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On the occurrence of Leatherback Turtles *Dermochelys coriacea* (VANDELLI, 1761), in Tunisian waters (Central Mediterranean Sea)

(Testudines: Dermochelydae)

Zum Vorkommen der Lederschildkröte, *Dermochelys coriacea* (VANDELLI, 1761) in den Gewässern vor Tunesien (Zentrales Mittelmeer)

(Testudines: Dermochelydae)

SAMI KARAA & IMED JRIBI & ABDERRAHMEN BOUAIN & MARC GIRONDOT & MOHAMED NEJMEDDINE BRADAÏ

KURZFASSUNG

Insgesamt liegen aus der Literatur und mit den hier präsentierten neuen Daten 51 Beobachtungen der Lederschildkröte *Dermochelys coriacea* (VANDELLI, 1761) aus den Gewässern vor der Küste Tunesiens aus dem Zeitraum 1907-2011 vor.

Die meisten der vermessenen Weibchen und Männchen waren erwachsen (Panzerlänge entlang der Wölbung > 145 cm). Schildkrötenfunde erfolgten das ganze Jahr über, die meisten davon in der mittleren und südlichen Untersuchungszone. Dabei wurden die Schildkröten vor allem im Süden von Tunesien in warmen Perioden des Jahres beobachtet, was mit dem zahlreichen Auftreten von Quallen zu dieser Jahreszeit zusammenhängen könnte.

Sechsunddreißig von 51 Nachweisen (70,58 %) stammen aus Beifang der Fischerei wobei Stellnetze die größte Bedrohung für Lederschildkröten in dieser Region darstellen. Die erhöhte Fundhäufigkeit der Lederschildkröte fällt zeitlich mit dem vermehrten Auftreten anderer Quallenfresser wie dem Mondfisch *Mola mola* zusammen. Systematische Überwachung der Lederschildkröten und das Sammeln der Daten ist notwendig, um das Wissen über Verbreitungsgebiet, Verhalten und Ernährung der Art in tunesischen Gewässern zu vermehren.

ABSTRACT

A total of 51 records of the Leatherback Turtle, *Dermochelys coriacea* (VANDELLI, 1761) from Tunisian waters during 1907-2011, are reviewed based upon published literature and present records.

Most measured females and males were adult (curve carapace length, CL > 145 cm). Findings occurred throughout the year, mostly in the central and southern study zones. However, more turtles were observed in the south during the warm period of the year possibly related to the abundance of jellyfishes during that season.

Thirty-six out of 51 records (70.58 %) derived from fishery bycatch; gillnets are the dominant threat to leatherbacks in the region. The relatively high frequency of the Leatherback coincides with an increased presence of other jellyfish consumers, such as the sunfish *Mola mola*. Systematic monitoring and Leatherback data collection is necessary to increase the knowledge on this species' distribution, behavior and feeding in Tunisian waters.

KEYWORDS

Reptilia: Testudines: Dermochelydae: *Dermochelys coriacea*, Leatherback Turtle, Tunisia, Central Mediterranean Sea, ecology, behavior, distribution, size, threats, gillnet fishing, conservation

INTRODUCTION

The Leatherback Turtle, *Dermochelys coriacea* (VANDELLI, 1761), is a highly negatively impacted and inadequately understood marine turtle which subsists almost entirely on jellyfish and other gelatinous zooplankton (JAMES & HERMAN 2001). Following a sharp global population decline over the past two decades (SPOTILA et al. 2000), this huge turtle is currently listed as critically endangered in the world conservation Union Red List (IUCN 2011) and is included in Appendix I of the Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES).

Due to its thermoregulatory skills (i.e., functional endothermy), Leatherbacks occur

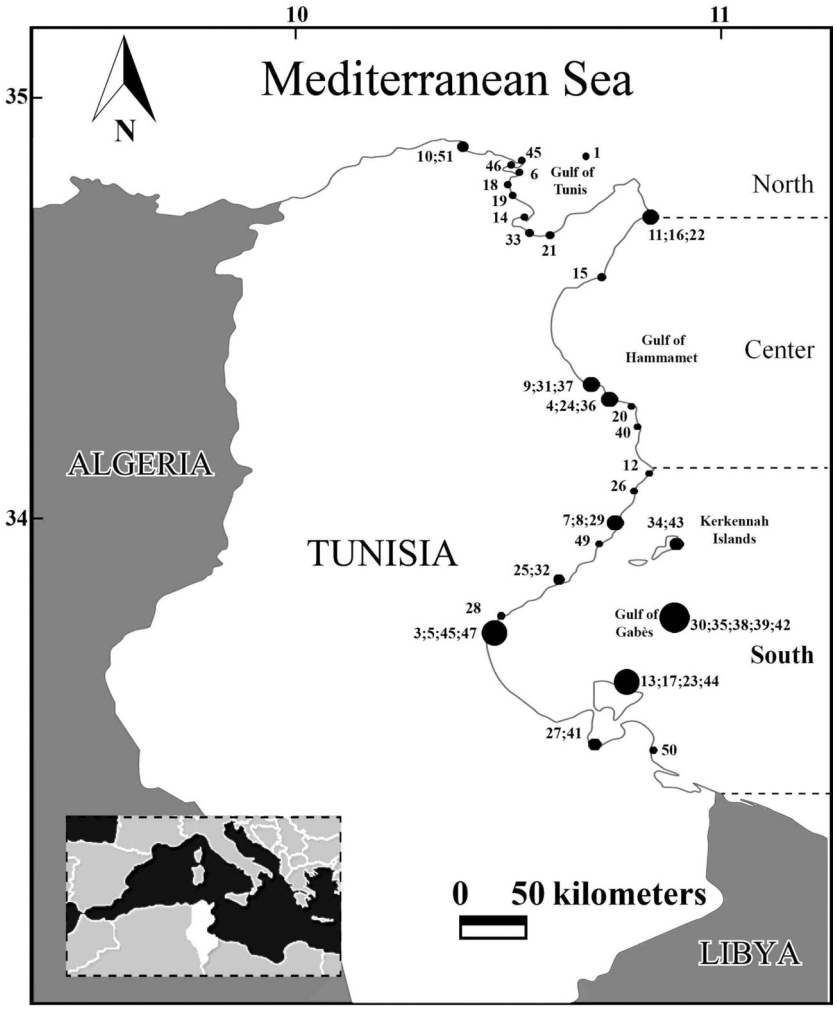

Fig. 1: Distribution of recoveries of Leatherback Turtles, *Dermochelys coriacea* (Vandelli, 1761), in the Tunisian Sea. Record numbers refer to corresponding numbers (No.) in Table 1.

Abb. 1: Verteilung der Funde von Lederschildkröten, *Dermochelys coriacea* (Vandelli, 1761) im Tunesischen Meer. Die Numerierung der Funde korrespondiert mit den Nummern der Nachweise (No.) in Tabelle 1.

even at unusual high latitudes and, thus have the widest distribution range among all sea turtle species (Paladino et al. 1990). Nesting colonies are distributed mainly in the tropics, but the turtle regularly utilizes temperate seas during its trans-oceanic journeys (Brongersma 1972; Hays et al. 2004).

Leatherbacks observed in the Mediterranean Sea are of Atlantic origin; their reproduction could occur in Guyana, Trinidad, Suriname and Gabon (Duguy 1983, 1986; Girondot & Fretey 1996; Eckert 1998; Fossette et al. 2008; Sonmez et al. 2008). Reproduction in the Mediterranean, if it occurs, is exceptional (Lescure et al. 1989; Groombridge 1990).

In Tunisia, leatherbacks have been described since the beginning of the century

(BLANC 1908). HELDT (1933) compiled captures and stranding of five individuals of this species along Tunisian coasts from 1930 to 1933. Recently, data on Leatherbacks were collected by BRADAÏ et al. (2004). However, information on Leatherback Turtles in Tunisia was mainly focused on a listing of their records without reviewing its distribution and its threats.

This work reviews information on *D. coriacea* in Tunisian waters, which will provide wildlife managers additional information for conservation planning in the area.

MATERIALS AND METHODS

Records and data on the size, weight, sex, condition at the time of recovery, and method of the recovery of Leatherback Turtles from the coastal and offshore waters of Tunisia were compiled based on the existing scientific and grey literature, including technical and scientific congress reports, as well as on unpublished/personal observations (BLANC 1908; HELDT 1933; HACHAICHI & RAIS 1985; LAURENT et al. 1990; BRADAÏ et al. 2004).

Specimens were classified as stranded or incidentally caught and the fishing gears were indicated. When available, lengths of specimens were indicated. Turtles with a curved carapace length (CL) less than 105 cm were considered juveniles (STEWART et al. 2007).

Given that the minimum size of reproductive females generally used as the threshold of maturity, varies by location and population (STEWART et al. 2007), and the nesting sites of the Mediterranean Leatherbacks are not known, CL = 145 cm was arbitrarily taken as the minimum size to determinate sex at maturity according to the external aspect of the tail. Tail length, a trait that changes with age, is longer in the male than in the female, therefore the presence of the large and muscular prehensile tail which extends well beyond the carapace characterize the adult male (WIBBELS 1999).

To analyze the spatio-temporal distribution of the Leatherback records, the coasts of Tunisia were arbitrarily divided into three zones: the north (from the border with Algeria to Kélibia), the center (from Kélibia to Chebba) and the south, viz. the Gulf of Gabès (from Chebba to the Libyan border) (Fig. 1).

Spatio-temporal repartition (north, center and south) was analyzed using a generalized linear model with multinomial distribution and logit link function. Independent variables were the months of capture or stranding, the status (dead or alive) and the curve carapace length. First order interactions were included during the fit. Independent variables with non-significant effect ($p > 0.05$) were eliminated until all remaining effects were significant.

RESULTS AND DISCUSSION

This report compiled 51 (42 from the literature and nine unpublished) records of Leatherback Turtles in Tunisian waters (Table 1 and reference therein). Considering that Tunisia's coastline covers 1,200 km, representing about 2.5 % of the coasts of the Mediterranean (about 46,000 km), and that the number of Leatherbacks recorded represents about 10 % of the entire Mediterranean Leatherback records (based upon 411 individual records from CASALE et al. [2003]), the frequency of occurrence of Leatherbacks in this area is about four times higher than the average of the entire Mediterranean Sea. Although a bias due to the difference in fishing and/or research effort cannot be totally excluded, such analysis suggests that the Tunisian waters are of some importance for the Leatherback Turtles as either a crossing point in their movement between the north and the south Mediterranean or as a foraging habitat rich in jellyfish.

Table 1: Records of the Leatherback Turtle, *Dermochelys coriacea* (Vandelli, 1761), in the Tunisian Sea. No. - number of the record; N - north; C - center; S - south; Condition - condition at the time of recovery; CL- carapace length; INSTM - National Institute of Sciences and Sea Technology, Salammbô; m - male; f - female; 1 - Blanc (1908); 2 - Heldt (1933); 3 - Hachaichi & Rais (1985); 4 - Laurent et al. (1990); 5 -Bradaï et al. (2004); 6 - present work.

Tab 1: Nachweise der Lederschildkröte *Dermochelys coriacea* (Vandelli, 1761) in tunesischen Gewässern. No. - Nummer des Datensatzes; N – Nord; C – Zentrum; S - Süd; CL - Karapaxlänge; INSTM - National Institute of Sciences and Sea Technology, Salammbô; m - männlich; f - weiblich; 1 - Blanc (1908); 2 - Heldt (1933); 3 - Hachaichi & Rais (1985); 4 - Laurent et al. (1990); 5 -Bradaï et al. (2004); 6 - diese Arbeit.

No	Date / Datum	Locality, Zone / Fundort, Zone	Condition / Zustand bei der Bergung	CL (cm)	Body mass (kg) Körper-masse	Sex Sex	Method of recovery / Bergungs-methode	Remark / Bemerkung	Reference / Quelle
1	1907	Gulf of Tunis, N	?	?	?	?	caught		1
2	1930 June	Sidi daoud, N	?	200	300	?	caught		2
3	1930 Sept. 13	Gabès, S	?	210	650	?	caught		2
4	1933 May 17	Monastir, C	?	150	300	f	caught	mature female (large follicles/ eggs of 5 cm diameter)	2
5	1933 May 27	Gabès, S	?	195	?	f	caught		2
6	1933 June 3	Sidi daoud, N	?	180	200	m	caught		2
7	1950 April 18	Sfax, S	?	167	200	f	caught		3
8	1955 Jan.	Sfax, S	dead	?	?	?	caught		3
9	1955 Feb.	Sousse, C	dead	?	?	?	caught		3
10	1955 Feb.	Bizerte, N	dead	?	?	?	caught		3
11	1965 Dec.	Kelibia, N	alive	180	?	?	caught, coastal fisheries	died in captivity (INSTM)	3
12	1975	Chebba, C	alive	?	?	?	caught, coastal fisheries	died in captivity (INSTM)	3
13	1978	Jerba, S	dead	?	?	?	stranded		3
14	1983 Sept. 09	Sidi Bou Said (Gulf of Tunis), N	alive	167	250	?	caught, trammel nets (25 m deep)	See footnote 1	3
15	1983 Nov. 23	Hammamet, C	alive	200	400	?	stranded	released in 6 m deep water	3
16	1983 Dec. 10	Kelibia, N	alive	207	500	m	caught, trammel nets	died in captivity (INSTM)	3
17	1985 Aug. 21	Jerba, S	?	167	?	m	caught, coastal fisheries		4
18	1985 Dec.	Tunis, N	?	?	?	?	caught		4
19	1985 Dec.	Ghar El Melh, N	?	?	?	?	caught		4
20	1986 Aug.	Ksibet El Mediouni, C	?	?	?	?	caught, coastal fisheries	photo-identification	4
21	1986 Nov. 11	Sidi Rais, N	?	?	?	?	caught		4
22	1987 Dec.	Kelibia, N	?	?	?	?	caught		4

Table 1 (continued from opposite page)
Tab. 1 (Fortsetzung der gegenüberliegenden Seite)

23	1987 March 25	Jerba, S	?	145	?	?	caught, coastal fisheries		4
24	1987 April	Monastir, C	?	?	?	?	caught, coastal fisheries		4
25	1987 July 02	Skhira, S	?	149	?	?	caught, trammel nets		4
26	1990 April 18	Ellouza, S	alive	150	?	f	caught, trammel nets	10-15 m deep	5
27	1990 June 27	Boughrara, S	alive	180	?	?	caught, coastal fisheries		5
28	1991 July 10	Ghannouch, S	dead	140	?	?	stranded		5
29	1991 Nov. 12	Sfax, S	alive	160	?	m	caught, driftnet, 6m deep		5
30	1994 Nov. 10	Gulf of Gabès, S	alive	?	?	?	caught, bottom trawl; 60 m deep	caught with 3 *Ramora remora*	5
31	1996 May 07	Sousse, C	alive	?	?	?	caught, coastal fisheries		5
32	1996 June 03	Skhira, S	dead	190	?	?	stranded		5
33	1996 June	Hammam Chott, N	dead	?	?	?	stranded	stranding reported in the press	5
34	1996 Oct. 23	Kerkennah island, S	alive	147	?	?	caught, drift net	caught with many *Naucrates doctor*	5
35	1996 Nov. 07	Gulf of Gabès, S	alive	129	?	?	caught, bottom trawl	caught with 2 *Naucrates doctor*	5
36	1997 July 28	Monastir, C	alive	170	?	?	caught, coastal fisheries		5
37	1998 Jan. 02	Sousse, C	alive	127	?	?	caught, coastal fisheries		5
38	1999 June 29	Gulf of Gabès, S (34°01'/10°22')	alive	134	?	?	caught, bottom trawl	tagged (No. f3461) and released	5
39	1999 June 29	Gulf of Gabès, S	alive	?	?	?	caught, bottom trawler		5
40	1999 July 17	Teboulba,, C	dead	130	?	?	stranded		5
41	2001 Jan. 26	Boughrara, S	dead	135	?	?	stranded		5
42	2001 Jan. 11	Gulf of Gabès, S (34°23'/11°37')	alive	120	?	?	caught		5
43	2006 Feb.12	Kerkennah island, S	alive	186	?	f	caught, trammel nets	10 m deep	6
44	2007 May 09	Jerba, S	dead	170	?	?	stranded		6
45	2007 Aug. 25	Sidi Ali El Makki, N	dead	130	?	?	stranded		6
46	2007 Aug. 27	Rafraf, N	dead	100	?	?	stranded		6
47	2008 June 04	Gabès, S	dead	180	?	?	stranded		6
48	2008 July 29	Gabès, S	dead	132	?	?	stranded		6
49	2010 June 12	Mahras, S	dead	110	?	?	stranded		6
50	2010 Aug. 07	Zarzis, S	dead	120	?	?	stranded		6
51	2011 Dec. 29	Bizerte, N	alive	172	?	f	stranded	stranded in 0.5 m depth without the right forelimb; died the next day.	6

Footnote 1 - Caught with one *Ramora remora* on the carapace; without the left forelimb and the half of the right forelimb was cut.

Distribution

A significant difference in the frequency of records was observed among the three zones ($\chi^2 = 7.88$; $p < 0.05$). Leatherbacks were mainly recorded in the south (49 %; $n = 51$) whereas 29.41 % and 21.56 % of the records were reported in the north and in the center, respectively. Since it is assumed that specimens originate from the Atlantic, which is closer to the north and central than south Tunisian coasts, the high proportion of Leatherbacks recorded in the south raises questions about their spatial distribution. The imbalanced frequency of observations could result from some potential methodological biases that should be taken into account. First, the numbers of stranded specimens were more likely to be reported in the south than in the other areas where some sites are not accessible and characterized by the absence of coastal communities. Second, the Gulf of Gabès, as the most productive fishing area in Tunisia (Anonymous 2006) and a region that includes many non-selective fisheries consistently producing catches of the Loggerhead Turtle, *Caretta caretta* (Linnaeus, 1758) (Echwikhi et al. 2011), could explain the many cases of bycatch of the Leatherback in the region. Moreover, the Leatherback was clearly better known (as "wild turtle" or "black turtle") to the fishermen of this region, than those of the center and in the north of Tunisia.

Based on the available recovery dates ($n = 48$), findings were present throughout the whole year in all studied areas (Figs. 1, 2) with no seasonal differences between the northern, the central and southern Tunisian coasts ($\chi^2 = 2.66$; $p = 0.44$) (Fig. 2A). Since it is assumed that the specimens originate in the Atlantic, this also suggests that the species is present in the Tunisian waters all the year round, without an evident seasonal movement pattern. However, when analyzed using the generalized linear model (GLM), the month effect becomes significant (Center–Month effect $t = -2.4736$, $p < 0.02$; South–Month effect $t = -2.6067$, $p < 0.01$). In the North, the highest numbers of observations were reported at the end of the year, whereas in the center and south most observations were made at the beginning of the year (Fig. 2B). However, large standard errors for the parameters hamper making definitive conclusions.

The temporal/seasonal distribution of the Leatherback should be viewed cautiously because of (1) the small sample size, (2) the fishing effort that could affect seasonal observations especially in the south (Jabeur et al. 2000), (3) the presence of potential feeding grounds that could provoke the concentration of animals in particular areas and (4) the increase of the human fishing activities, which is responsible for the findings rather than the actual temporal distribution of the species.

The increase of fishing activities in the warm period of the year is simultaneous with jellyfish blooms when planktonic food is available in great abundance (UNEP, 2007; Feki et al. 2008) which is essential for the Leatherbacks' feeding. Thus, Bradaï et al. (2004) described the effect of the jellyfish blooms, especially *Pelagia noctiluca* (Forsskål, 1775), on the prevalence of the Leatherback Turtle along the east Tunisian coast at the end of the summer and in autumn. Information about *Pelagia noctiluca*, a jellyfish apparently endemic to the Mediterranean and perhaps the only species of jellyfish from which regular population fluctuations are known (Goy et al. 1989; Licandro et al. 2010), shows that climatic conditions including low rainfall, high temperature and high atmospheric pressure appear to correlate well with the *P. noctiluca* blooms between May and August. These conditions occurring during the reproductive period of this jellyfish species are likely to influence its reproductive success (Mills 2001).

Anthropogenic impact

Most records (70.58 %; $n = 36$) derived from incidental capture in fisheries. Seventeen out of these refer to live specimens. Specimens reported by fishermen were caught by drift nets (2; 3.92 %), trammel nets (5; 9.80 %); bottom trawl (4; 7.84 %), coastal fisheries (10; 19.60 %) and unknown fishing gear (15; 29.41 %).

Despite the turtle project operating in the Gulf of Gabès since 2004, which focuses particularly on longline fishing, and the fact that the pelagic longlining is considered

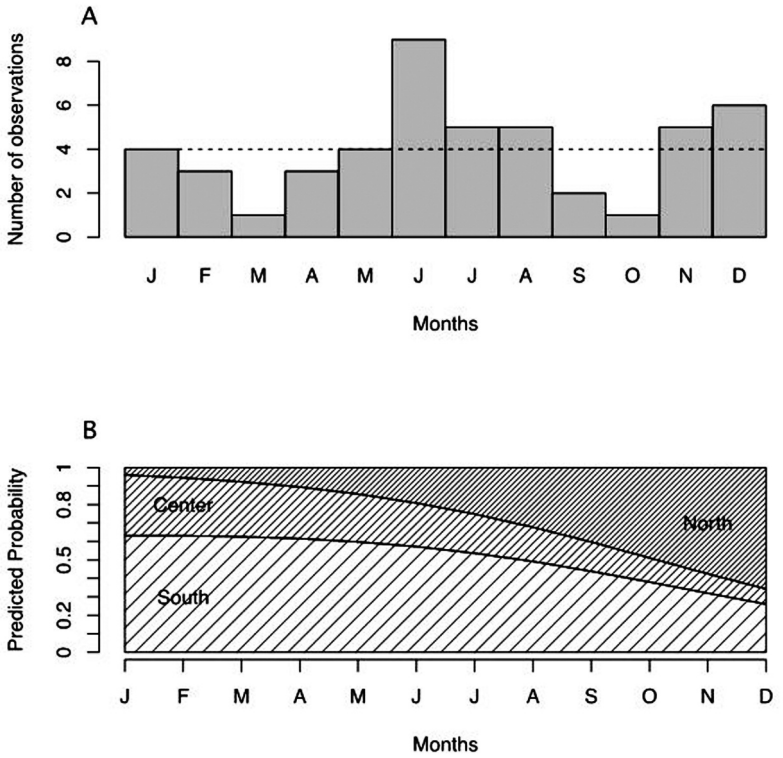

Fig. 2: Spatio-temporal distribution of records of the Leatherback Turtle *Dermochelys coriacea* (VANDELLI, 1761), in the Tunisian Sea. A - Number of records per month. The dashed line represents the average value; B - modeled distribution of Leatherback records from the zones north, central and south during the year.

Abb. 2: Räumlich-zeitliche Verteilung der Funde von Lederschildkröten *Dermochelys coriacea* (VANDELLI, 1761) im Tunesischen Meer. A - Anzahl der Nachweise pro Monat. Die strichlierte Linie bezeichnet den Durchschnittswert; B - modellierte Verteilung von Lederschildkrötenfunden auf die Zonen Nord, Mitte und Süd im Laufe des Jahres.

the major source of Leatherback mortality worldwide (SPOTILA et al. 2000; LEWISON et al. 2004), no interactions with this gear has been detected. This behavior is similar to that described by CASALE et al. (2003) in which Mediterranean Leatherbacks were caught mainly in the set/drift gillnets (at least 36.0 %). Comparisons between long-line catch rates in the Atlantic (WATSON et al. 2004) and the Mediterranean (CASALE et al. 2003) show that the Atlantic catch rate is 54 times higher. This suggests that the frequency of Leatherbacks is much lower in the Mediterranean than the Atlantic, and so bycatch in Mediterranean fisheries was considered to have a negligible impact on the population (CASALE et al. 2003).

Evidence of collisions with boats was detected in two cases of adult turtles in north Tunisian waters (see Table 1, turtles # 14 and 51). Turtle # 14 was captured alive in trammel nets in 25 m deep water; this turtle was placed in a pool filled with seawater, but died after three days. Turtle # 51 stranded alive but died the day after its discovery; its necropsy showed a heavy plastic sheet and several pieces of plastic of about 170 g in the intestine, with no clear evidence of digestive tract blockage.

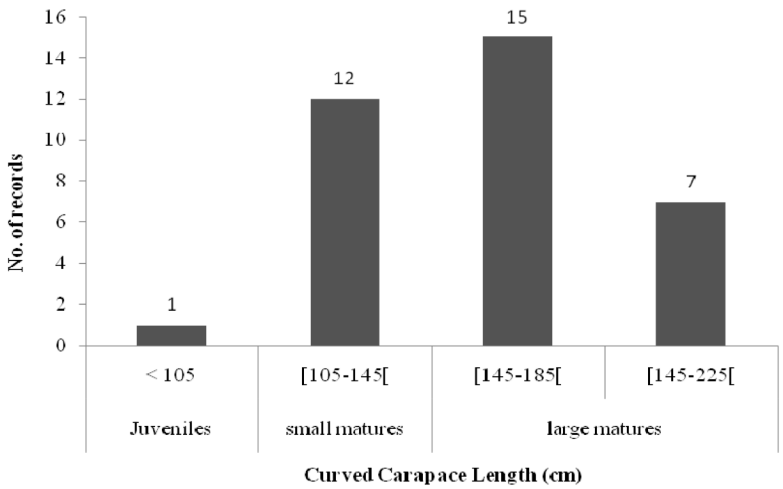

Fig. 3: Frequency distribution by age class of Leatherback Turtles *Dermochelys coriacea* (Vandelli, 1761), recovered in the Tunisian Sea (n = 35).

Fig. 3: Häufigkeitsverteilung nach Altersklassen der geborgenen Lederschildkröten, *Dermochelys coriacea* (Vandelli, 1761) im Tunesischen Meer. (n = 35).

Size and sex

Sex was determined only for approximately a fifth of documented species: six specimens were reported to be female (three through observation of ovaries at necropsy, one having externally a short tail and two through an unknown method) and four to be male (one through observation of the testes at necropsy and three determined by the presence of the elongated tail).

Size-class analysis based upon animals with known carapace length (n = 35) showed that the curved carapace lengths (CL) ranged between 100 and 210 cm; twenty-two were categorized as large mature (CL > 145 cm), twelve as small mature (105 ≤ CL ≤ 145 cm) and one individual as a large juvenile (CL = 100 cm) (Fig. 3); small juveniles were never reported. Based on size distribution analysis, Eckert (2002) suggested that Leatherbacks spend their early juvenile stage (until reaching CL of about 100 cm) in tropical waters, probably because of thermal constraints. Consequently, in the Atlantic, these juveniles are probably not migrating as far to the north as the Strait of Gibraltar and, thus cannot enter the Mediterranean (comp. Brongersma (1972). As a result, only large juveniles and adults of both sexes immigrate into the Mediterranean Sea and Tunisian waters and one may hypothesize that they do this most likely for feeding reasons .

If at least some adult Leatherbacks do not leave the Mediterranean basin, one can speculate on the potential presence of nesting beaches/events. However, even continuous presence of Leatherback Turtles in Tunisian waters seems not to implicate breeding in the Mediterranean since regular nesting of the species is not known. There is a single report of nesting and two juvenile specimens in Italy (Bruno 1978) as well as of a nesting attempt in Israel (Sella 1981). On the other hand, Leatherbacks are well known for their long travels over the oceans (Bjorndal 1997). The presence of Trinidad Leatherbacks in Turkey (northeastern Mediterranean) (Sönmez et al. 2008) as well as other records in the east Mediterranean may indicate that the Mediterranean Sea is a foraging area for Atlantic Leatherbacks.

CONCLUSIONS

This study reports organized data regarding the occurrence of the Leatherback in Tunisian waters. Due to their big size and rare occurrence, the finding of a Leatherback Turtle is considered an exceptional event that is usually reported.

Despite that *Dermochelys coriacea* was generally regarded as an oceanic species that does not have a neritic juvenile and adult phase (Bolten 2003), this chelonian was regularly mentioned in stranding events and bycatch reports throughout the year in Tunisian waters. This behavior was also described in many areas of the world; in North Carolina waters, in early May, Leatherbacks appeared to enter near shore waters, coincident with the appearance of jellyfish (Epperly et al. 1995). The Leatherback was also described to regularly forage in Australian continental shelf and inshore waters, even as shallow as three meters deep, from July to September (Limpus 2009).

Although Tunisian waters were never considered a high-use habitat for Leatherback Turtles in the Mediterranean, this analysis suggests their importance as a foraging habitat for the species. This may be due to both the Atlantic surface currents entering the Mediterranean Sea (Crespo et al. 1988) and the abundance of jellyfish along the Tunisian coasts (Bradaï et al. 2004). But maybe, the specimens caught in the shallow waters of the Gulf of Gabès come from another area of concentration of the Leatherback in the south Mediterranean Sea, for instance the Aegean Sea (Casale & Margaritoulis 2010).

Data presented in this study suggest the potential relevance of the Tunisian waters, and especially the Gulf of Gabès, as a foraging habitat for Leatherbacks within the Mediterranean, as it could be an important habitat for other large pelagic vertebrates, e.g., the fin whale *Balaenoptera physalus* (Karaa et al. 2012) or their neritic developmental stages, e.g., for Green and Loggerhead Turtles (Bradaï et al. 2009; Karaa et al. 2012).

Bearing in mind the position of Tunisia in the central Mediterranean Sea, this region is an important passageway for the Mediterranean Leatherback Turtle. These turtles may enter the Mediterranean Basin without finding the way home to their nesting/hatching beaches. Therefore, and from a conservation point of view, the authors recommend that the Tunisian waters, and especially the Gulf of Gabès, be included as a target area in recovery effort planning for the conservation of the sea turtles in the region, the Leatherback in particular.

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AUTHORS: Sami KARAA (corresponding author < k-sami@hotmail.fr >) - Sfax Faculty of Sciences, Life Sciences department, Sfax University, Sfax, Tunisia and National Institute of Sea Sciences and Technologies, P. O. Box 1035, 3018 Sfax, Tunisia; Imed JRIBI and Abderahmen BOUAIN - Sfax Faculty of Sciences, Life Sciences department, Sfax University, Sfax, Tunisia; Marc GIRONDOT - Laboratoire d'Ecologie, Systématique et Evolution, Université Paris Sud et CNRS; Mohamed Nejmeddine BRADAÏ - National Institute of Sea Sciences and Technologies, P. O. Box 1035, 3018 Sfax, Tunisia