo embrional no suceden concomitantemente en *D. licha*. Esta especie probablemente se reproduce bianualmente. El parto sucede en verano en esta región. *D. licha* se alimenta principalmente de peces, ocasionalmente de cefalópodos.

Palabras clave: biología reproductiva, hembra preñada, tamaño al nacer, dieta.

Introduction

The kitefin shark *Dalatias licha* (Bonnaterre 1788) has a widespread distribution known on both sides of the Atlantic (Bigelow & Schroeder 1948, Mc Eachran & Branstetter 1984). *D. licha* is largely distributed off the eastern Atlantic from both British and Irish waters (Wheeler, 1969) to Morocco (Collignon & Aloncle 1972). Southward, the species

is reported off Madeira and Azores Islands (Perrotta 2004), and from Senegal (Cadenat & Blache 1981) to South Africa (Bass *et al.* 1976). Additionally, the species is also known elsewhere off New Zealand, Australia, Japan and Taiwan (Mc Eachran & Branstetter 1984). In the Mediterranean, *D. licha* was previously reported in the western basin only,

and the coast of Greece was its easternmost range extension (McEachran & Branstetter 1984). Nevertheless, further reports showed that the species occurs in the eastern Levantin Basin: off Turkey (Meriç 1995; Kabasakal & Kabasakal 2002), Israel (Golani, 2004) and Syria (Saad *et al.* 2004).

In the south-western Mediterranean, *D. licha* is reported as very rare off the northern coast of Tunisia, and unknown southward (Bradaï *et al.* 2002). Dieuzeide *et al.* (1953) previously noted that the species was also very rare off the Algerian coast. Investigations conducted in the area from 1998 to date offered us the opportunity to capture several specimens. These captures allowed us to give new biological data on this poorly known species, for which information in the literature is scarce according to Bass *et al.* (1976) and Compagno (1984). Additionally, these captures suggest us to reconsider the occurrence of the species in the area, in order to assess its real status in the region, for establishing elasmobranch monitoring and to prepare a plan for elasmobranch species in the region, as well.

Material and Methods

Of the 47 specimens of *Dalatias licha* observed, 8 were caught off the northern Tunisian coast between 1970 and 2007, by bottom trawling at depths between 200 and 600 on sandy-muddy bottoms, and 39 off the Algerian coast between 1996 and 2007, also by bottom trawling at similar depths and bottoms types. All the specimens were measured to the nearest mm, 22 were weighed to the nearest gramme. In addition, six embryos were removed from a pregnant female, sexed and measured.

Stomachs of the specimens caught off the Tunisian coast were dissected and their contents identified to the lowest taxon when possible.

Sexual maturity in males was determined from the length of claspers following Collenot (1969) and condition of the claspers following Capapé *et al.* (2008). Only a single adult pregnant female was dissected, the condition of other females was not determined.

With special regard to the relationship between total length (TL) and total mass (TM), the linear regression was expressed in decimal logarithmic coordinates. Correlations were assessed by least-squares regression. Test for significance was performed by using the chi-square test ($p > 0.05$).

Results

Of the 39 specimens caught off the Algerian coast, 28 were from Annaba, off the eastern region, 4 from Algiers, off the Central region and 7 from Ouahran, off the western region (Fig. 1); 23 were males, 10 females and 6 other specimens cannot be sexed; in addition, six developing embryos, 3 males and 3 females were removed from a pregnant female. Regarding the specimens from the Tunisian coast, 5 males and 3 females, were caught off the northern area, close to Algerian border (Fig. 1). In the total sample, among the sexed specimens, including embryos, males significantly outnumbered females ($df = 1$; $\chi^2 = 4.8$; $p > 0.05$), with sex-ratio F: M = 1: 2.1.

The size composition of the total sample is plotted in Fig. 2. Most of the observed specimens were larger than 700 mm TL, while the other specimens were smaller than 600 mm TL.

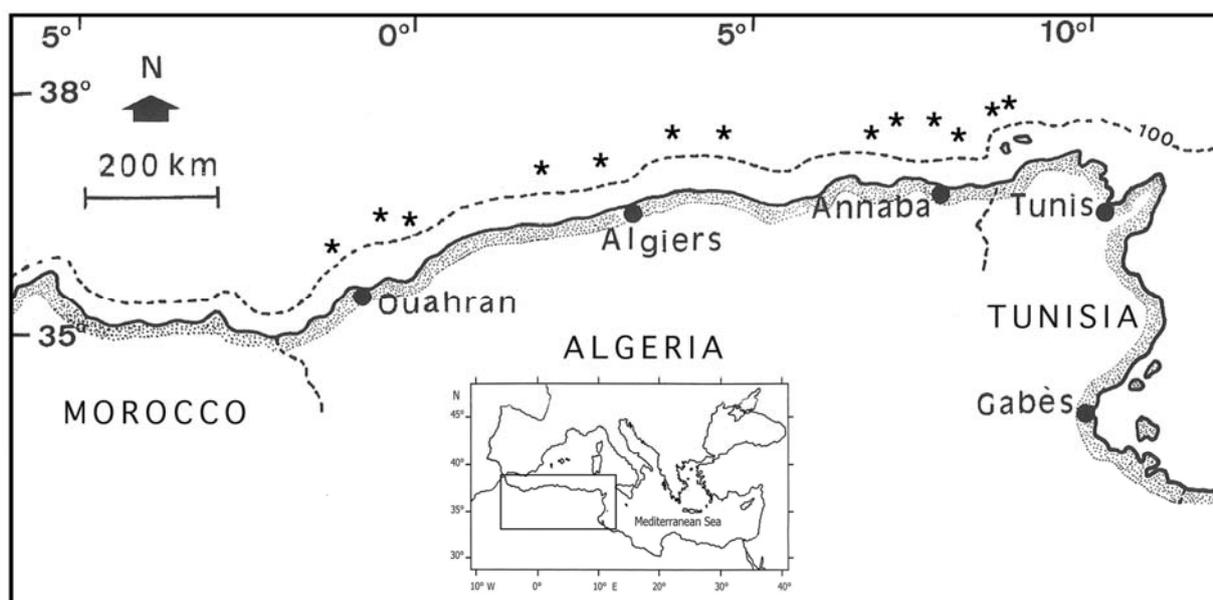


Figure 1. Map of the Mediterranean Sea showing the Maghreb coast, blackstars pointing out the capture sites of *Dalatias licha* from the studied sample.

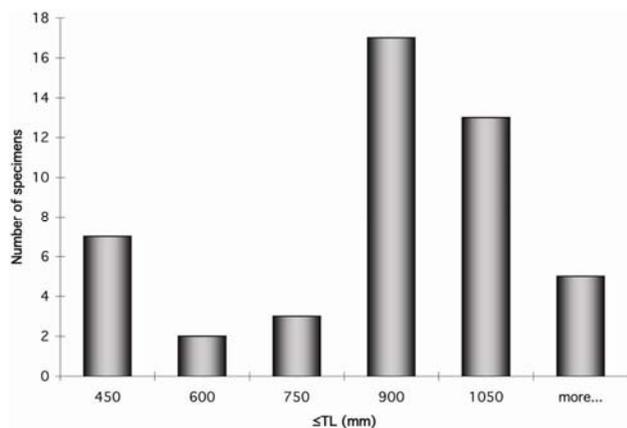


Figure 2. Size composition of total studied sample, total length (TL) expressed in millimetre.

The 4 smallest free-swimming specimens were between 320 and 390 mm TL, and weighed between 256 and 300 g. They exhibited an unhealed scar on the ventral surface and remains of yolk in the internal vitelline vesicle indicating that they probably were neonates (Fig. 3). The largest specimen recorded was a pregnant female with 1170 mm TL (Fig. 4), carrying six developing embryos, 3 in each uterus not compartmented in chambers. Two males and one female were found in the left uterus, and two females and one male in the right one. All embryos exhibited an obvious yolk sac and measured between 340 and 360 mm TL (Fig. 5). Both ovaries bore translucent oocytes and atretic follicles. The heaviest weighed specimen had 3300 g TM and reached 925 mm TL. The relationship TL between and TM was: $\log TM = 2.629 \log TL - 4.267$, $r = 0.99$, $n = 22$ (Fig. 6). The smallest adult male was 740 mm TL, and weighed 2000 g, all males over this TL were adults.

Of the 8 examined stomach contents from specimens caught off the Tunisian coast, two were empty. Four stomach contained remains of unidentified teleost species, one stomach contained a neurocranium of *Merluccius merluccius* and one stomach, a complete egg capsule of the blackmouth catshark *Galeus melastomus* Bonaparte, 1810 and remains of two cephalopod species belonging to the genus *Sepiola*.

Discussion

Although, *Dalatias licha* is widely distributed, it is considered rare in most of its range areas. The species was targeted off the Azores Islands to obtain liver oil and therefore subjected to a drastic population decline between 1991 (900 tons) and 1998 (18 tons) according to Perrotta (2004). Moreover, *D. licha* is included in the IUCN Red List of threatened species (Compagno & Cook 2000), due probably to its *K*-selected biological

characteristics (*sensu* McAuley *et al* 2007). The captures of several specimens off the Algerian coast, area where *D. licha* was formerly considered as very rare did not suggest a recovery of the species; instead these records would be due to the fact that the species occurs in a deep area previously unexploited by the usual fishing gears according to information provided by fishermen, what suggests that the species is not already disappeared from the area. In our sample, males significantly outnumbered females, in agreement with Bottaro *et al.* (2003),



Figure 3. Juvenile specimen 660 mm total length caught off Algiers, central region of the Algerian coast (photo F. Hemida).

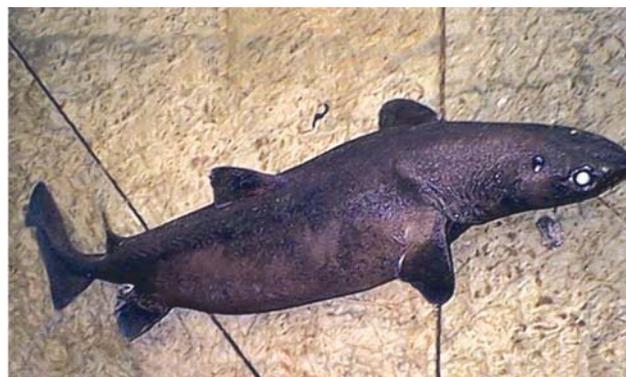


Figure 4. Pregnant female 1170 mm total length caught off Algiers, central region of the Algerian coast (photo F. Hemida).

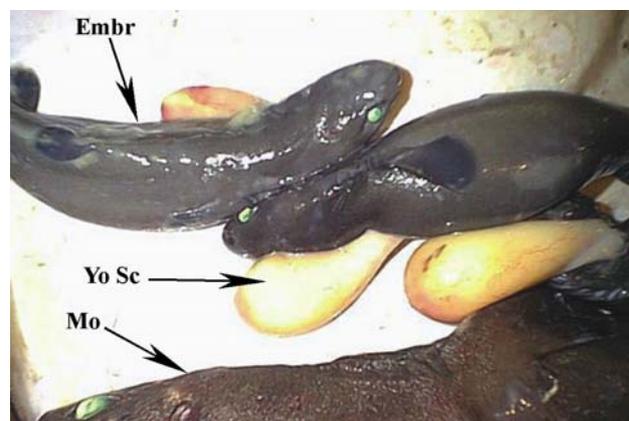


Figure 5. Developing embryos (Embr) with yolk sac (Yo SC) removed from a pregnant female (Mo) 1170 mm total length caught off Algiers, central region of the Algerian coast (photo F. Hemida).

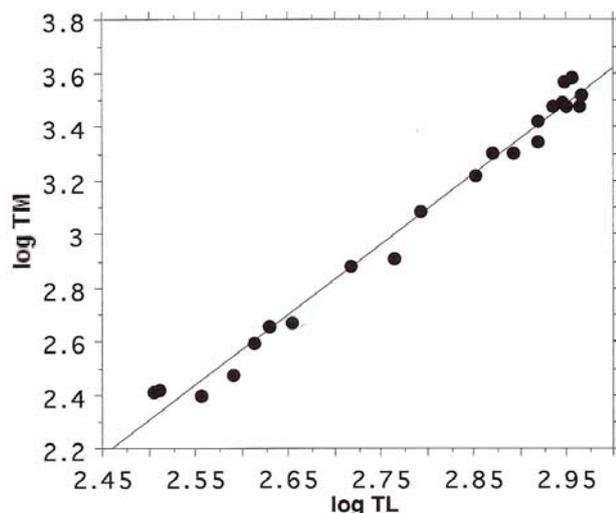


Figure 6. Relationship between total length (TL) and total mass (TM), expressed in decimal logarithmic coordinates, in *Dalatias licha* from the Maghreb coast.

who noted that in Gulf of Genoa (Ligurian Sea, northern Mediterranean), 'the sex-ratio is unbalanced 1: 5 (F: M)'. In the opposite, off South Africa Bass *et al.* (1976) reported that of the 38 specimens of *D. licha* observed 18 were males and 20 females. These differences may be the result of sampling mode. Additionally, among the embryos we have observed, males and females were equally distributed, and they were also equally distributed in both uteri.

Off south Africa, the maximum TL recorded for *D. licha* was 1590 mm (Bass *et al.* 1976), and possibly 1820 mm according to Compagno (1984). Males mature between 770 and 1210 mm, while females between 1170 to 1590 mm. Specimens from this area are larger and mature at a larger size than those from the Maghrebine coast, this phenomenon could be explained by intraspecific variations in size according to area in elasmobranch species, probably due to environmental conditions (Mellinger 1989, Capapé *et al.* 2004). Bigelow & Schroeder (1948) noted that size at birth occurred at about 300 mm total length and recorded an embryo of 270 mm TL with a large yolk sac. The smallest specimen observed by Bass *et al.* (1976) was a 360 mm female with an unhealed umbilical scar but having begun to feed on squid. Bottaro *et al.* (2003) noted that in the Gulf of Genoa, 'smallest and largest specimen found (TL) were respectively 355 mm, and 1164 mm, for females, while 369 mm, and 955 mm, for males' and added that all females larger than 980 TL were mature. The developing embryos from the Algerian coast were slightly larger, between 340 and 360 mm, however two neonates from this area were 360 and 390 mm TL respectively; additionally two neonates from the Tunisian coast were 320 and 325 mm TL

respectively, having the gut empty. Size at birth probably occurred between 320 and 390 mm off the Maghreb coast. Kabasakal & Kabasakal (2002) found 3 specimens with healing umbilical scar on the ventral surface, and considered them as probably neonates although they had food in gut. Size at birth probably occurs at larger size off the Maghreb coast. Consequently, it seems that it exists no relation between maximum size, size at maturity and size at birth in *D. licha*, and larger specimens did not give birth to larger neonates.

According to Bigelow & Schroeder (1948) pregnant females contained from 10 to 16 embryos, Chen (1963) reported a pregnant female carrying 15 embryos from Taiwan. Quéro *et al.* (1987) recorded from the Bay of Biscaye a 1360 mm TL pregnant female carrying 7 embryos. Bottaro (personal communication 2008) informed us that in the Gulf of Genoa, a first pregnant female, having 1056 mm TL and weighing 3428 g, carried 3 embryos, while a second, having 985 mm TL and weighing 4400 g, carried a single embryo. All observed embryos were developing in uteri of each female. Litter size is related to female size in *D. licha*. Bass *et al.* (1976) did not report captures of pregnant females, but recorded females with ripe oocytes, from 70 to 90 mm, in both ovaries, the number of oocytes ranging between 10 and 20, occasionally less, the uteri being empty and probably in a resting phase. The pregnant female described in this study carried developing embryos while both ovaries were in a resting phase. So, vitellogenesis did not proceed in parallel with embryonic development in *D. licha*. Similar patterns were reported in related species such as the velvet belly *Etmopterus spinax* (Linnaeus 1758) from the Tunisian coast (Capapé *et al.* 2001) and the angular rough shark *Oxynotus centrina* from Mediterranean areas (Capapé *et al.* 1999, Megalofonou & Damalas 2004). Consequently, *D. licha* probably reproduces in alternate years. Off the Maghreb coast, developing embryos were observed in July, while neonates were caught in August and early September, parturition probably occurs in summer in the region. Additionally, Tortonese (1956) stated that the breeding season of *D. licha* from the Mediterranean is autumn. Kabasakal & Kabasakal (2002) noted that captures of neonates and post-neonatal specimens suggests that the breeding season of *D. licha* from the northern Aegean Sea is also autumn.

Bigelow & Schroeder (1948), Capapé (1975) and Compagno (1984) noted that the kitefin sharks mainly feed on fishes. McPherson (1980) recorded mainly fishes in the stomach contents of *D. licha* from western Mediterranean and occasionally

crustaceans and decapods. Similar patterns were reported by Kabasakal & Kabasakal (2002) from Aegean Sea. Occurrence of cephalopods were observed in our sample. Records of *G. melastomus* were reported in guts of *D. licha* by McPherson (1980), Matallanas (1982), Kabasakal & Kabasakal (2002) and Bottaro *et al.* (2003), while we have found an egg capsule in one specimen. Additionally, Matallanas (1982) in Catalan waters and Bottaro *et al.* (2003) in the Gulf of Genoa recorded the velvet belly and other deep sea teleost species in guts of *D. licha*. Additionally, the occurrence of neonates, the pregnant female

observed, and the relationship between total length and total mass showed that *D. licha* found in the area favorable environmental conditions, and sufficient available food to reproduce and develop in the area.

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Received September 2008
 Accepted October 2008
 Published online November 2008