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Inventory of elasmobranch species caught in the Lagoon of Bizerte (North-eastern Tunisia, central Mediterranean)

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Abstract. Eight elasmobranch species were reported for the Lagoon of Bizerte, north-eastern Tunisia, central Mediterranean. These species were: *Torpedo marmorata*, *Torpedo torpedo*, *Dasyatis chrysonota*, *Dasyatis pastinaca*, *Dasyatis tortonesei*, *Gymnura altavela*, *Myliobatis aquila* and *Pteromylaeus bovinus*. General and local distribution of these eight species are discussed and commented while morphological and biological data are provided. Of the eight species reported, only one could represent a locally established population, the common torpedo *Torpedo torpedo*, as it was constant inhabitant of this brackish, even acomplishing developement and reporducing there. Two of the three dasyatid species occurring in the Lagoon of Bizerte, could be considered as relatively abundant, *Dasyatis chrysonota* and *D. pastinaca*, the third *D. tortonesei* being rare. Their occurrence could be related with the mussels abundance in the Lagoon of Bizerte, as well as oysters and several gastropod species which constitute their main food. Similar observations could also explain the presence of *Gymnura altavela*, *Myliobatis aquila* and *Pteromylaeus bovinus* in the area in question, which were, by contrast, rather rare.

Key words. Morphology and meristics, size-mass relationship, reproduction, migration, diet

Resumen. Inventario de especies de elasmobranquios capturadas en la Laguna de Bizerte (Noreste de Túnez, Mediterráneo Central). Ocho especies de elasmobranquios fueron reportadas para la Laguna de Bizerte, noreste de Túnez, Mediterráneo Central. Estas especies fueron: *Torpedo marmorata*, *Torpedo torpedo*, *Dasyatis chrysonota*, *Dasyatis pastinaca*, *Dasyatis tortonesei*, *Gymnura altavela*, *Myliobatis aquila y Pteromylaeus bovinus*. La distribución local y general de estas ocho especies es discutida y comentada y datos morfológicos y biológicos son dados. De las ocho especies citadas solamente una población localmente establecida, el torpedo común, *Torpedo torpedo*, pues constituyó un habitante permanente en este ambiente estuarino, completando además allí su desarrollo y reproduciéndose. Dos de las tres especies de dasyatídeos que ocurren en la Laguna de Bizerte, podrían se consideradas como relativamente abundante, *Dasyatis chrysonota* y *D. pastinaca*, la tercera, *D. tortonesei* siendo rara. La ocurrencia de estas especies podría estar relacionada con la abundancia de mejillones en la Laguna de Bizerte, así como de ostras y varias especies de gasterópodos que constituyen su principal alimento. Observaciones similares podrían también explicar la presencia de *Gymnura altavela*, *Myliobatis aquila* y *Pteromylaeus bovinus* en el área en cuestión, que son, a diferencia de las anteriores, muy raras.

Palabras clave: morfología y mirística, relación tamaño-peso, reproducción, migración, dieta.

Introduction

Inventories concerning elasmobranch species in the Tunisian coast allowed to state that 62 species are known in the area (Quignard & Capapé 1971, 1972, Capapé 1989, Bradaï *et al.* 2002, 2004, Ben Souissi *et al.* 2007). Some of them were recorded in brackish areas such as the Bahiret El Biban, hyperhaline lagoon from southern Tunisia (Capapé *et al.* 2004) and, northward, in Tunis Southern Lagoon (Ben Souissi *et al.* 2005 a, b, Mejri *et al.* 2004).

Surveys recently conducted in the northern Lagoon of Bizerte allowed recording eight elasmobranch species which are reported in the present paper. An overview of the distribution and occurrence of these species in Tunisian waters and in the lagoon is presented. In addition, data such as morphology, morphometric measurements, meristic counts, and on reproductive biology are provided. The paper also aids to assess the real status of these eight elasmobranch species in the area, in order to prepare a regional national plan for elasmobranch conservation and management.

Materials and Methods

Description of the study area. The Lagoon of Bizerte is a brackish water body located in north-eastern Tunisia, between 37°8' and 37°14' N, and between 9°46' and 9°56' E (Fig. 1). The Lagoon of Bizerte appears as an ellipse, 11 km width and 13 km long, covering 15 000 ha and it is connected to the Mediterranean Sea by an artificial navigation channel, 12 km long, 650 m width and 12 m depth maximum (Fig. 2). The average and maximum depth of the Lagoon of Bizerte are 7 m and 12 m rspectively the latter close to the navigation channel, with sandy, muddy or detritic bottoms, and by places seagrass meadows (Zaouali 1974). The Lagoon of Bizerte receives a freshwater imput from eight 'wadi' (river in Arabic), unfortunately containing pesticides and both inorganic and organic material. It also receives marine water that increases water salinity from 33 (Zaouali 1974) to 36.09 (Aïssa 1991).

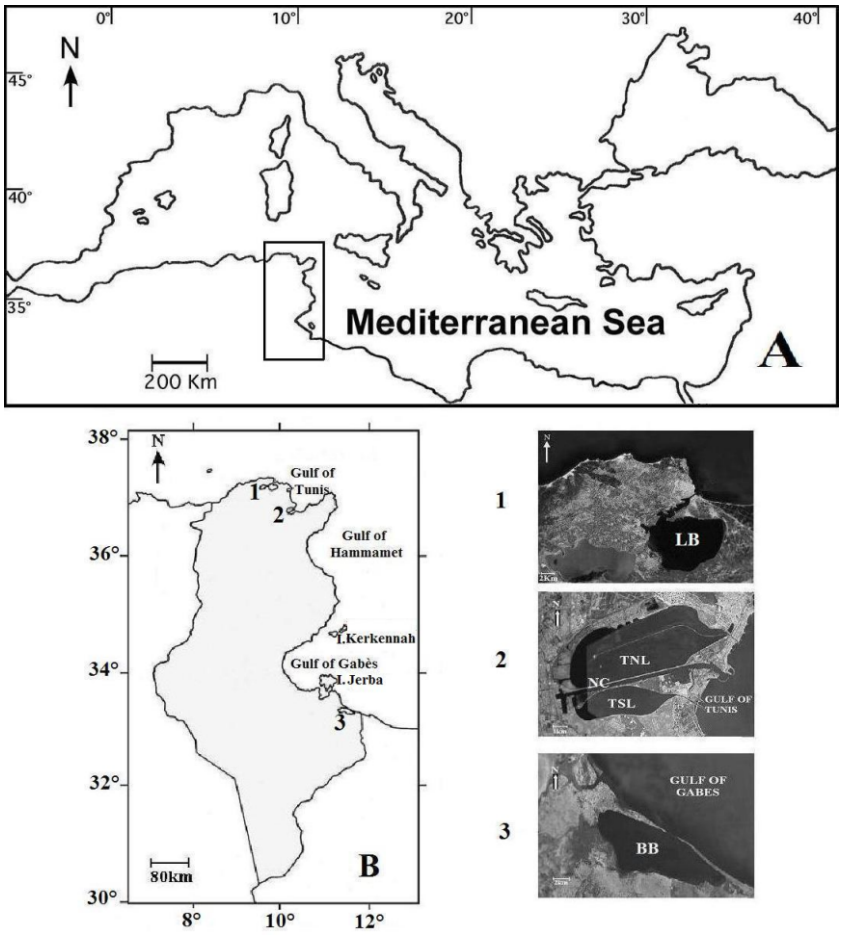

Figure 1. A. Map of the Mediterranean Sea showing Tunisia. B. Map of Tunisia showing the three main Tunisian lagoons. 1. Lagoon of Bizerte (LB). 2. Lagoon of Tunis divided in Tunis Northern Lagoon (TNL) and Tunis Southern Lagoon (TSL). 3. Bahiret El Biban (BB).

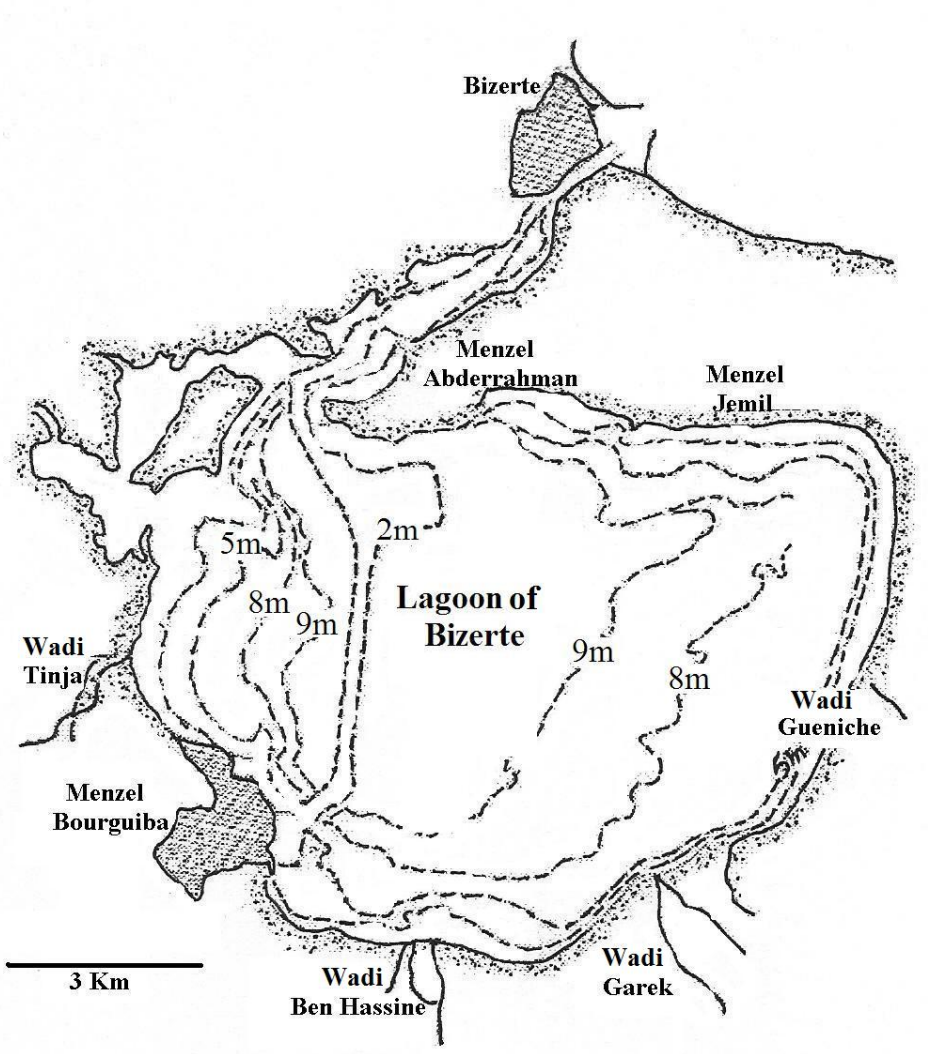

Figure 2. Map of the Lagoon of Bizerte.

Local fisheries. At least, thirty teleost species are known to be reported in the Lagoon of Bizerte (Harzallah 2003), among them syngnathid species, which found in the area favourable environmental conditions to develop and reproduce (Ben Amor *et al.* 2008). Additionally, the lagoon is commercially exploited by artisanal craft fisheries and oyster and mussel farms, landing fishery sites were at Menzel Abderrahman and Menzel Jemil (Aïssa 1991). Gastropods are collected in the area, such as the purple dye murex *Bolinus brandaris* (Linnaeus 1758) and the banded dye murex *Hexaplex trunculus* (Linnaeus 1758), both species, at present, exhibited development of imposex in females, a phenomenon linked to the use of organotin biocides, such as tributyltin, consequence of environmental pollution due to sea traffic (Lahbib *et al* 2004, Abidli *et al.* 2008). Bivalvs are also collected in the area such as the grooved carpet-shell clam *Ruditapes decussatus* (Linnaeus 1758) and the warty venus *Venus verrucosa* (Linaeus 1758) according to Trigui El Menif (1996, 2005). However, wild gastropods and bivalvs have low economical value.

Sample collection. Observations were made twice a week from January 2006 to November 2008. Identification of specimens were carried out using keys and field guides such as Tortonese (1956), Bini (1967), Fischer *et al.* (1987), and McEachran & Capapé (1984 a, b, c). Measurements were recorded to the nearest millimetre while total mass (TM) to the nearest gram. Total length (TL) was only considered in both torpedinid species as measurement of reference, while disc witdh (DW) was only used for the six other batoid species following Clark (1926).

Data analysis. In all species, for both male and female specimens, two maturity categories were considered: juvenile and adult. Reproductive condition in males was made by examination of claspers, following Collenot (1969), while some aspects of the testes and other reproductive organs

are given following Hamlett *et al.* (1999), and Capapé *et al.* (2004). In juveniles, claspers were flexible, uncalcified and shorter than pelvic fins, while testes and genital ducts were unconspicuous, membranous and slightly developed. In adults, claspers were rigid, calcified larger than pelvic fins, while the testes were well-developed and exhibited spermatocysts externally visible. The genital duct was twisted and sperm was visible in the seminal vesicles. Size at sexual maturity was determined in females from the condition of ovaries, the reproductive tract morphology and the mass of oviducal glands (see Capapé *et al.* 2004, Callard *et al.* 2005). The juvenile females had whitish and undeveloped ovaries, thread-like oviducts and inconspicuous oviducal glands. The adult females exhibited ovaries containing batches of yolky oocytes and exhibited fully developed genital ducts. The oviducal glands were conspicuously rounded and the mass considerably increased in adults. In dasyatid species, a single uterus, the right one, was functional. The observed sample is presented including number of males and females, and for both sexes number of juveniles and adults. Both size and mass ranges are provided and when possible the relation size *versus* total mass is calculated. A morphological, meristic and morphometric description for all the species is given, following Golani & Capapé (2004) and Mejri *et al.* (2004).For each species, a subsample was preserved in 5% buffered formaline and deposited in the Ichthyological Collection of the Faculté des Sciences of Bizerte. The preserved specimens received catalogue numbers which are given in Tables I to VIII. Tests for significance ($p < 0.05$) were performed using ANOVA and chi-square test. The relationship between total length (TL) or disc width (DW) and total mass (TM) was calculated; such relationship being useful as an indication of species for condition or for stock assessment (Petrakis & Stergiou 1995, Froese 2006). Comparisons of curves were carried out by ANCOVA. The linear regression was expressed in decimal logarithmic coordinates. Correlations were assessed by least-squares regression.

Results an Discussion

Family Torpedinidae

Marbled electric ray, ***Torpedo marmorata*** *Risso 1810. Torpedo marmorata* is reported in the eastern Atlantic from off Scandinavia (Kattegat, Skagerrak) according to Muus & Dahlstrøm (1964-1966), off British Isles (Wheeler 1969), France (Quéro *et al.* 2003), Spain (Ortea & De La Hoz 1979) and Portugal (Albuquerque1954-1956). South Strait of Gibraltar, the species was reported off Morocco (Collignon & Aloncle 1972), Mauritania (Maurin & Bonnet 1970), it was frequently caught off Senegal according to Capapé *et al.* (2001), and occurred southward in the Gulf of Guinea (Blache *et al.* 1970) and in South Africa waters (Smith & Heemstra 1986). This species is also known throughout the Mediterranean Sea, in both western and eastern basins (Quignard & Tomasini 2000), occurring in the eastern Levant Basin (Golani 2005). However, the species seems to be more abundantly caught from northern areas of the western Mediterranean basin (Capapé, 1989). *Torpedo marmorata* also occurs off the Algerian coast (Dieuzeide *et al.* 1953, Hemida pers. comm.) and throughout the Tunisian coast (Capapé 1979, Bradaï *et al.* 2004). The species was first recorded by Le Danois (1925), then Quignard and Capapé (1971) considered the species more frequent in northern areas, these observations were furtherly confirmed by Capapé (1979) and Bradaï *et al.* (2004).

Torpedo marmorata was recorded for the first time in a Tunisian brackish area, Tunis Southern Lagoon by Mejri *et al.* (2004), in contrast, it was not recorded southward in the Bahiret El Biban (Capapé *et al.* 2004). All *T. marmorata* collected for this study were caught in the north-western region of the Lagoon of Bizerte, and represented the first record to date in the area (Fig. 3). Of the 16 electric marble rays examined, 7 were males ranging in size between 160 and 320 mm TL, and weighing between 122 and 430 g TM, whereas 9 were females ranging in size between 290 and 610 mm TL, and weighing between 163 and 2020 g TM. Females slightly outnumbered males, but the overall sex ratio was not significantly different from 1:1 ($\chi 2 = 0.98$, $p < 0.05$, $df = 1$). Of the 9 females collected 4 were juveniles and 5 adults, while for the 7 males collected 5 were juveniles and 2 were adults.

Females were larger and heavier than the males. Similar patterns were observed for *T. marmorata* from the Bay of Biscay (Mellinger 1971), off Tunisian coast (Capapé 1979), coast of Senegal (Capapé *et al.* 2001) and off Italian coast (Consalvo *et al.* 2007). The female found in the Lagoon of Bizerte (610 mm TL) is the largest electric marbled ray recorded in Tunisian waters. Mellinger (1971), Capapé *et al.* (2001), Consalvo *et al.* (2007) reported 630 mm, 580 mm TL and 553 mm in females from the Bay of Biscay, the coast of Senegal and the coast of Italy, respectively.

The relationship between total length TL

and TM, plotted in Figure 4, showed significant difference between males and females ($F = 169.68$, $p < 0.001$, $df = 1$). The relationships were for the males: log TM = 3.09 log TL - 5.05; r = 0.98; n = 7, and for the females: log TM = 2.80 log TL - 4.33; r = 0.97; n = 9.

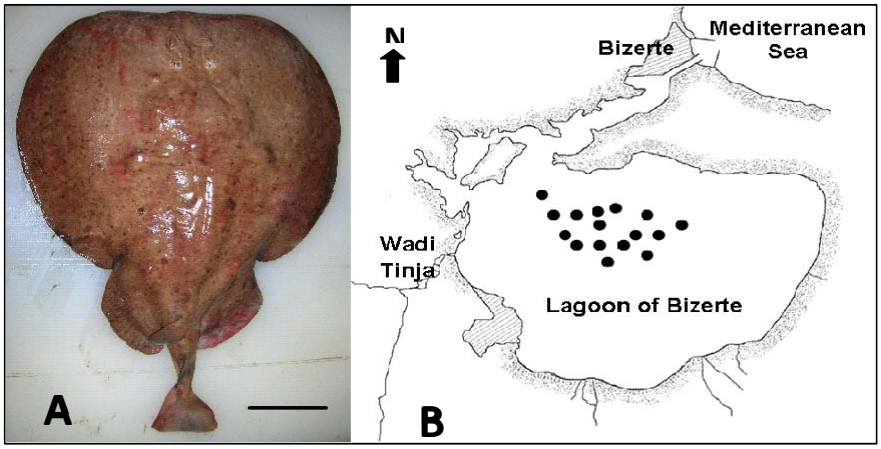

Figure 3. Specimen of *Torpedo marmorata* captured in the Lagoon of Bizerte, scale bar = 100 mm. B. Map of Lagoon of Bizerte showing the capture sites (black circles) of *Torpedo marmorata.*

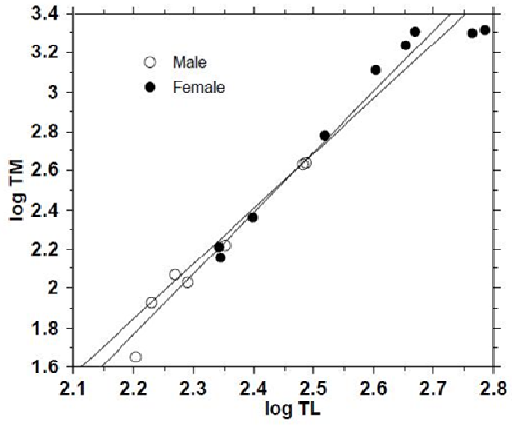

Figure 4. Relationship between total length (TL) and total mass (TM), expressed in decimal logarithmic coordinates, in *Torpedo marmorata* from the Lagoon of Bizerte.

Measurements were carried out on two specimens and are presented in Table I. Identification was made by skin entirely smooth, in both dorsal and ventral surfaces; disc rather rounded and sub-circular, snout short, subtruncate; pelvic fins quite separate from pectoral fins, subtruncate at distal end; tail distinct with two dorsal fins and caudal fin well-developed; spiracle with seven tentacles, one tentacle on posterior margin being the largest. Disc-width 63-68 %, disc-length 56-58 %, disc-depth 2-3 %, pre-oral length 9-11 %, pelvic span 35-36 %, pelvic fin anterior margin 10-11%, caudal careen 11-15 % all in total length. Dorsal surface uniform brownish with dark notches; belly beige with margin slightly brownish. Morphology, measurements and colouration are in agreement with those of Dieuzeide *et al.* (1953), Tortonese (1956), Bini (1967), Cadenat *et al.* (1978) and Mejri *et al.* (2004).

Common torpedo, ***Torpedo torpedo*** *(Linnaeus 1758). Torpedo torpedo* is known to occur in the eastern Atlantic from the Bay of Biscay (Quéro *et al* 2003), off Spain (Ortea & De La Hoz 1979) to Portugal (Albuquerque 1954-1956). In South Strait of Gibraltar, *T. torpedo* was reported off Morocco (Collignon & Aloncle 1972), Mauritania (Maurin & Bonnet 1970), off Senegal where it is the most abundant torpedinid species according to Capapé *et al.* (2000). Southward the common torpedo was reported off Guinea-Bissau (Sanchès 1991), in the Gulf of Guinea (Blache *et al.* 1970), and, probably, to South Africa waters (Smith & Heemstra 1986).

The species also occurs throughout the Mediterranean Sea, being more frequently caught in southern areas (Capapé 1989), especially off the Maghreb coast (Dieuzeide *et al* 1953, Capapé 1989, Bradaï *et al.* 2004). The common torpedo was also recorded in Tunisian brackish areas such as the Bahiret El Biban (Capapé *et al.* 2004) and Tunis Southern Lagoon (Mejri *et al.* 2004). *Torpedo torpedo* is frequently captured in the Bahiret El Biban where probably a sustainable population develop and reproduce. It is relatively less abundant in Tunis Southern lagoon which recently was the focus of an environmental restoration (Ben Souissi *et al.* 2005 b), records were recently reported in the area.

Table I. Measurements carried out in two specimens of *Torpedo marmorata* captured in the Lagoon of Bizerte.

References	**FSB Tor-mar.01**		**FSB Tor-mar.02**	
Sex	Female		Male	
Total mass (g)	205		231	
Measurements	**mm**	**% of TL**	**mm**	**% of TL**
Total lenth (TOT)	580	100.00	250	100.00
Disc-length	335	57.76	140	56.00
Disc-width	370	63.79	168	67.20
Disc-depth	69	11.90	18	7.20
Eyeball lenth	12	2.07	8	3.20
Cornea	7	1.21	4	1.60
Pre-orbital length	40	6.90	21	8.40
Inter-orbital width	29	5.00	11	4.40
Nasal curtain	26	4.48	12	4.80
Spiracle diameter	8	1,38	3	1.20
Inter-nasal width	24	4,14	12	4.80
Space between eye and spiracle	19	3.28	10	4.00
Inter-spiracular width	26	4.48	12	4.80
Pre-oral length	55	9.48	27	10.80
Mouth width	37	6.38	16	6.40
First gill slit	16	2.76	6	2.40
Second gill slit	17	2.93	7	2.80
Third gill slit	19	3.28	7	2.80
Fourth gill slit	18	3.10	4	1.60
Fifth gill slit	13	2.24	4	1.60
Width between first gill slit	86	14.83	36	14.40
Width between fifth gill slit	88	15.17	33	13.20
Snout tip to eye	42	7.24	24	9.60
Snout tip to mouth	45	7.76	26	10.40
Snout tip to first gill slit	120	20.69	61	24.40
Snout tip to fifth gill slit	195	33.62	84	33.60
Snout tip pelvic fin	330	56.90	135	54.00
Snout tip to vent	352	60.69	150	60.00
Pectoral fin posterior	140	24.14	56	22.40
Pectoral fin posterior margin	220	37.93	90	36.00
Pectoral fin inner margin	17	2.93	8	3.20
Pelvic fin anterior margin	64	11.03	26	10.40
Pelvic fin posterior margin	110	18.97	42	16.80
Pelvic fin inner margin	26	4.48	10	4.00
Span of pelvic fins	205	35.34	88	35.20
Tail base width	36	6.21	18	7.20
Tail base depth	27	4.66	12	4.80
Tail length	184	31.72	80	32.00
Snout tip to first dorsal	394	67.93	163	65.20
Snout tip to second dorsal	450	77.59	188	75.20
Snout tip to birth of dorsal caudal	507	87.41	209	83.60
Snout tip to birth of ventral caudal	497	85.69	207	82.80
Caudal superior edge	76	13.10	39	15.60
Caudal inferior edge	94	16.21	33	13.20
Caudal posterior edge	58	10.00	46	18.40
First dorsal anterior edge	64	11.03	26	10.40

Table I. Measurements carried out in two specimens of *Torpedo marmorata* captured in the Lagoon of Bizerte (continued).

Measurements	mm	% of TL	mm	% of TL
First dorsal posterior edge	32	5.52	15	6.00
First dorsal inner edge	10	1.72	9	3.60
First dorsal base	30	5.17	12	4.80
Second dorsal anterior edge	50	8.62	22	8.80
Second dorsal posterior edge	25	4.31	12	4.80
Second dorsal inner edge	11	1.90	7	2.80
Second base	24	4.14	10	4.00
Inter-dorsal distance	19	3.28	9	3.60
Second dorsal to caudal birth	27	4.66	10	4.00
Caudal careen	87	15.00	29	11.60
Clasper	-	-	57	22.80

A total of 443 specimens were collected in the central region of the Lagoon of Bizerte (Fig. 5), 218 were males and ranged between 145 and 403 mm TL and between 50 and 522 g; 225 were females and ragned between 139 and 435 mm TL and between 48 and 722 g. The relationship between TL and TM, plotted in Figure 6, showed significant difference between males and females ($F = 359.38$, $p < 0.001$, $df = 1$). The relationships were for males: log TM = 2.39 log TL – 3.39; r = 0.92; n = 218, and for females log TM = 2.63 log TL – 3.94; r = 0.95; n = 225.

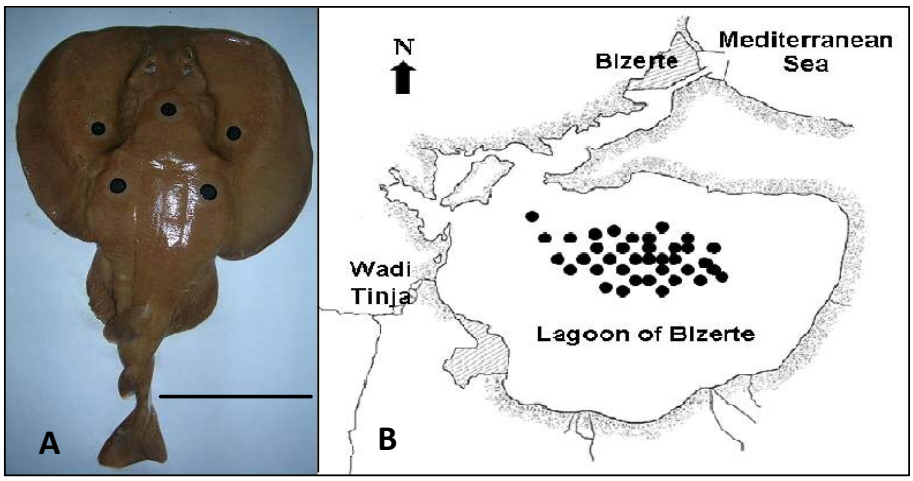

Figure 5. A. Specimen of *Torpedo torpedo* captured in the Lagoon of Bizerte, scale bar = 100 mm. B. Map of Lagoon of Bizerte showing the capture sites (black circles) of *Torpedo torpedo*.

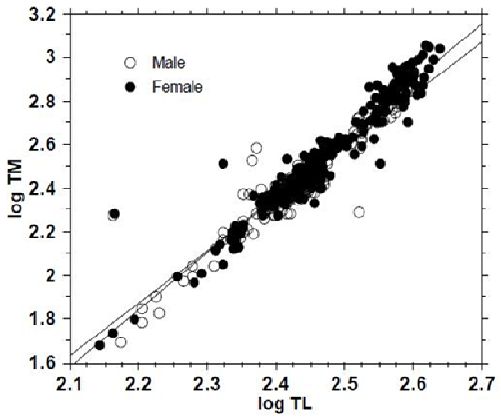

Figure 6. Relationship between total length (TL) and total mass (TM), expressed in decimal logarithmic coordinates, in *Torpedo torpedo* from the Lagoon of Bizerte.

Table II. Measurements carried out in two specimens of *Torpedo torpedo* captured in the Lagoon of Bizerte.

References	**FSB T-torp.04**		**FSB T-torp.02**	
Sex	Female		Male	
Total mass (g)	261		252	
Measurements	**mm**	**% of TL**	**mm**	**% of TL**
Total lenth (TOT)	260	100.00	261	100.00
Disc-length	125	48.08	127	48.66
Disc-width	155	59.62	171	65.52
Disc-depth	22	8.46	26	9.96
Eyeball length	7	2.69	7	2.68
Cornea	4	1.54	3	1.15
Pre-orbital length	17	6.54	19	7.28
Inter-orbital width	13	5.00	14	5.36
Nasal curtain	14	5.38	15	5.75
Spiracle diameter	4	1.54	5	1.92
Inter-nasal width	12	4.62	14	5.36
Space between eye and spiracle	7	2.69	4	1.53
Inter-spiracular width	12	4.62	14	5.36
Pre-oral length	14	5.38	13	4.98
Mouth width	18	6.92	18	6.90
First gill slit	5	1.92	5	1.92
Second gill slit	4	1.54	7	2.68
Third gill slit	5	1.92	6	2.30
Fourth gill slit	5	1.92	5	1.92
Fifth gill slit	4	1.54	4	1.53
Width between first gill slit	35	13.46	37	14.18
Width between fifth gill slit	33	12.69	36	13.79
Snout tip to eye	20	7.69	22	8.43
Snout tip to mouth	22	8.46	24	9.20
Snout tip to first gill slit	50	19.23	54	20.69
Snout tip to fifth gill slit	75	28.85	82	31.42
Snout tip pelvic fin	120	46.15	124	47.51
Snout tip to vent	135	51.92	142	54.41
Pectoral fin posterior	52	20.00	59	22.61
Pectoral fin posterior margin	80	30.77	90	34,52
Pectoral fin inner margin	9	3.46	9	3.45
Pelvic fin anterior margin	30	11.54	34	13.03
Pelvic fin posterior margin	56	21.54	30	11.49
Pelvic fin inner margin	12	4.62	4	1.53
Span of pelvic fins	79	30.38	79	30.27
Tail base width	55	21.15	51	19.54
Tail base depth	18	6.92	15	5.75
Tail length	141	54.23	136	52.11
Snout tip to first dorsal	160	61.54	160	61.30
Snout tip to second dorsal	190	73.08	190	72.80
Snout tip to birth of dorsal caudal	216	83.08	218	83.52
Snout tip to birth of ventral caudal	210	80.77	214	81.99
Caudal superior edge	40	15.38	42	16.09
Caudal inferior edge	31	11.92	38	14.56
Caudal posterior edge	39	15.00	42	16.09
First dorsal anterior edge	32	12.31	32	12.26

Table II. Measurements carried out in two specimens of *Torpedo torpedo* captured in the Lagoon of Bizerte (continued).

Measurements	**mm**	**% of TL**	**mm**	**% of TL**
First dorsal posterior edge	20	7.69	23	8.81
First dorsal inner edge	2	0.77	3	1.15
First dorsal base	17	6.54	19	7.28
Second dorsal anterior edge	24	9.23	26	9.96
Second dorsal posterior edge	14	5.38	20	7.66
Second dorsal inner edge	2	0.77	2	0.77
Second base	12	4.62	13	4.98
Inter-dorsal distance	12	4.62	13	4.98
Second dorsal to caudal birth	13	5.00	14	5.36
Caudal careen	44	16.92	44	16.86
Clasper	-	-	51	19.47

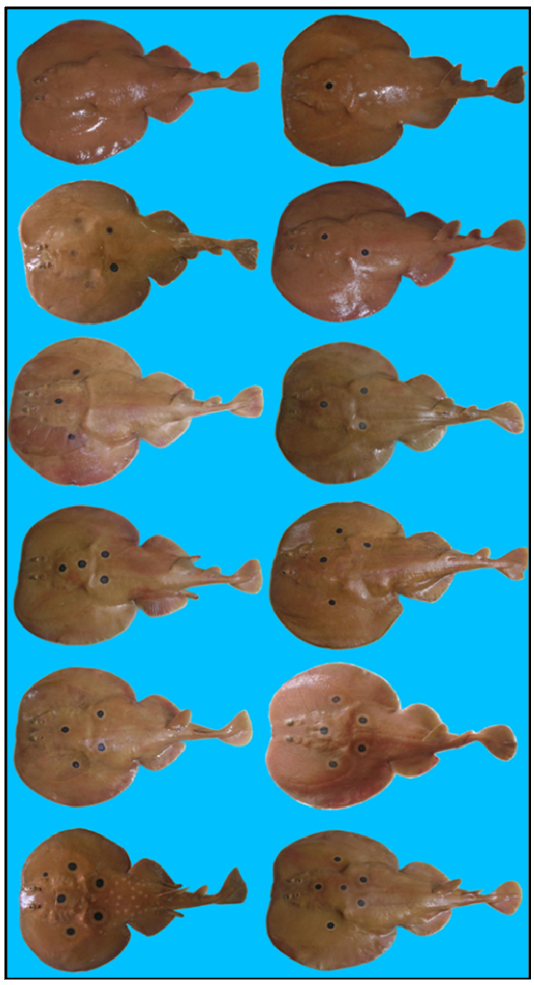

Figure 7. Specimen of *Torpedo torpedo* captured in the Lagoon of Bizerte, with different numbers of ocellae, from 0 to 6, on the dorsal surface.

Of the 218 males collected, 141 were juveniles and 77 adults, while of the 225 females collected, 77 were juveniles and 148 adults. Female adults significantly outnumbered male adults ($\chi 2$ = 22, $p > 0.05$, df = 1). Of the 148 female adults, 69 were pregnant. Additionally, the sample included 9 neonates.

The largest juvenile male was 263 mm TL and weighed 249 g TM, while the largest juvenile female was 275 mm TL and weighed 329 g TM. Sexual dimorphism in size and mass was observed, females being larger than males in *T. torpedo* from the Lagoon of Biban, such as in specimens from other Tunisian marine areas, the Gulf of Tunis (Quignard & Capapé 1974), the Gulf of Gabès (Ennajar *et al.* 2002), and elsewhere off Italian coast (Consalvo *et al.* 2007) and coast of Senegal (Capapé *et al.* 2000). Specimens of *T. torpedo* from the Lagoon of Bizerte were larger than those from other Tunisian marine areas. Quignard & Capapé (1974) noted that the largest male and the largest female recorded in the Gulf of Tunis were 390 mm and 410 mm TL respectively, while in the Gulf of Gabès, Ennajar *et al.* (2002) recorded 365 mm for males and 410 mm TL for females, respectively. Conversely,, larger sizes were observed by Consalvo *et al.* (2007), for common torpedo from the Italian coast, with records of 445 mm and 477 mm TL for males and females respectively, and by Capapé *et al.* (2000) for specimens from off the coast of Senegal, males and females reaching 445 mm and 550 mm TL respectively.

Measurements carried out on two specimens are presented in Table II. General morphology was similar to that described for *T. marmorata*, however the posterior tip of pelvic fin before second dorsal fin origin, spiracle with short tentacles or knobs. Disc-width 59-66 %, disc-length 48-49 %, disc-depth 8-9 %, pre-oral length 4-5 %, pelvic span 31 %, pelvic fin anterior margin 11-14%, caudal careen 17 % all in total length. These percents are generally used in systematics of torpdinids and should not be deleted, even if they do not appear in Table II, following Golani & Capapé (2004) and Mejri *et al* (2004). Other characteristics:

dorsal surface uniform brownish with whitish notches and five blue centred ocellae with yellowish margin, number of ocellae ranged from 0 to 6 in some specimens (Fig. 7); Capapé & Desoutter (1981) found 7 and 8 ocellae in specimens from the Gulf of Tunis, and Capapé *et al.* (2006b) described a specimen from the Languedocian coast (southern France) having 9 ocellae; belly beige with margin slightly brownish. Morphology, measurements and colour are in agreement with Dieuzeide *et al.* (1953), Tortonese (1956), Bini (1967), Quignard & Capapé (1974), Capapé & Desoutter (1981) and Mejri *et al.* (2004).

Family Dasyatidae

Blue stingray, ***Dasyatis chrysonota*** *(Smith 1828)*. *Dasyatis chrysonota* was previously considered as a synonym of the common stingray *D. pastinaca* (Linnaeus 1758), rather known in the north eastern Atlantic and in the Mediterranean (Ebert & Cowley 2008) and re-evaluated by Cowley & Compagno (1993). The blue stingray's preference for warm waters is evident from its geographic distribution (Capapé & Zaouali 1995). *Dasyatis chrysonota* is found in the eastern Atlantic southward of the Strait of Gibraltar. It was reported off Mauritania (Maurin & Bonnet 1970), Senegal (Capapé *et al.* 1995), Gulf of Guinea (Fowler 1936), Angola (Krefft 1968) to South Africa (Cowley & Compagno 1993). In the Mediterranean, the blue stingray was previously known to be only caught in the Gulf of Gabès, in southern Tunisia (Maurin & Bonnet 1970, Capapé & Zaouali 1995). More recently Golani & Capapé (2004) reported records of the species off the Mediterranean coast of Israel. With special regard to Tunisian waters, *D. chrysonota* was abundantly recorded in the Bahiret El Biban and in the close Gulf of Gabès where it developed and reproduced (Capapé & Zaouali 1995). In contrast, it was not recorded northward in Tunis Southern Lagoon, for instance. Consequently, the records of *D. chrysonota* in the central region Lagoon of Bizerte constitute its northernmost distributional range, not only for the Tunisian waters (Fig. 8), but also for the Mediterranean Sea.

Of the 12 specimens recorded in the area, 6 were males and 6 females, with sex ratio (M:F) being 1:1. Males ranged between 183 and 395 mm DW and weighed between 162 and 2600 g TM, while females ranged between 156 and 605 mm DW and weighed between 605 and 12,000 g TM. The largest juvenile male was 270 mm DW and 682 g TM, while the largest juvenile female was 305 mm DW and 966 g TM. The relationship between DW and TM, plotted in Figure 9, showed significant difference between males and females ($F = 865.31$, $p < 0.001$, $df = 1$). The relationships were for males: $\log TM = 3.38 \log DW - 5.41$; $r = 0.99$; $n = 6$, and for females $\log TM = 3.26 \log DW - 5.05$; $r = 0.99$; $n = 6$.

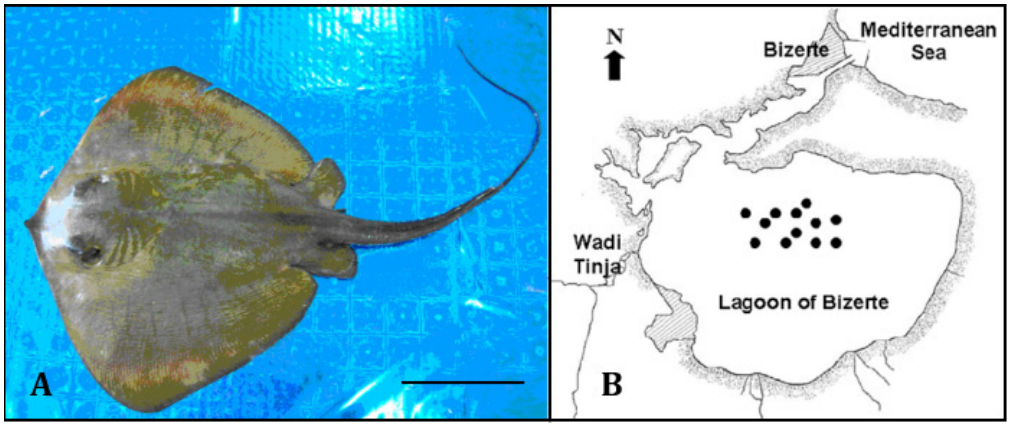

Figure 8. A. Specimen of *Dasyatis chrysonota* captured in the Lagoon of Bizerte, scale bar = 100 mm. B. Map of Lagoon of Bizerte showing the capture sites (black circles) of *Dasyatis chrysonota*.

Data were not enough to provide an estimation of size at sexual maturity in *D. chrysonota* from the Lagoon of Bizerte. Capapé & Zaouali (1995) noted that size at sexual maturity occurred for males and for females at about 300 mm and 320 mm DW, respectively, while the largest male and the largest female were 400 mm and 440 mm DW, respectively, from specimens collected in southern Tunisian waters. Off South African waters, Wallace (1967) reported that size at maturity occurred at 450 mm and 584 mm for males and females respectively. Ebert & Cowley (2008) noted that size at maturity occurred between 392 and 395 mm DW for males and between 500 and 505 mm for females, with maximum DW 531 mm (female) and 711 mm (male). In all areas, the females matured at

a larger size than the males and reached larger maximum sizes. However, the specimens from Tunisian waters were clearly smaller than those from South African waters. Size at birth occurred at about 118 mm DW and 178 mm DW in Tunisian and South African waters respectively. The smaller free-swimming specimen found in the Lagoon of Bizerte was 156 mm DW.

Measurements were carried out on two specimens and presented in Table III and describe as follows: disc rhomboid with anterior margins slightly convex at level of eyes while the posterior margins rather straight posteriorly. Snout pointed. Pelvic fins quadrangular and with rounded outer corner. Tail slender and slightly depressed dorso-ventrally. Dorsal and ventral surface of the tail with fold posterior to the sting but not extending to the end of the tail. Dorsal fold of tail higher than ventral fold. Disc-depth 15%- 18.0%, disc-length 82-86.6%, preoral length 15.0-18%, pelvic span 40.0-48.0%, pelvic fin anterior margin 17.5-17.8 %, all of disc-width. Mouth slightly arched, skin flap on upper jaws with 24 oral papillae. Five elongated papillae, three central and a single papilla on both sides. Dorsal surface beige along the margin of the pectoral fin and toward the snout; pelvic fins also beige. Slightly darker between the eyes, along the center of the body and the length of the tail. Irregularly shaped, gray to slate blue blotches, some interconnected, bordered by a thin dark, flint gray margin, that spread along the central part of the back, from between the eyes to just before the beginning of the tail. Caudal sting beige. Belly off-white to beige. Ventral surface uniformly whitish to beige with margin grey to slightly brownish at tip of snout. Morphology, measurements and colour are in agreement with Cowley & Compagno (1993) and Golani & Capapé (2004).

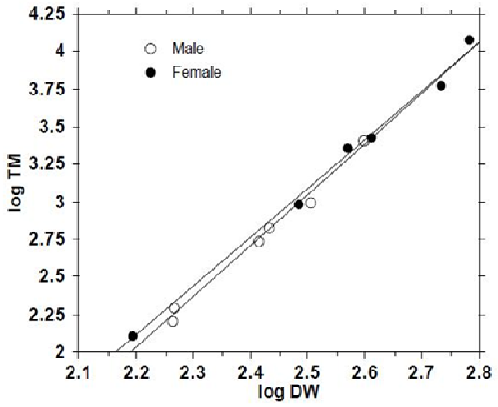

Figure 9. Relationship between total length (TL) and total mass (TM), expressed in decimal logarithmic coordinates, in *Dasyatis chrysonota* from the Lagoon of Bizerte.

Table III. Measurements carried out in two specimens of *Dasyatis chrysonota* captured in the Lagoon of Bizerte.

References	**FSB D-chry 01**		**FSB D-chry 02**	
Sex	Male		Female	
Total mass(g)	552		2288	
Measurements	**mm**	**% of TL**	**mm**	**% of TL**
Total length	475	182.69	688	185.44
Disc-length	215	82.69	321	86.52
Disc-width	260	100.00	371	100.00
Disc-depth	39	15.00	65	17.52
Eyeball width	11	4.23	17	4.58
Cornea	11	4.23	15	4.04
Pre-orbital length	45	17.31	52	14.02
Inter-orbital width	26	10.00	48	12.94
Spiracle length	18	6.92	30	8.09
Spiracle width	13	5.00	20	5.39
Inter-nasal width	25	9.62	37	9.97
Nasal curtain	25	9.62	43	11.59
Interspiracular width	39	15.00	66	17.79
Pre-oral length	48	18.46	52	14.02
Mouth width	21	8.08	35	9.43

Table III. Measurements carried out in two specimens of *Dasyatis chrysonota* captured in the Lagoon of Bizerte (continued).

Measurements	**mm**	**% of TL**	**mm**	**% of TL**
First gill slit	10	3.85	15	4.04
Second gill slit	11	4.23	16	4.31
Third gill slit	11	4.23	15	4.04
Fourth gill slit	10	3.85	14	3.77
Fifth gill slit	8	3.08	11	2.96
Width between first gill slit	51	19.62	85	22.91
Width between fifth gill slit	33	12.69	52	14.02
Snout tip to eye	51	19.62	67	18.06
Snout tip to mouth	50	19.23	59	15.90
Snout tip to fist gill slit	72	27.69	88	23.72
Snout tip to fifth gill slit	105	40.38	141	38.01
Snout tip to pelvic fin	180	69.23	270	72.78
Snout tip to sting	285	109.62	437	117.79
Sting length 1	62	23.85	125	33.69
Sting length 2	10	3.85	119	32.08
Snout tip to vent	187	71.92	280	75.47
Pectoral fin anterior margin	170	65.38	239	64.42
Pectoral fin posterior margin	149	57.31	242	65.23
Pectoral fin inner margin	29	11.15	39	10.51
Pelvic fin anterior margin	45	17.31	60	16.17
Pelvic fin posterior margin	29	11.15	77	20.75
Pelvic fin inner margin	27	10.38	23	6.20
Pelvic fin base	34	13.08	60	16.17
Span of pelvic fin	107	41.15	177	47.71
Clasper length	44	16.92	-	-
Tail base width	22.3	8.58	35	9.43
Tail base depth	14	5.38	20	5.39
Tail length	277	106.54	390	105.12
Ventral tail fold length	185	71.15	265	71.43
Dorsal tail fold length	24	9.23	40	10.78

Common stingray, ***Dasyatis pastinaca (Linnaeus, 1758).*** *Dasyatis pastinaca* is known in the eastern Atlantic from off southern Norway according to Muus & Dahlstrøm (1964-1966), off British Isles (Wheeler 1969), France (Quéro *et al.* 2003), Spain (Ortea & De La Hoz 1979) and Portugal (Albuquerque 1954-1956). South Strait of Gibraltar, the species was reported off Morocco (Collignon & Aloncle 1972) and Mauritania (Maurin & Bonnet 1970). Southward, the occurrence of *D. pastinaca* is doubtful, because it was probably confused with the close relative blue stingray, *D. chrysonota* (Smith 1828). The occurrence of *D. pastinaca* remains also questionable in South African waters (Smith & Heemstra 1986, Capapé & Desoutter 1990).

Dasyatis pastinaca occurred thoughout the Mediterranean Sea according to McEachran & Capapé (1984a), but seems to be more abundant in southern and eastern areas (Capapé 1989). Previously known off the Mediterranean coast of France (Quignard *et al.* 1962, Capapé 1977a), it is no more recorded to date in the area (Capapé *et al.* 2006a). The species is rather abundant off the

Algerian coast (Dieuzeide *et al.* 1953, Hemida pers. comm.). The species is considered abundant in Tunisian waters (Capapé 1976, Bradaï *et al.* 2004), moving the estuaries to birth giving and was recently found in Tunis Southern Lagoon (Capapé *et al*. 2004, Mejri *et al.* 2004). There are no records of the common stingray in the Bahiret El Biban where (Capapé & Zaouali 1995, Capapé *et al*. 2004).

Of the 17 common stingrays collected in the north-western region of the Lagoon of Bizerte (Fig. 10), 11 were males and 6 females, however, the former did not significantly outnumbered the latter ($\chi 2 = 1.8$, $p < 0.05$, $df = 1$). Males ranged between 169 and 400 mm DW and weighed between 145 and 2813 g TM, 10 specimens were juvenile and a single one, adult. The largest juvenile was 310 mm DW and 952 g TM. Females ranged between 250 and 441 mm DW and between 533 and 2974 g TM. The largest juvenile was 280 mm DW and 680 g TM. The relationship between DW and TM, plotted in Figure 11, showed significant difference between males and females ($F = 359.38$, $p < 0.001$, $df = 1$). The relationships were for males: log TM = 3.33 log DW –5.28; r = 0.98; n =11, and for females log TM = 3.03 log DW – 4.55; r = 0.99; n = 6.

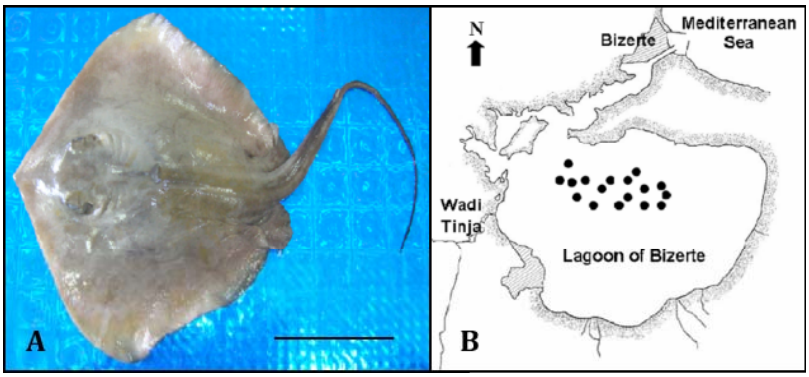

Figure 10. A. Specimen of *Dasyatis pastinaca* captured in the Lagoon of Bizerte, scale bar = 100 mm. B. Map of Lagoon of Bizerte showing the capture sites (black circles) of *Dasyatis pastinaca*.

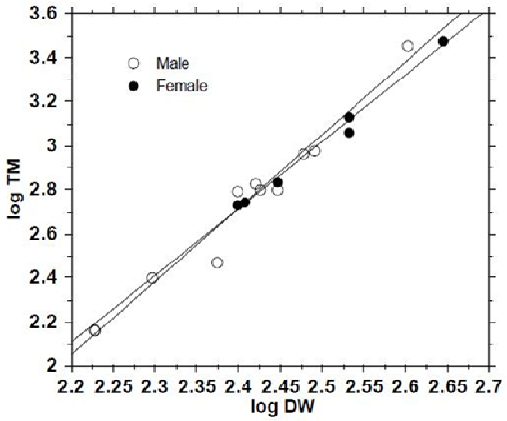

Figure 11. Relationship between total length (TL) and total mass (TM), expressed in decimal logarithmic coordinates, in *Dasyatis pastinaca* from the Lagoon of Bizerte.

No sufficient data were available to estimate size at maturity for male and female *Dasyatis pastinaca* from the Lagoon of Bizerte. However Capapé (1976) noted that males and females from Tunisian waters were adult at DW up to 310 mm and 380 mm, respectively, while the largest male and the largest female recorded were 570 mm and 680 mm DW, respectively. Similar sizes were found for specimens from the north-eastern Mediterranean, coastal waters of Turkey by Ismen (2003) and by Yeldan *et al.* (2008).

Measurements were carried out on two specimens and presented in Table IV. General morphology was similar to that of *Dasyatis chrysonota*, anterior margins of disc rather straight. Dorsal fold of tail lower than ventral fold. Disc-depth 12%- 14.0%, disc-length 80%, preoral length 16.0%-18%, pelvic span 37-48.0%, pelvic fin anterior margin 17.5%-18.0 %, all of disc-width.. Snout angle 120°. Mouth slightly arched, skin flap

on upper jaws with 32 oral papillae. Five buccal papillae, three central elongated and a single one, verruca-like, on both sides. Dorsal surface rather olive-brown, fairly rosy along the margin of the pectoral fin and toward the snout; pelvic fins also beige with golden marks surrounding the eyes and along the mid-part of the pectoral. Caudal sting beige with margins grey and tip of snout brownish. Belly beige with margins grey and tip of snout brownish. Morphology, measurements and colour are in agreement with Tortonese (1956), Bini (1967), Capapé (1977b, 1983), McEachran & Capapé (1984a), Cowley & Compagno (1993), Golani & Capapé (2004) and Mejri *et al.* (2004).

Table IV. Measurements carried out in two specimens of *Dasyatis pastinaca* captured in the Lagoon of Bizerte.

References	**FSB D-past 01**		**FSB D-past 02**	
Sex	Male		Female	
Total mass (g)	635		535	
Measurements	**mm**	**% of TL**	**mm**	**% of TL**
Total length	465	174.16	450	180.00
Disc-length	215	80.52	200	80.00
Disc-width	267	100.00	250	100.00
Disc-depth	35	13.11	32	12.80
Eyeball width	13	4.87	14	5.60
Cornea	11	4.12	12	4.80
Pre-orbital length	45	16.85	42	16.80
Inter-orbital width	29	10.86	29	11.60
Spiracle length	19	7.12	19	7.60
Spiracle width	14	5.24	13	5.20
Inter-nasal width	25	9.36	25	10.00
Nasal curtain	27	10.11	26	10.40
Interspiracular width	39	14.61	41	16.40
Pre-oral length	46	17.23	42	16.80
Mouth width	20	7.49	21	8.40
First gill slit	10	3.75	12	4.80
Second gill slit	13	4.87	9	3.60
Third gill slit	13	4.87	8	3.20
Fourth gill slit	12	4.49	9	3.60
Fifth gill slit	8	3.00	7	2.80
Width between first gill slit	54	20.22	50	20.00
Width between fifth gill slit	33	12.36	31	12.40
Snout tip to eye	55	20.60	47	18.80
Snout tip to mouth	44	16.48	44	17.60
Snout tip to first gill slit	69	25.84	65	26.00
Snout tip to fifth gill slit	106	39.70	99	39.60
Snout tip to pelvic fin	185	69.29	176	70.40
Snout tip to sting	300	112.36	272	108.80
Sting length1	59	22.10	77	30.80
Sting length2	7	2.62	47	18.80
Snout tip to vent	190	71.16	181	72.40

Table IV. Measurements carried out in two specimens of *Dasyatis pastinaca* captured in the Lagoon of Bizerte (continued).

Measurements	**mm**	**% of TL**	**mm**	**% of TL**
Pectoral fin anterior margin	161	60.30	145	58.00
Pectoral fin posterior margin	154	57.68	157	62.80
Pectoral fin inner margin	29	10.86	24	9.60
Pelvic fin anterior margin	49	18.35	29	11.60
Pelvic fin posterior margin	37	13.86	54	21.60
Pelvic fin inner margin	36	13.48	12	4.80
Pelvic fin base	32	11.99	39	15.60
Span of pelvic fin	100	37.45	109	43.60
Clasper length	31	11.61	-	-
Tail base width	21	7.87	21	8.40
Tail base depth	13	4.87	16	6.40
Tail length	272	101.87	250	100.00
Ventral tail fold length	176	65.92	112	44.80
Dorsal tail fold length	73	27.34	19	7.60

Tortonese's stingray, ***Dayatis tortonesei*** *Capapé 1975.* The description of *Dasyatis tortonesei* was given by Capapé (1975, 1977b) from specimens caught off the Tunisian coast. The specimen was considered as a junior synonym of the common stingray *D. pastinaca* (Séret & McEachran 1986), then re-assigned as valid species by Golani (1996, 2005) and Saad *et al.* (2005) from observations based on specimens collected in the eastern Levant Basin and by Neifar *et al.* (2000) on specimens caught in Tunisian waters. Kabasakal (2002) recorded *D. tortonesei* from Turkey. Outside the Mediterranean Sea, Diatta *et al* (2001) recorded the species off Senegal, while Beveridge *et al.* (2004) considered its occurrence as possible in Arcachon Basin (Atlantic coast of France). In Tunisian waters, Capapé (1978) noted that size at sexual maturity occurred for males and females at 380 mm and 460 mm DW, respectively, while the largest male and the largest female ever recorded in the area were 680 mm and 790 mm DW, respectively. Two specimens were caught in the Lagoon of Bizerte, an adult male, having 402 mm in DW and weighing 2321 g TM and an adult female having 420 mm in DW and weighing 2401 g, this latter was the smallest adult female *Dasyatis tortonesei* recorded to date. Both specimens were caught by trammel nets in the north-eastern region of the Lagoon of Bizerte (Fig. 12). Only two specimens were collected, so it is impossible to carry out a relationship size *versus* total mass.

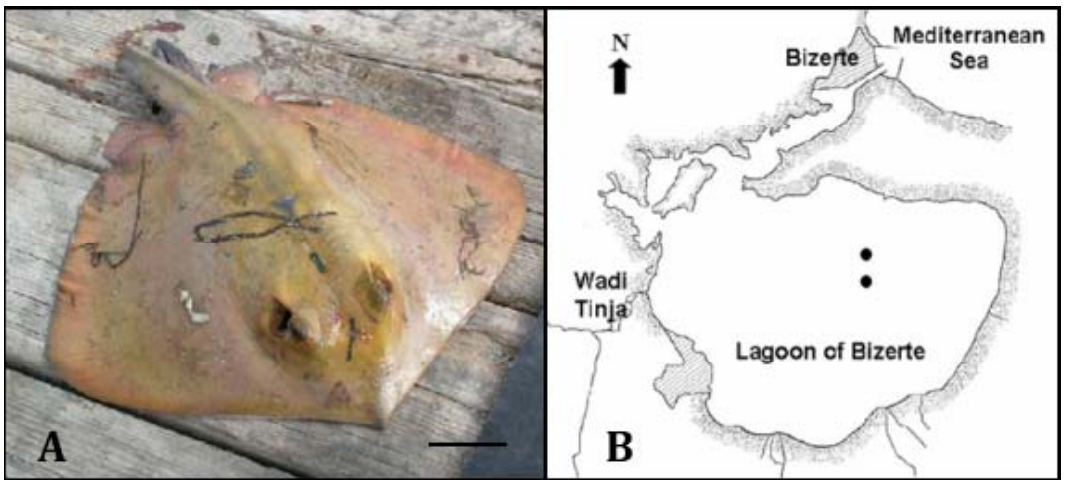

Figure 12. A. Specimen of *Dasyatis tortonesei* captured in the Lagoon of Bizerte, scale bar = 100 mm. B. Map of Lagoon of Bizerte showing the capture sites (black circles) of *Dasyatis tortonesei.*

Measurements were carried out on these two specimens and are presented in Table V. General morphology was similar to that described for *Dasyatis chrysonota* and *D. pastinaca* with anterior margins slightly convex at level of eyes while the posterior margins straight anteriorly and convex posteriorly. Carene or keel on dorsal surface of tail extending posteriorly behind sting to distal end of tail, fold on ventral surface lower than those of *D. chrysonota* and *D. pastinaca*. Disc-depth 12%-13.0%, disc-length 85%-86%, preoral length 18.0%-20%, pelvic span 33-42.0%, pelvic fin anterior margin 18%-20.0 %, all of disc-width. Snout angle 125°. Mouth slightly arched, skin flap on upper jaws with 32-36 oral papillae. Three elongated central buccal papillae, and a single one, verruca-like, on both sides. Dorsal surface rather olive-brown, fairly yellowish along the margin of the pectoral fin and toward the snout; pelvic fins also beige with golden marks surrounding the eyes and along the mid-part of the pectoral. Caudal sting beige with margins grey and tip of snout brownish. Belly beige with margins grey and tip of snout brownish. Morphology, measurements and colour are in agreement with Capapé (1977b, 1983), McEachran & Capapé (1984a) and Golani (1996).

Table V. Measurements carried out in two specimens of *Dasyatis tortonesei* captured in the Lagoon of Bizerte.

References	**FSB D-tort 01**		**FSB D-tort 02**	
Sex	Male		Female	
Total Mass(g)	2321		2401	
Measurements	**mm**	**% of TL**	**mm**	**% of TL**
Total length	640	159.20	700	166.67
Disc-length	345	85.82	357	85.00
Disc-width	402	100.00	420	100.00
Disc depth	50	12.44	53	12.62
Eyball width	15	3.73	16	3.81
Cornea	14	3.48	15	3.57
Pre-orbital length	76	18.91	81	19.29
Inter-orbital width	47	11.69	47	11.19
Spiracle length	26	6.47	26	6.19
Spiracle width	19	4.73	20	4.76
Inter-nasal width	37	9.20	38.7	9.21
Nasal curtain	46	11.44	44	10.48
Interspiracular width	64	15.92	65	15.48
Pre-oral length	82	20.40	85	20.24
Mouth width	41	10.20	40	9.52
First gill slit	16	3.98	13	3.10
Second gill slit	14	3.48	17	4.05
Third gill slit	14	3.48	17	4.05
Fourth gill slit	15	3.73	17	4.05
Fifth gill slit	12	2.99	11	2.62
Width between first gill slit	78	19.40	79	18.81
Width between fifth gill slit	46	11.44	45	10.71
Snout tip to eye	87	21.64	95	22.62
Snout tip to mouth	85	21.14	89	21.19
Snout tip to fist gill slit	128	31.84	127	30.24
Snout tip to fifth gill slit	180	44.78	181	43.10
Snout tip to pelvic fin	300	74.63	310	73.81

Table V. Measurements carried out in two specimens of *Dasyatis tortonesei* captured in the Lagoon of Bizerte (continued).

Measurements	**mm**	**% of TL**	**mm**	**% of TL**
Snout tip to sting	457	113.68	475	113.10
Sting length1	12	2.99	99	23.57
Sting length2	-	-	59	14.05
Snout tip to vent	316	78.61	322	76.67
Pectoral fin anterior margin	252	62.69	270	64.29
Pectoral fin posterior margin	252	62.69	257	61.19
Pectoral fin inner margin	39	9.70	43	10.24
Pelvic fin anterior margin	73	18.16	82	19.52
Pelvic fin posterior margin	55	13.68	68	16.19
Pelvic fin inner margin	13	3.23	26	6.19
Pelvic fin base	59	14.68	61	14.52
Span of pelvic fin	167	41.54	138	32.86
Clasper length	134	33.33	-	-
Tail base width	39	9.70	37	8.81
Tail base depth	20	4.98	20	4.76
Tail length	305	75.87	371	88.33
Ventral tail fold length	173	43.03	240	57.14
Dorsal tail fold length	81	20.15	68	16.19

Family Gymnuridae

Spiny butterfly ray, ***Gymnura altavela*** *(Linnaeus, 1758)*. The spiny butterfly ray presents a widespread amphi-atlantic distribution (McEachran & Capapé 1984b). Off the western Atlantic, the species was recorded from New England (Bigelow & Schroeder 1953) to Argentina (Roux 1979). Off the eastern Atlantic, the species was recorded from the Bay of Biscay (Cazaux & Labourg 1971, Quéro *et al.* 2003), off Spain (Ortea & De La Hoz 1979), Portugal (Albuquerque 1954-1956). The species is known to be reported south Strait of Gibraltar, off Morocco (Collignon & Aloncle 1972), Mauritania (Maurin & Bonnet 1970), Senegal (Capapé *et al.* 1995) to the Gulf of Guinea (Blache *et al* 1970), and probably off Angola (Fowler 1936).

The species was known throughout the Mediterranean Sea according to McEachran & Capapé (1984b) where it was historically not uncommon, but abundance and landings fluctuated with marine area (Capapé 1981, Capapé *et al.* 1992). To date, a drastic decline of captures was reported not only in the Mediterranean Sea, but unfortunately throughout the world, and *G. altavela* is considered to date as an endangered species (Vooren *et al.* 2007). Captures of rare specimens were sporadically observed in marine areas such as in the Adriatic Sea (Dulcic *et al.* 2003) and the Tyrrhenian Sea (Psomadakis *et al.* 2005).

The spiny butterfly ray was regularly captured as by-catch species off the Tunisian coast, rather in southern areas according to Postel (1956) and Quignard & Capapé (1971). Through surveys conducted in the area, Capapé (1989) reported the species northward in the Gulf of Tunis. Capture of two specimens in the Lagoon of Bizerte constitutes the northernmost range extension of *G. altavela* in Tunisian waters and the first record in a perimediterranean lagoon (*sensu* Quignard & Zaouali 1980). Capapé *et al.* (1992) noted that for the Tunisian coast, female *G. altavela* matured at a larger size than males, 780 mm DW and between 680 and 1020 mm DW, respectively; moreover, the largest male and the largest female reached 1140 mm and 1620 mm, respectively. Elsewhere, a mature male of about 1068 mm DW was recorded from off Madeira by Günther (1870). Bigelow & Schroeder (1953) observed a young male (1208 mm DW) from off north-eastern coast of America while the largest specimen recorded in the area was a female 2082 mm DW.

Measurements were carried out on these two specimens and presented in Table VI. The specimens from the north-western region only, of course of the Lagoon of Bizerte were 366 mm and 370 mm DW, respectively, weighed 1186 and 1203

g TM and were juveniles (Fig. 13). Morphologic characteristics were: disc lozenge-shaped about twice as broad as long with anterior margins slightly sinuous and moderately convex at level of eyes while increasing convex posteriorly. Snout with blunted tip, snout angle more or less 135°. Slender tentacle-like process pointing backward from inner margin of spiracle. Pelvic fins quadrangular and with rounded outer corner. Tail short and slightly depressed dorso-ventrally. Dorsal and ventral surfaces of the tail with lower ridge posterior to the sting extending to the end of the tail. Dorsal fin absent. Disc-depth less than 3%, disc-length 50%-52%, preoral length 9%-10%, pelvic span less than 5%, pelvic fin anterior margin 5%, all of disc-width. Mouth slightly arched, skin flap on upper jaws. Dorsal surface brown-olivaceous reddish on posterior margin of disc, with small dark or whitish spots, pelvic fins also brownish. Slightly darker between the eyes, along the center of the body and the length of the tail. Tail with darkish transversal strips on dorsal surface. Caudal sting beige. Belly off-white to beige. Morphology, measurements and colour are in agreement with Bigelow & Schroeder (1953), Tortonese (1956), Bini (1967), Capapé (1981), McEachran & Capapé (1984b), Dulcic *et al*. (2003) and Psomadakis *et al.* (2005).

Table VI. Measurements carried out in two specimens of *Gymnura altavela* captured in the Lagoon of Bizerte.

References	**FSB G-alta 01**		**FSB G-alta 02**	
Sex	Male		Female	
Total mass (g)	1186		1203	
Measurements	**mm**	**% of TL**	**mm**	**% of TL**
Total length	366	67.03	370	67.77
Disc-length	275	50.37	280	51.28
Disc-width	546	100.00	546	100.00
Disc-depth	23	4.21	25	4.58
Eyeball width	16	2.93	16	2.93
Cornea	8	1.47	8	1.47
Pre-orbital length	41	7.51	41	7.51
Inter-orbital width	39	7.14	40	7.33
Spiracle length	21	3.85	22	4.03
Spiracle width	12	2.20	12	2.20
Inter-nasal width	34	6.23	25	4.58
Nasal curtain	40	7.33	41	7.51
Interspiracular width	41	7.51	41	7.51
Pre-oral length	50	9.16	52	9.52
Mouth width	46	8.42	48	8.79
First gill slit	13	2.38	13	2.38
Second gill slit	14	2.56	15	2.75
Third gill slit	13	2.38	15	2.75
Fourth gill slit	13	2.38	13	2.38
Fifth gill slit	9	1.65	9	1.65
Width between first gill slit	85	15.57	86	15.75
Width between fifth gill slit	62	11.36	63	11.54
Snout tip to eye	48	8.79	49	8.97
Snout tip to mouth	52	9.52	53	9.71
Snout tip to first gill slit	68	12.45	70	12.82
Snout tip to fifth gill slit	115	21.06	117	21.43
Snout tip to pelvic fin	230	42.12	233	42.67
Snout tip to sting	180	32.97	183	33.52
Pectoral fin anterior margin	241	44.14	243	44.51
Pectoral fin posterior margin	330	60.44	331	60.62
Pectoral fin inner margin	260	47.62	261	47.80
Pelvic fin anterior margin	20	3.66	21	3.85

Table VI. Measurements carried out in two specimens of *Gymnura altavela* captured in the Lagoon of Bizerte (continued).

Measurements	**mm**	**% of TL**	**mm**	**% of TL**
Pelvic fin posterior margin	42	7.69	43	7.88
Pelvic fin inner margin	30	5.49	31	5.68
Pelvic fin base	8	1.47	9	1.65
Span of pelvic fin	26	4.76	27	4.95
Clasper length	57	10.44	57	10.44
Tail base width	31	5.68	32	5.86
Tail base depth	14	2.56	15	2.75
Tail length	7	1.28	7	1.28
Ventral tail fold length	104	19.05	106	19.41
Dorsal tail fold length	86	15.75	86	15.75
Clasper length	51	9.34	52	9.52

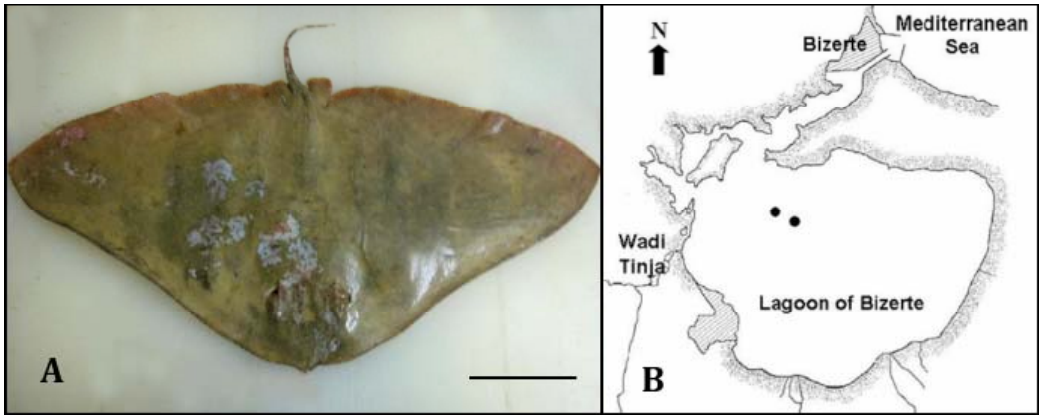

Figure 13. A. Specimen of *Gymnura altavela* captured in the Lagoon of Bizerte, scale bar = 100 mm. B. Map of Lagoon of Bizerte showing the capture sites (black circles) of *Gymnura altavela.*

Family Myliobatidae

Common eagle ray, ***Myliobatis aquila*** *(Linnaeus, 1758).* The common eagle ray was reported in the north-eastern Atlantic from off Scandinavia Muus & Dahlstrøm (1964-1966), off British Isles (Wheeler 1969), France (Quéro *et al.* 2003), Spain (Ortea & De La Hoz 1979) and Portugal (Albuquerque1954-1956). South Strait of Gibraltar, the species was reported off Morocco (Collignon & Aloncle 1972) and Mauritania (Maurin & Bonnet 1970). *Myliobatis aquila* was also recorded off Senegal by Cadenat (1951), but recent observations reported only the occurrence of its close relative species, the bull ray *Pteromylaeus bovinus* (E. Geoffroy Saint-Hilaire 1817) by Seck *et al.* (2002). Fowler (1936) noted that the common eagle ray occurred off the western coast of Africa from Angola to South African waters (Smith & Heemstra 1986).

The common eagle ray occurred in the Mediterranean but captures seem to be rather rare (see Capapé 1989). The species was reported in several areas off the southern coast of France and was not uncommon in the Gulf of Lion (Capapé *et al.* 2007). The common eagle ray is frequently captured off the Maghreb coast: Morocco (Collignon & Aloncle 1972), Algeria (Dieuzeide *et al.* 1953, Hemida pers. comm. 2009) and it rather common to date in Tunisian waters according to Bradaï *et al.* (2004).

Off the coast of Languedoc, size at sexual maturity was attained at 500-540 mm DW for the males and 730 mm DW for the females. The largest male and female were 720 and 1140 mm DW, respectively. Sexual dimorphism in size was also observed in *M. aquila* from the Tunisian coast (Capapé & Quignard 1974). Nevertheless, in this latter area both males and females matured at a smaller size than off the coast of Languedoc. Tunisian male matured between 360 and 410 mm DW, and females between 480 and 580 mm DW. The largest Tunisian male was 550 mm DW and the largest female 830 mm DW. Common eagle rays from the coast of Languedoc were larger than those caught off the Tunisian coast. This suggests that two different populations occur in each area.

Two specimens were captured in the north-eastern region of the Lagoon of Bizerte (Fig. 14): an

adult male having 524 mm DW and weighing 2138 g TM and an adult female having 765 mm DW and weighing 4230 g TM. Measurements were carried out on these two specimens and presented in Table VII. The specimen description was as follows: disc broad with pectoral slightly falciform continued along the side of the head to the end of the snout forming a single lobe. Head moderately prominent with snout broadly rounded. Spiracles large 3 times as long as width. Tail slender and elongated with dorsal fin beginning behind tips of pelvic fins. Disc-depth 13%-14%, disc-length 60%-62%, preoral length 9%-10%, pelvic span 16%-17%, pelvic fin anterior margin 17%, all of disc-width. Mouth slightly arched, with teeth fused in plates. Supra-orbitary horns in male adult. Dorsal surface naked with small tubercles down midline of disc. Brown-olivaceous reddish on posterior margin of disc, with small dark or whitish spots, pelvic fins also darkish. Slightly darker between the eyes, along the center of the body and the length of the tail. Caudal sting beige. Belly off-white to beige. Morphology, measurements and colour are in agreement with Bigelow & Schroeder (1953), Tortonese (1956), Bini (1967), Capapé & Quignard (1974) and McEachran & Capapé (1984c).

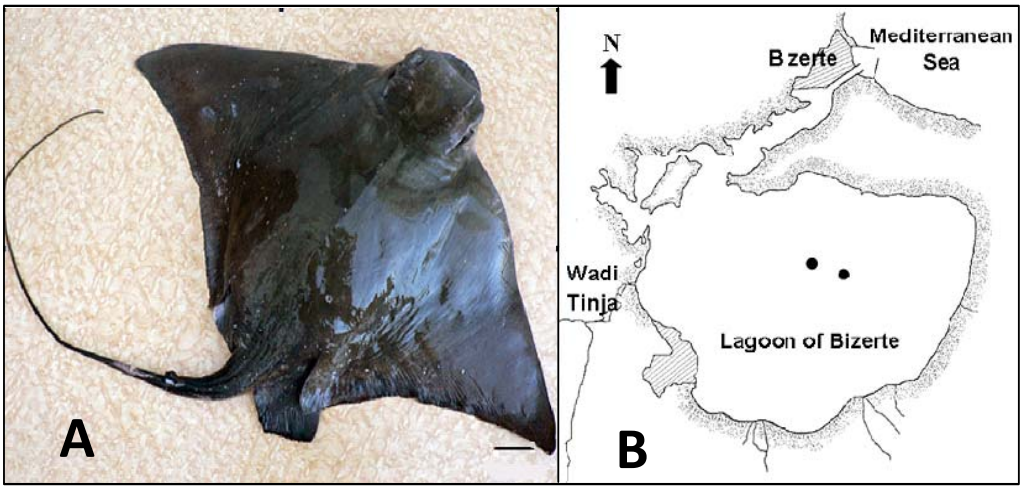

Figure 14. A. Specimen of *Myliobatis aquila* captured in the Lagoon of Bizerte, scale bar = 100 mm. B. Map of Lagoon of Bizerte showing the capture sites (black circles) of *Myliobatis aquila.*

Table VII. Measurements carried out in two specimens of *Myliobatis aquila* captured in the Lagoon of Bizerte.

References	**FSB. M-aqu. 01**		**FSB. M-aqu. 02**	
Sex	Male		F emale	
Total mass(g)	2138		4230	
Measurements	**mm**	**% of TL**	**mm**	**% of TL**
Total length	860	164.12	1162	151.90
Disc-length	320	61.07	475	62.09
Disc-width	524	100.00	765	100.00
Disc-depth	68	12.98	103	13.46
Maximum snout width	86	16.41	155	20.26
Dorsal snout width	73	13.93	98	12.81
Snout length	67	12.79	84	10.98
Snout depth	29	5.53	22	2.88
Snout tip to pectoral	66	12.60	110	14.38
Anterior interspiracular width	78	14.89	110	14.38
Posterior interspiracular width	75	14.31	104	13.59
Eyeball length	22	4.20	29	3.79
Eyeball width	22	4.20	22	2.88

Table VII. Measurements carried out in two specimens of *Myliobatis aquila* captured in the Lagoon of Bizerte (continued).

Measurements	**mm**	**% of TL**	**mm**	**% of TL**
Cornea length	13	2.48	16	2.09
Cornea width	14	2.67	14	1.83
Pre-orbital length	53	10.11	50	6.54
Inter-orbital length	84	16.03	87	11.37
Spiracle length	33	6.30	42	5.49
Spiracle width	10	1.91	16	2.09
Inter-nasal width	45	8.59	50	6.54
Nasal curtain	44	8.40	65	8.50
Pre-oral length	51	9.73	77	10.07
Mouth width	45	8.59	71	9.28
First gill slit	11	2.10	18	2.35
Second gill slit	12	2.29	21	2.75
Third gill slit	13	2.48	21	2.75
Fourth gill slit	13	2.48	21	2.75
Fifth gill slit	10	1.91	15	1.96
Width between first gill slit	73	13.93	135	17.65
Width between fifth gill slit	40	7.63	67	8.76
Snout tip to eye	53	10.11	82	10.72
Snout tip to mouth	46	8.78	80	10.46
Snout tip to first gill slit	96	18.32	140	18.30
Snout tip to fifth gill slit	144	27.48	215	28.10
Snout tip to pelvic fin	310	59.16	420	54.90
Snout tip to sting	470	89.69	615	80.39
Snout tip to dorsal	420	80.15	580	75.82
Snout tip to vent	340	64.89	455	59.48
Pectoral fin anterior margin	320	61.07	350	45.75
Pectoral fin posterior margin	260	49.62	370	48.37
Pectoral fin inner margin	33	6.30	41	5.36
Pelvic fin anterior margin	87	16.60	41	5.36
Pelvic fin posterior margin	47	8.97	82	10.72
Pelvic fin inner margin	20	3.82	55	7.19
Span of pelvic fin	88	16.79	-	-
Clasper length	19	3.63	46	6.01
Tail base width	16	3.05	27	3.53
Tail base depth	480	91.60	680	88.89
Sting length	17	3.24	23	3.01
Dorsal anterior edge	13	2.48	18	2.35
Dorsal posterior edge	3	0.57	5	0.65
Dorsal inner edge	23	4.39	32	4.18

Bull ray, ***Pteromylaeus bovinus*** *(E. Geoffroy Saint-Hilaire, 1817).* The bull ray is reported in the Eastern Atlantic from Portugal (Albuquerque 1954-1956) to Angola including Madeira and the Canary islands, from Saldanha bay to Natal (Wallace 1967) and also southern Mozambique (Compagno *et al.* 1989). In the Mediterranean, *Pteromylaeus bovinus* is more frequently captured in the eastern basin than in the western basin, rather in southern areas (Capapé 1989). For instance, the bull ray was only reported from the Mediterranean coast of France by Moreau in 1881, since further papers did report it (Capapé *et al.* 2006 a). The bull ray was previously reported as a rare elasmobranch species in the Adriatic Sea (Soljan 1975, Jardas 1985), however recent investigations allow Dulcic *et al.* (2008) to capture several specimens and to provide thorough data on the life history of *P. bovinus* from the area.

Southward, *Pteromylaeus bovinus* was reported throughout the Maghreb shore: Morocco (Collignon & Aloncle 1972), Algeria (Dieuzeide *et al.* 1953, Hemida personal communication 2009) and Tunisia (Capapé & Quignard 1975, Bradaï *et al.* 2004). Additionally, investigations conducted in Tunisian waters showed that *P. bovinus* migrated toward northern areas entering brackish waters areas such as the Lagoon of Bizerte (Neifar *et al.* 1999) and Tunis Southern Lagoon (Mejri *et al.* 2004). The captures of two specimens in the Lagoon of Bizerte confirm the migration to northern Tunisian areas.

Off the coast of Senegal adult males and females of *Pteromyaleus bovinus* were over 820 mm and 900 mm DW, respectively, while the largest and the largest female recorded being 1150 and 1480 mm DW, respectively, and weighed, 29.8 kg and 47.9 kg, respectively. The largest specimens ever recorded were from the northern Adriatic Sea; they ranged between 1540 and 2220 mm DW and weighed between 68 and 116 kg (Dulcic *et al.* 2008). Off the Tunisian coast, size at sexual maturity occurred for males at 800 mm DW, and for females between 900 and 1000 mm DW. Size at birth occurred between 250 and 270 mm DW for bull rays from Senegal, near term embryos weighed between 310 to 345 g TM, similar patterns were observed for near terms from off Tunisian coast, while Dulcic *et al.* (2008) recorded near term pregnant females that bore embryos having from 370 and 450 mm in DW and weighing from 740 to 1080 g TM.

The two specimens captured in the central Lagoon of Bizerte were 426 mm and 450 mm DW, respectively, and weighed 1020 g and 1005 g (Fig. 15). They bore a healed scar and probably, were recently born in the lagoon. Size at birth was probably underestimated for local bull rays by Capapé & Quignard (1975). Measurements were carried out on these two specimens and presented in Table VIII. General morphology similar to *Myliobatis aquila* but stouter.

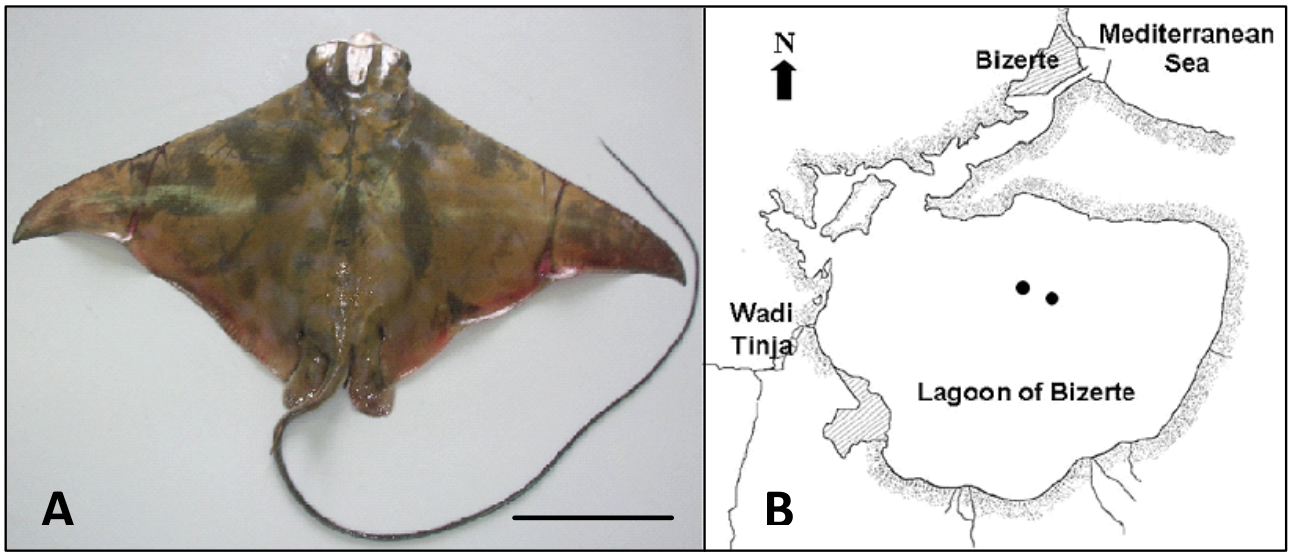

Figure 15. A. Specimen of *Pteromylaeaus bovinus* captured in the Lagoon of Bizerte, scale bar = 100 mm. B. Map of Lagoon of Bizerte showing the capture sites (black circles) of *Pteromylaeus bovinus.*

Table VIII. Measurements carried out in two specimens of *Pteromylaeus bovinus* captured in the Lagoon of Bizerte.

References	**FSB P-bov. 01**		**FSB. P-bov. 02**	
Sex	Male		Female	
Total mass (g)	1005		1030	
Measurements	**mm**	**% of TL**	**mm**	**% of TL**
Total length	780	173.33	787	184.74
Disc-length	220	48.89	281	65.96
Disc-width	450	100.00	426	100.00
Disc-depth	45	10.00	53	12.44
Maximum snout width	65	14.44	62	14.55
Dorsal snout width	38	8.44	39	9.15
Snout length	24	5.33	34	7.98
Snout depth	14	3.11	19	4,46
Snout tip to pectoral	66	14.67	64	15.02
Anterior interspiracular width	60	13.33	62	14.55
Posterior interspiracular width	53	11.78	51	11.97
Eyball length	21	4.67	21	4.93
Eyball width	15	3.33	14	3.29
Cornea length	12	2.67	11	2.58
Cornea width	8	1.78	9	2.11
Pre-orbital length	35	7.78	40	9.39
Inter-orbital length	40	8.89	64	15.02
Spiracle length	21	4.67	38	8.92
Spiracle width	7	1.56	14	3.29
Inter-nasal width	21	4.67	19	4.46
Nasal curtain	31	6.89	25	5.87
Pre-oral length	51	11.33	49	11.50
Mouth width	27	6.00	32	7,51
First gill slit	9	2.00	8	1.88
Second gill slit	10	2.22	9	2.11
Third gill slit	10	2.22	10	2.35
Fourth gill slit	10	2.22	10	2.35
Fifth gill slit	7	1.56	6	1.41
Width between first gill slit	56	12.44	58	13.62
Width between fifth gill slit	38	8.44	40	9,39
Snout tip to eye	45	10.00	50	11.74
Snout tip to mouth	48	10.67	50	11.74
Snout tip to fist gill slit	78	17.33	82	19.25
Snout tip to fifth gill slit	118	26.22	112	26.29
Snout tip to pelvic fin	222	49.33	223	52.35
Snout tip to sting	305	67.78	292	68.54
Snout tip to dorsal	256	56.89	241	56.57
Snout tip to vent	235	52.22	229,5	53.87
Pectoral fin anterior margin	220	48.89	210	49.30
Pectoral fin posterior margin	218	48.44	200	46.95
Pectoral fin inner margin	31	6.89	31	7.28
Pelvic fin anterior margin	60	13.33	59	13.85
Pelvic fin posterior margin	24	5.33	33	7.75
Pelvic fin inner margin	16	3.56	36	8.45
Span of pelvic fin	84	18.67	77	18.08
Clasper length	30	6.67	58	13.62

Table VIII. Measurements carried out in two specimens of *Pteromylaeus bovinus* captured in the Lagoon of Bizerte (continued).

Measurements	**mm**	**% of TL**	**mm**	**% of TL**
Tail base width	13	2.89	15	3.52
Tail base depth	12	2.67	12	2.82
Tail length	540	120.00	552	129.58
Sting length	-	-	25	5.87
Dorsal anterior edge	26	5.78	22	5.16
Dorsal posterior edge	10	2.22	18	4.23
Dorsal inner edge	7	1.56	1	0.23
Dorsal base	32	7,.1	32	7.51

The species morphological characteristics were: head large prominent, snout produced, narrower than the skull, blunted at the end. Rostral fins at lower level and separate from the pectoral fins along the side of the head. Pectoral fins with outer angle acute strongly falciform. Spiracles large 3 times as long as width. Tail slender and elongated with dorsal fin beginning in front of tips of pelvic fins. Disc-depth 10%-13%, disc-length 48%-65%, preoral length 11%-12%, pelvic span 18%-19%, pelvic fin anterior margin 13%-14%, all of disc-width. Mouth slightly arched, with teeth fused in plates. Pre-orbitary horns in male adult. Dorsal surface naked with small tubercles down midline of disc. Dorsal surface of disc fairly brownish with 7 to 9 pale transverse streaks in juveniles, plain brown in adults. Slightly darker between the eyes, along the center of the body and the length of the tail. Caudal sting beige. Belly off-white to beige. Morphology, measurements and colour are in agreement with Tortonese (1956), Bini (1967), Capapé & Quignard (1975), McEachran & Capapé (1984c), Seck *et al.* (2002) and Dulcic *et al.* (2008).

Conclusions

Of the 62 elasmobranch species reported in Tunisian waters 8 were recorded in the Lagoon of Bizerte. Seven species were strictly Atlanto-Mediterranean *sensu* Quignard (1978), a single species *Gymnura altavela* had a widespread amphi-atlantic distribution.

All were batoids, due to fact that the navigation channel constitutes a main obstacle at the entrance of sharks in the area. Similar pattern was also reported for Tunis Southern Lagoon which does not communicate directly with sea, no shark was recorded in this area (Mejri *et al.* 2004). In contrast, Capapé *et al.* (2004) recorded shark species in the southern Bahiret El Biban, communicating directly with the Gulf of Gabès, additionally considered as a potential nursery area for shark species (Bradaï *et al.* 2002, 2005). However, captures of sharks were considered as occasional, and generally small specimens were observed. A single small shark species appeared to inhabit the Bahiret El Biban, the oviparous small spotted catshark *Scyliorhinus canicula* (Linnaeus 1758). The Bahiret El Biban is also the largest brackish area, this explains why elasmobranch species are qualitatively and quantitatively more abundant in this area than in the two other areas.

Only one species the common torpedo *Torpedo torpedo* could be considered as an inhabitant of this brackish area where it develops and reproduces. So, a population seems to be definitively established in the area. The reasons for success are probably to fact that the species does not reach a large size and could live in a restricted area. *T. torpedo* lives buried in sandy-muddy bottoms and its capture is not very easy by fishing gears. The species has no commercial value and generally discarded alive in the lagoon soon after being captured. Additionally, *T. torpedo* is one of the most abundant species in the neighbouring shallow coastal waters, and find no difficulties to enter the lagoon through navigation channel. Its recruitment remains permanent. The marbled electric ray *T. marmorata* presented similar patterns that its congeneric species. However, *T. marmorata* is larger than *T. torpedo* and is less abundant in the neighbouring areas. This explains why we have found few specimens in the area. Moreover, an interspecific competition cannot be excluded between the two species.

Of the 3 dasyatid species occurring in the Lagoon of Bizerte, 2 only could be considered as relatively abundant, *Dasyatis chrysonota* and *D. pastinaca*, the third *D. tortonesei* is rare. Their occurrence could be explained by the abundance in the Lagoon of Bizerte of mussels, oysters and several gastropod species which constitute their main food (Capapé 1975), similar patterns could explain also the presence in the area of *Gymnura altavela*, *Myliobatis aquila* and *Pteromylaeus*

bovinus.

These 6 species have not important economical value, however they are consumed by local population having low income, and they are not discarded as it was the case for torpedinid species. They are vulnerable to fishing pressure due to fact they adhere to K-selected life-histories and their recruitment remains difficult, these species are not very abundant in the neighbouring shallow coastal waters.

Consequently, *Torpedo torpedo* is a species of small size and it was abundantly and regularly caught in the area, so it could be considered as a sedentary species. *T. marmorata*, *D. chrysonota* could also be potentially considered as sedentary species, however, their real status in the aera needs to be assessed. *Gymnura altavela*, *Myliobatis aquila* and *Pteromylaeus bovinus* are species of which fry and juveniles enter the lagoon to find sufficient resources and to develop; they are rather regular migratory species. The relation size *versus* disc width corroborated this hypothesis.

Additionally, following both classifications of Compagno & Cook (1995) and Aidan Martin (2005), 6 species maximum could be considered as marginal species, inshore marine and marginal in fresh water. The three other species, all dasyatids are probably euryhaline species, they entered estuarine rivers to breed, such as the marbled stingray *Dasyatis chrysonota* and the common stingray *D. pastinaca* according to Capapé & Zaouali (1995).

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