

**A CASE OF HERMAPHRODITISM IN TORTONESE'S STINGRAY, *DASYATIS TORTONESEI*  
(ELASMOBRANCHII: RAJIFORMES: DASYATIDAE)  
FROM THE LAGOON OF BIZERTE, TUNISIA**

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**Abstract.** A normal hermaphrodite Tortonese's stingray, *Dasyatis tortonesei* Capapé, 1975, captured in the brackish Lagoon of Bizerte (north-eastern Tunisia) is described in this note. It was a large specimen measuring 685 mm total length, 350 mm disk width, and 2190 g of the total body mass. The specimen externally presented medial cuspidate tooth rows on both jaws, and two claspers were present, that were rigid and calcified although shorter than those observed in normal specimens. The dissection of the abdominal cavity revealed on each side, an ovary normally developed that contained yolked oocytes, a complete genital tract and an uterus less developed than in normal adult. Conversely the testes were rudimentary, both Leydig's glands were developed and a complete, slightly convoluted, male duct existed on the left side only. In all, 13 cases of normal (4) and abnormal (9) hermaphroditism, including the Tunisian *D. tortonesei*, have been found in batoid species, to date, confirming that the phenomenon is very rare among these chondrichthyan fishes..

**Keywords:** *Dasyatis tortonesei*, normal hermaphrodite, Lagoon of Bizerte, Tunisia, central Mediterranean

The Tortonese's stingray, *Dasyatis tortonesei* Capapé, 1975, was described from specimens caught off the Tunisian coast (Capapé 1975, 1977). The species, however, was considered a junior synonym of the common stingray *D. pastinaca* (L.) by Séret and McEachran (1986), then re-instated as a valid species by Golani (2005) and Saad et al. (2005), based on the specimens caught in the eastern Levant Basin, and by Neifar et al. (2000) who studied the 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 the Bassin of Arcachon (Atlantic coast of France).

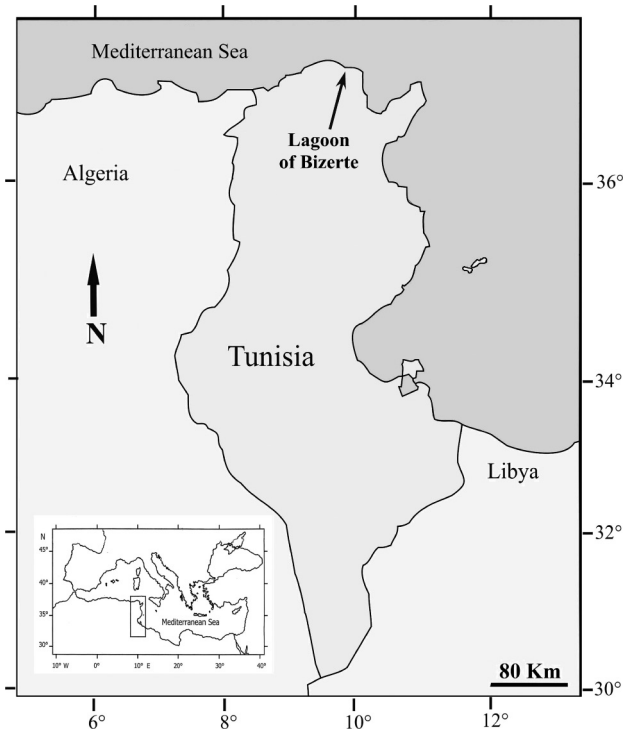
The occurrence of *D. tortonesei* was reported from the entire stretch of the Tunisian coast (Bradai et al. 2004), although it was the most common in southern areas, especially in the Gulf of Gabès, and less common in northern areas such as the Gulf of Tunis (Capapé 1989). Two specimens were first recorded on 16 January 2009 by El Kamel et al. (2009a), in the brackish Lagoon of

Bizerte, located in north-eastern Tunisia (Fig. 1). Furthermore, survey conducted in the area, between January 2007 and May 2012 yielded 25 additional specimens. In total, 27 specimens were observed including 13 males, 13 females, and an abnormal specimen, described the present note.

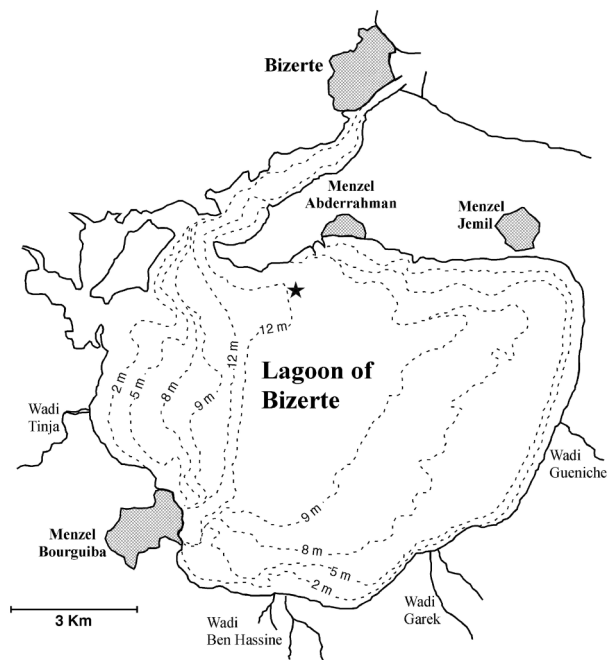
The abnormal specimen was captured on 14 May 2010, from the depth of approximately 9 m, on soft bottom, off Menzel Abderrahman, close to the nautical channel (37°13'03.67"N and 9°49'32.28"E), using commercial gill-nets of 40 mm stretched mesh (Fig. 2). Immediately after the capture, total length (TL) and disk width (DW) were measured to the nearest mm, and total mass weighed to the nearest g (Fig. 3). Additionally, some organs were removed from the abdominal cavity and weighed to the nearest g.

The abnormal *D. tortonesei* was 685mm TL, 350 mm DW and weighed 2190 g. Morphometric measurements and meristic counts, following the methodology of Golani and Capapé (2005), are given in Table 1. Two other specimens of *D. tortonesei* caught in the Lagoon of Bizerte

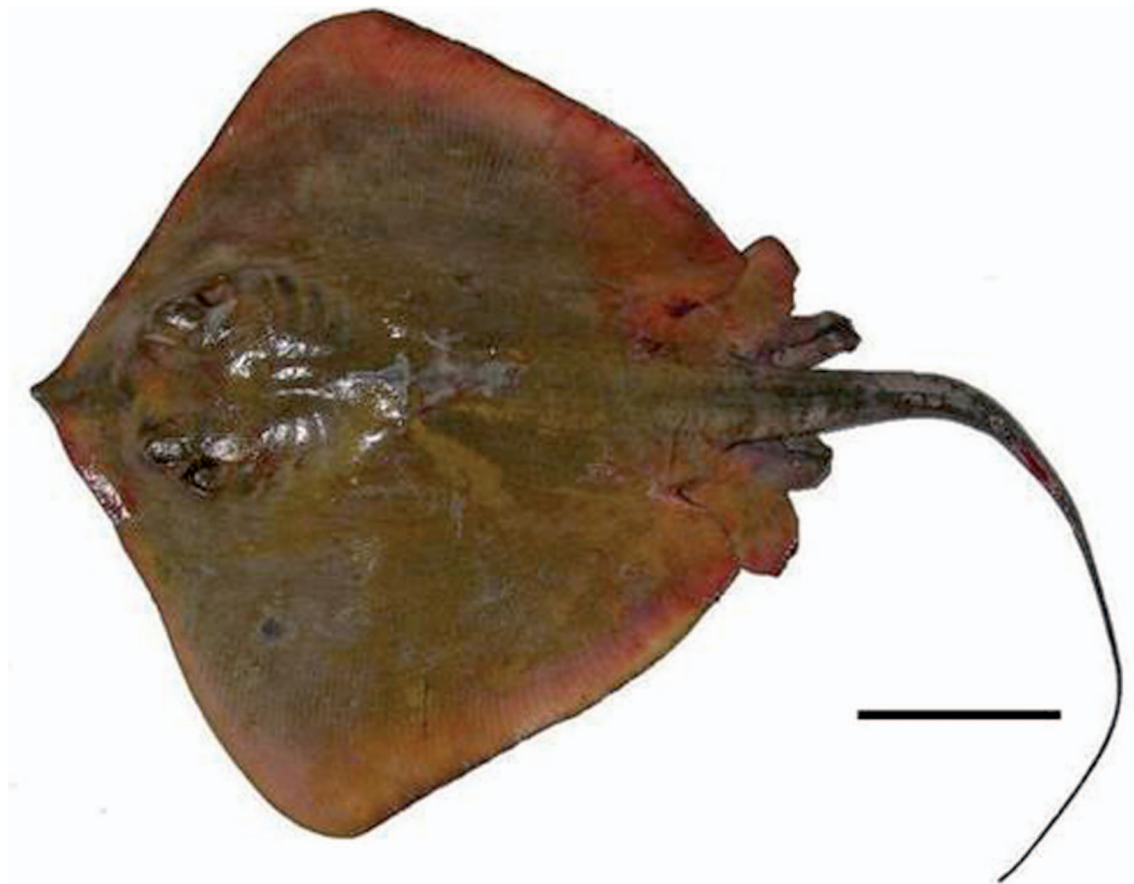
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**Fig. 1.** Map of the Mediterranean showing Tunisia and map of the coast of Tunisia showing the collection site of hermaphrodite Tortonese's stingray, *Dasyatis tortonesei* (Lagoon of Bizerte)



**Fig. 2.** Map of the Lagoon of Bizerte pointing out the capture site (black star) of the hermaphrodite specimen of *Dasyatis tortonesei*



**Fig. 3.** Hermaphrodite specimen of *Dasyatis tortonesei* (FSB-D-tort 03) caught in the Lagoon of Bizerte, Tunisia; Scale bar = 100 mm

**Table 1**

Morphometric measurements (in mm and as % TL), meristic counts and masses recorded in the hermaphrodite specimen of *Dasyatis tortonesei* (FSB-D-tort 03) and comparison with two specimens (FSB-D-tort 04, FSB-D-tort 05)) from the Lagoon of Bizerte

	FSB-D-tort 03	%DW	FSB-D-tort 04	%DW	FSB-D-tort 05	%DW
Sex	Hermaphrodite		Male		Female	
Total mass [g]	2190		1572		1700	
Total lenght	685	167.07	682	197.68	688	185.95
Disk-length	350	85.37	308	89.28	300	81.08
Disk-width	410	100.00	345	100.00	370	100.00
Disk depth	70	17.07	47	13.71	64	17.32
Eyball width	16	3.90	17	4.97	17	4.46
Cornea	13	3.17	13	3.80	14	3.80
Pre-orbital length	68	16.59	63	18.26	59	15.86
Inter-orbital width	40	9.76	42	12.42	32	8.58
Spiracle length	29	7.07	28	8.21	26	7.11
Spiracle width	19	4.63	20	5.88	16	4.24
Inter-nasal width	39	9.51	35	10.23	33	9.02
Nasal curtain	44	10.73	41	12.02	39	10.41
Interspiracular width	64	15.61	67	19.38	59	15.99
Pre-oral length	70	17.07	65	18.85	57	15.31
Mouth width	42	10.24	35	10.06	34	9.26
First gill slit	11	2.68	12	3.53	12	3.19
Second gill slit	12	2.93	12	3.43	13	3.41
Third gill slit	13	3.17	11	3.29	13	3.64
Forth gill slit	13	3.17	95	27.54	12	3.36
Fifth gill slit	9	2.20	8	2.21	6	1.74
Width between first gill slit	80	19.51	73	21.25	72	19.44
Width between fifth gill slit	50	12.20	44	12.73	45	12.04
Snout tip to eye	83	20.24	69	20.07	70	19.01
Snout tip to mouth	72	17.56	69	20.07	55	14.95
Snout tip to first gill slit	107	26.10	100	28.98	96	26.00
Snout tip to fifth gill slit	166	40.49	148	42.76	141	38.14
Snout tip to pelvic fin	310	75.61	265	76.81	260	70.27
Snout tip to sting	455	110.98	418	121.16	420	113.51
Sting length	—	—	—	—	—	—
Snout tip to vent	293	71.46	270	78.26	275	74.32
Pectoral fin anterior margin	240	58.54	205	59.42	220	59.46
Pectoral fin posterior margin	227	55.37	200	57.97	220	59.46
Pectoral fin inner margin	52	12.68	43	12.59	31	8.42
Pelvic fin anterior margin	59	14.39	61	17.67	63	17.00
Pelvic fin posterior margin	40	9.76	52	15.11	53	14.22
Pelvic fin inner margin	21	5.12	16	4.63	26	6.91
Pelvic fin base	34	8.29	30	8.74	49	13.21
Span of pelvic fin	142	34.63	148	43.01	142	38.25
Clasper length	90	21.95	137	39.71	—	0.00
Tail base width	36	8.78	28	8.16	29	7.96
Tail base depth	21	5.12	21	6.01	20	5.39
Tail length	365	89.02	395	114.49	380	102.70
Ventral tail fold length	113	27.56	102	29.48	129	34.86
Dorsal tail fold length	42	10.24	25	7.25	18	4.96
<b>Counts</b>						
Oral papillae	29		28		28	
Bucal papillae	1 + 3 + 1		1 + 3 + 1		1 + 3 + 1	
Teeth rows upper jaw	47		45		45	
Teeth rows lower jaw	42		39		42	

were added for comparison. The parameters presented in Table 1 were consistent with previous accounts of *D. tortonesei* provided by Capapé (1977) and Mc Eachran and Capapé (1984). The three specimens were preserved and deposited in the Ichthyological Collection of the Faculté des Sciences de Bizerte, with catalogue numbers, FSB-D-tort 03, 04, and 05 respectively.

The analysis of the medial tooth rows on both jaws of the abnormal specimen showed that they were the typical cuspidate teeth of males, described in dasyatid species (Mc Eachran and Capapé 1984). Both claspers were present, rigid and calcified but shorter than those observed in normal specimens (Capapé 1983); additionally their distal end was not elongate and sharp but broadly rounded, although entirely covered by skin; no scar was visible; the teeth were probably functional (Fig. 4). Both claspers were measured following methodology of Collenot (1969), the left clasper, 90 mm, being slightly smaller than the right one, 92 mm. Additionally, the clasper of the hermaphrodite specimen was smaller than that of the normal specimen of similar size (Table 1). The loss of tail clasper was the consequence of an abnormal development during growth, and not the result of a predation, such pat-

tern was rather reported for tail of skate species (Mnasri et al. 2009, Orlov 2011).

Dissection of the abdominal cavity allowed the primary sexual characters to be investigated (Fig. 5). Two ovaries were present and contained large yolke oocytes (Fig. 6); the left ovary weighed 35.9 g and contained 16 oocytes ranging in diameter from 17 to 21 mm, the right ovary weighed 22.9 g and contained 16 oocytes ranging in diameter from 13 to 18 mm. Both spermiducts were developed, the oviducal gland was more developed in the right side, while two uteri were present, the left uterus appeared to be more developed than the right one, but less than those generally observed in normal female specimens. Occurrence of two ovaries and two uteri could be considered a morphological aberration in a dasyatid species, in which only a single ovary and a single uterus are functional in large specimens (Mellinger 1989).

The specimen exhibited two Leydig's gland normally developed and two rudimentary testes, both spermiducts were present and slightly convoluted, although no sperm was found in either ducts. In adult male of *D. tortonesei*, as in other dasyatid species, the genital apparatus is typically fully developed on both sides (Capapé 1978,



**Fig. 4.** Claspers of the hermaphrodite specimen of *Dasyatis tortonesei* caught in the Lagoon of Bizerte, Tunisia; Scale bar = 20 mm

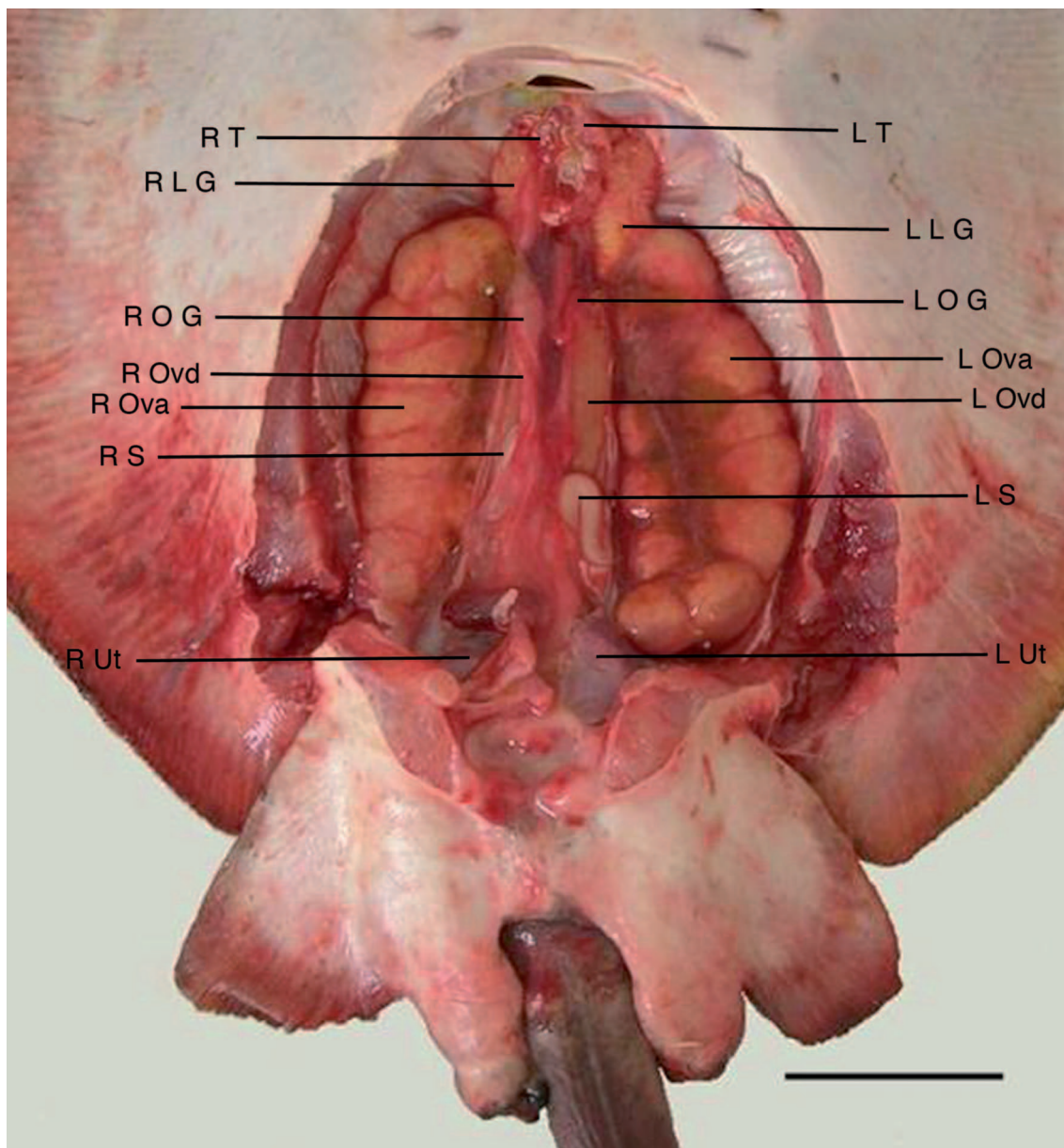


Mellinger 1989). The liver mass was 123.9 g, the digestive tract mass was 67.7 g. The gut contained remains of food totally digested and unidentifiable, weighing approximately 1 g.

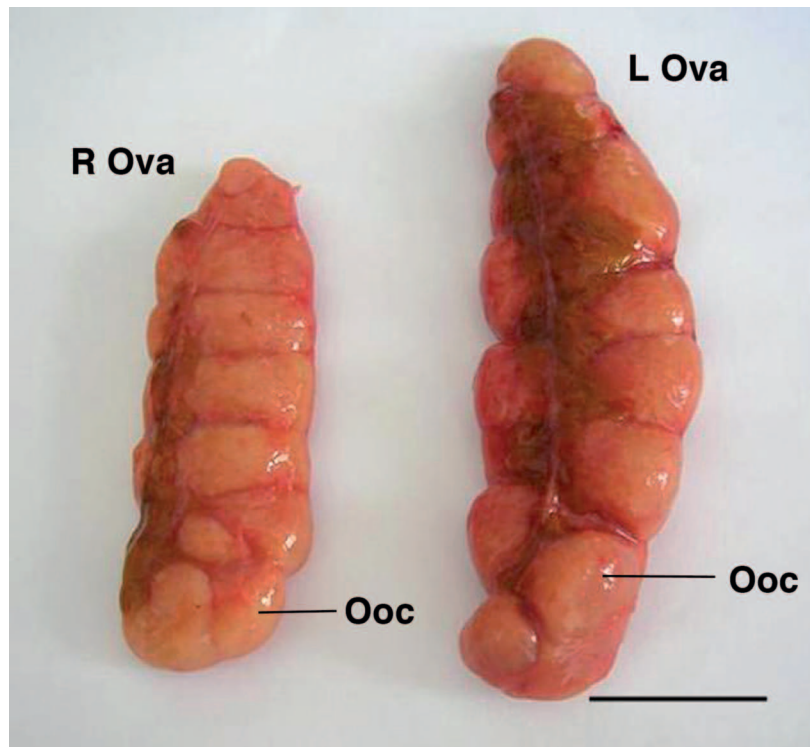
Of the three categories of abnormalities reported by Dawson (1964, 1966, 1971) and Dawson and Heal (1971) in chondrichthyans, hermaphroditism is probably the most interesting due to the fact that it directly concerns reproductive organs and reproduction. Atz (1964) noted that hermaphroditism was rarely recorded in chondrichthyans. Two types of hermaphroditism are generally reported in chondrichthyans such as 'abnormal hermaphrodite' and 'normal hermaphrodite' following Atz (1964) and Iglésias et al. (2005), defined also as 'pseudo-hermaphrodite' and 'true hermaphrodite' by Irvine et al. 2002. Normal hermaphrodites or true-hermaphrodites exhibit internally

both sexes with claspers and when mature it could assume functions of both male and female, all other cases of hermaphroditism would be defined as abnormal or pseudo-hermaphroditism (Irvine et al. 2002, Iglésias et al. 2005). Additionally, Atz (1964) and Bortone and Davis (1994) noted that intersexuality is considered when primary or secondary characters of both sexes are present in a same specimen.

Externally, the studied specimen exhibited, male secondary characters such as cuspidate teeth and claspers. Internally, it possessed developed female organs and yolked oocytes of ovulatory size; so it could be considered a functioning adult female. On the other hand, the male reproductive organs are consistent with a sub-adult male, totally developed in the left side only, even if the structure of both claspers are characteristic of an adult



**Fig. 5.** Ventral view of the abdominal cavity of the hermaphrodite specimen of *Dasyatis tortonesei* caught in the Lagoon of Bizerte, Tunisia; showing on left side (L) and on right side (R): Leydig's gland (LG), oviducal gland (OG), ovary (Ova), oviduct (Ovd), spermiduct (S), testis (T), uterus (Ut); Scale bar = 40 mm



**Fig. 6.** Left ovary (L Ova) and right ovary (R Ova) removed from the abdominal cavity of the hermaphrodite specimen of *Dasyatis tortonesei* caught in the Lagoon of Bizerte, Tunisia; oocyte (Ooc); Scale bar = 25 mm

**Table 2**

Normal and abnormal cases of hermaphroditism recorded in batoid species from other marine regions, including the specimen described in this note

Family	Species	Hermaphroditism	Reproductive mode	Capture site	Reference
Rhinobatidae	<i>Rhinobatos horkelii</i>	Normal	Aplacental viviparous	Southern coast of Brazil	Gianeti and Vooren 2007
Narcinidae	<i>Narcine timlei</i>	Normal	Aplacental viviparous	Coast of India	Nair and Soundararajan 1973
Torpedinidae	<i>Torpedo marmorata</i>	Abnormal	Aplacental viviparous	Coast of Tunisia	Capapé 1974
Torpedinidae	<i>Torpedo torpedo</i>	Abnormal	Aplacental viviparous	Coast of Tunisia	Quignard and Negla 1971
Arhynchobatidae	<i>Bathyrhaja multispinis</i>	Abnormal	Oviparous	Coast of Argentina	Scenna et al. 2007
Rajidae	<i>Raja asterias</i>	Abnormal	Oviparous	French Mediterranean coast	Quignard and Negla 1971
Rajidae	<i>R. clavata</i>	Abnormal	Oviparous	British waters	Matthews 1895 (in Atz 1964)
Rajidae	<i>R. clavata</i>	Abnormal	Oviparous	?	Hoek 1894 (in Atz 1964)
Rajidae	<i>R. miraletus</i>	Normal	Oviparous	Coast of Tunisia	Quignard and Capapé 1972
Rajidae	<i>R. miraletus</i>	Abnormal	Oviparous	Coast of Tunisia	Quignard and Capapé 1972
Dasyatidae	<i>Dasyatis tortonesei</i>	Normal	Aplacental oviparous	Lagoon of Bizerte (Tunisia)	This study
Dasyatidae	<i>Pteroplatytrygon violacea</i>	Abnormal	Aplacental viviparous	Southern coast of Brazil	Ribeiro-Prado et al. 2009
Myliobatidae	<i>Aetomylaeus nichofii</i>	Abnormal	Aplacental viviparous	Indian Ocean (off Pakistan?)	Capapé and Desoutter 1979

male. It appears that the specimen could subsequently assume the function of male, but such hypothesis remains suitable. The specimen was a normal or true hermaphrodite following the definitions of Atz (1964), Irvine et al. (2002), and Iglésias et al. (2005). The presently reported observation is likely to be the first case of a true hermaphrodite in a dasyatid species. Previously, Ribeiro-Prado et al. (2009) described an abnormal hermaphrodite of the pelagic stingray, *Pteroplatytrygon violacea* (Bonaparte, 1832).

Although such abnormalities are considered rare in chondrichthyans, a high percentage of true hermaphrodites were observed in the brown lantern shark, *Etmopterus unicolor* (Engelhardt, 1912), by Yano and Tanaka (1989) and the black dogfish, *Centroscyllium fabricii* (Reinhardt 1825), by Yano (1995), while Iglésias et al. (2005) stated that hermaphroditism is the normal condition of reproduction in the longhead catshark, *Apristurus longicephalus* Nakaya, 1975. No similar patterns were reported in batoid species, from which, few instances were recorded, only 15, to date (Table 2).

The causes of hermaphroditism in chondrichthyans remain obscure. Atz (1964) noted that they may be due to endogenous-, hormonal-, or genetic factors as in other vertebrate species. Abnormalities in fish species occur during the early stages of development and could constitute an important indicator on unfavourable environmental conditions and pollutants, induced stress in the wild (Sfakianakis et al. 2004). Heavy metals such as Cd, Pb, Zn, and Cu are suspected to cause reduction or absence of fins (Sloof 1982). Several cases of abnormalities were described from animal species collected in the Lagoon of Bizerte, a restricted brackish area polluted by both inorganic and organic nutrients and heavy metals (Mzoughi et al. 2002, Harzallah 2003). Louiz et al. (2007) noted that skeletal deformities observed in 3 gobiid species were significantly higher in the areas severely polluted. Such pollution could explain why abnormal specimens of *Torpedo torpedo* (L.) were reported from the Lagoon of Bizerte (Ben Brahim and Capapé 1997, Ben Brahim et al. 1998, El Kamel et al. 2009b, Mnasri et al. 2010, El Kamel-Moutalibi et al. 2011), common torpedoes such as stingrays live buried in sandy bottoms, known to accumulate pollutants. The role of pollution in hermaphroditism concerning elasmobranch species seems to be worth further investigations.

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## REFERENCES

- Atz J.W. 1964. Intersexuality in fishes. Pp. 145–232. In: Armstrong C.N., Marshall A.J. (eds.). Intersexuality in vertebrates including man. Academic Press, London.
- Ben Brahim R., Capapé C. 1997. Nageoire dorsale supplémentaire chez une torpille ocellée, *Torpedo (Torpedo) torpedo* des eaux tunisiennes (Méditerranée centrale). *Cybio* **21** (2): 223–225.
- Ben Brahim R., Seck A.A., Capapé C. 1998. Albinisme chez la torpille ocellée, *Torpedo (Torpedo) torpedo* (Linnaeus, 1758). *Cybio* **22** (1): 83–86.
- Beveridge I., Neifar L., Euzet L. 2004. Review of the genus *Progrillotia* Dollfus, 1946 (Cestoda: Trypanorhyncha), with a redescription of *Progrillotia pastinacae* Dollfus, 1946 and description of *Progrillotia dasyatidis* sp. n. *Folia Parasitologica* **51** (1): 33–44.
- Bortone S.A., Davis W.P. 1994. Fish intersexuality as indicator of environmental stress. Monitoring fish reproductive systems can serve to alert humans to potential harm. *BioScience* **44** (3): 165–172.
- Bradai M.N., Quignard J.-P., Bouain A., Jarboui O., Ouannes-Ghorbel A., Ben Abdallah L., Zaouali J., Ben Salem S. 2004. Ichtyofaune autochtone et exotique des côtes tunisiennes: Recensement et biogéographie. *Cybio* **28** (4): 315–328.
- Capapé C. 1974. Anomalie de l'appareil urogénital chez *Torpedo (Torpedo) marmorata* Risso, 1810. *Archives de l'Institut Pasteur de Tunis* **51** (4): 321–328.
- Capapé C. 1975. Sélaciens nouveaux et rares le long des côtes tunisiennes. Premières observations biologiques. *Archives de l'Institut Pasteur de Tunis* **52** (1–2): 107–128.
- Capapé C. 1977. Les espèces du genre *Dasyatis* Rafinesque, 1810 (Pisces, Rajiformes) des côtes tunisiennes. *Cybio* **3** 2ème série **2**: 75–105.
- Capapé C. 1978. Contribution à la biologie des Dasyatidae des côtes tunisiennes. III. *Dasyatis tortonesei* Capapé, 1975. Répartition géographique et bathymétrie, sexualité, reproduction, fécondité. *Bulletin de l'Institut national scientifique et technique d'Océanographie et de Pêche de Salammbô* **5**: 97–110.
- Capapé C. 1983. Nouvelles données sur la morphologie des Dasyatidae (Pisces, Rajiformes) des côtes tunisiennes. *Bulletin de l'Institut national scientifique et technique d'Océanographie et de Pêche de Salammbô* **10**: 69–98.
- Capapé C. 1989. Les Sélaciens des côtes méditerranéennes: aspects généraux de leur écologie et exemples de peuplements. *Océanis* **15** (3): 309–331.
- Capapé C., Desoutter M. 1979. Nouvelle description de *Aetomylaeus nichofii* (Bloch et Schneider, 1801) (Pisces, Myliobatidae). Premières observations biologiques. *Cahiers de l'Indo-Pacifique* **1** (3): 305–322.
- Collenot G. 1969. Etude biométrique de la croissance relative des ptérygopodes chez la roussette *Scyliorhinus canicula* L. *Cahiers de Biologie marine* **10** (4): 309–329.
- Dawson C. 1964. A bibliography of anomalies of fishes. *Gulf Research Reports* **1** (6): 308–399.
- Dawson C. 1966. A bibliography of anomalies of fishes. *Gulf Research Reports* **2** (2): 169–176.
- Dawson C. 1971. A bibliography of anomalies of fishes. *Gulf Research Reports* **3** (2): 215–239.
- Dawson C., Heal E. 1971. A bibliography of anomalies of fishes. *Gulf Research Reports supplement* **3** **5** (2): 35–41.
- Diatla Y., Clotilde-Ba F.L., Capapé C. 2001. Rôle trophique du poulpe commun, *Octopus vulgaris*, chez les Elasmobranches de la côte du Sénégal (Atlantique oriental tropical). Comparaison avec les espèces des côtes tunisiennes (Méditerranée centrale). *Acta Adriatica* **42** (1): 77–88.



- El Kamel O., Mnasri N., Ben Souissi J., Boumaïza M., Ben Amor M.M., Capapé C.** 2009a. Inventory of elasmobranch species caught in the Lagoon of Bizerte (north-eastern Tunisia, central Mediterranean). *Pan-American Journal of Aquatic Sciences* **4** (4): 383–412.
- El Kamel O., Mnasri N., Boumaïza M., Capapé C.** 2009b. Atypical abnormality in a common torpedo, *Torpedo torpedo* (Chondrichthyes: Torpedinidae) from the Lagoon of Bizerte (northern Tunisia, central Mediterranean). *Cahiers de Biologie Marine* **50** (1): 97–101.
- El Kamel-Moutalibi O., Mnasri N., Boumaïza M., Reynaud C., Capapé C.** 2011. Abnormalities in common torpedos, *Torpedo torpedo* (Chondrichthyes: Torpedinidae) from the Lagoon of Bizerte (Northern Tunisia, Central Mediterranean). *Annales Series Historia Naturalis* **20** (2): 181–190.
- Gianeti M.G., Vooren C.M.** 2007. A hermaphrodite guitarfish, *Rhinobatos horkelii* (Müller & Henle, 1841) (Rajiformes: Rhinobatidae), from southern Brazil. *Cahiers de Biologie Marine* **48** (4): 407–409.
- Golani D.** 2005. Check-list of the Mediterranean Fishes of Israel. *Zootaxa* **2005** (947): 1–200.
- Golani D., Capapé C.** 2005. First records of the blue stingray, *Dasyatis chrysonota* (Smith, 1828) (Chondrichthyes: Dasyatidae), off the coast of Israel. *Acta Adriatica* **45** (1): 107–112.
- Harzallah A.** 2003. Transports de polluants dans la lagune de Bizerte simulé par un modèle de circulation de l'eau. *Bulletin de l'Institut des Sciences et Technologies de la Mer de Salammbô* **30** (numéro spécial): 121–133.
- Iglésias S.P., Sellos D.Y., Nakaya K.** 2005. Discovery of a normal hermaphroditic chondrichthyan species: *Apristurus longicephalus*. *Journal of Fish Biology* **66** (2): 417–428. DOI: 10.1111/j.0022-1112.2005.00607.x
- Irvine S.B., Laurenson L.J.B., Stevens J.D.** 2002. Hermaphroditism in the southern lantern shark, *Etmopterus granulosus*. In: International Congress on the Biology of Fish. 21–26 July 2002. University of British Columbia, Vancouver Canada. <http://www-heb.pac.dfo-mpo.gc.ca/congress/2002/DeepSea/Irvine2.pdf>
- Kabasakal H.** 2002. Elasmobranch species of the seas of Turkey. *Annales, series Historia Naturalis* **12** (1): 15–22.
- Louiz I., Menif D., Ben Attia M., Ben Hassine O.K.** 2007. Incidence des déformations squelettiques chez trois espèces de Gobiidae de la lagune de Bizerte (Tunisie). *Cybiu* **31** (2): 209–216.
- McEachran J.D., Capapé C.** 1984. Dasyatidae. Pp. 197–201. In: Whitehead P.J.P., Bauchot, M.L., Hureau J.C., Nielsen J., Tortonese, E. (eds), *Fishes of the North-western Atlantic and the Mediterranean*. Vol. 2. UNESCO, Paris.
- Mellinger J.** 1989. Reproduction et développement des Chondrichthyens. *Océanis* **15**: 283–303.
- Mnasri N., Boumaïza M., Capapé C.** 2009. Morphological data, biological observations and occurrence of a rare skate, *Leucoraja circularis* (Chondrichthyes: Rajidae), off the northern coast of Tunisia (central Mediterranean). *Pan-American Journal of Aquatic Science* **4** (1): 70–78.
- Mnasri N., El Kamel O., Boumaïza M., Ben Amor M.M., Reynaud C., Capapé C.** 2010. Morphological abnormalities in two batoid species (Chondrichthyes) from northern Tunisian waters (central Mediterranean). *Annales Series Historia Naturalis* **20** (2): 181–190.
- Mzoughi N., Hellal F., Dachraoui M., Villeneuve J.-P., Cattini C., de Mora S.J., El Abed A.** 2002. Méthodologie de l'extraction des hydrocarbures aromatiques polycycliques. Application à des sédiments de la lagune de Bizerte (Tunisie). *Comptes Rendus Géoscience* **334** (12): 893–901. DOI: 10.1016/S1631-0713(02)01827-8
- Nair R.V., Soundararajan R.** 1973. On an instance of hermaphroditism in the electric ray *Narcine timlei* (Bloch and Schneider). *Indian Journal of Fisheries* **20** (1): 260–264.
- Neifar L., Euzet L., Ben Hassine O.K.** 2000. New species of the Monocotylidae (Monogenea) from the stingray *Dasyatis tortonesei* Capapé (Euselachii, Dasyatidae) off the Tunisian coast, with comments on host-specificity and the specific identities of Mediterranean stingrays. *Systematic Parasitology* **47** (1): 43–50. DOI: 10.1023/A:1006354423136
- Orlov A.M.** 2011. Record of a tailless Richardson's ray *Bathyrja richardsoni* (Garriick, 1961) (Rajiformes: Arhynchobatidae) caught off the Mid-Atlantic ridge. *Pan-American Journal of Aquatic Sciences* **6** (3): 232–236.
- Quignard J.-P., Capapé C.** 1972. Cas d'hermaphroditisme chez *Raja miraletus* L., 1758. *Travaux du Laboratoire de Biologie Halieutique de l'Université de Rennes* **6**: 133–143.
- Quignard J.-P., Negla N.** 1971. Anomalies au niveau du système génital chez les sélaciens rajiformes. *Travaux du Laboratoire de Biologie Halieutique de l'Université de Rennes* **5**: 121–124.
- Ribeiro-Prado C.C., Oddone M.C., Ferreira de Amorim A., Capapé C.** 2009. An abnormal hermaphrodite pelagic stingray *Pteroplatytrygon violacea* (Dasyatidae) captured off the southern coast of Brazil. *Cahiers de Biologie Marine* **50** (1): 91–96.
- Saad A., Séret B., Ali M.** 2005. Liste commentée des Chondrichthyens de Syrie. Rapport de la Commission internationale pour l'Exploration scientifique de la Mer Méditerranée **37**: 430.
- Scenna L.B., Díaz De Astarloa J.M., Cousseau M.B.** 2007. Abnormal hermaphroditism in the multispine skate *Bathyrja multispinis* (Chondrichthyes, Rajidae). *Journal of Fish Biology* **71** (4): 1232–1237. DOI: 10.1111/j.1095-8649.2007.01586.x
- Séret B., McEachran J.D.** 1986. Catalogue critique des types de poissons du Muséum national d'Histoire naturelle (suite). Poissons Batoïdes (Chondrichthyes, Elasmobranchii, Batoidea). *Bulletin du Muséum national d'Histoire naturelle de Paris, 4ème série*, **8**, section A, 4, supplément: 3–50.
- Sfakianakis D.G., Koumoundouros G., Divanach P., Kentouri M.** 2004. Osteological development of the vertebral column and of the fins in *Pagellus erythrinus* (L. 1758). Temperature effects on the development plasticity and morpho-anatomical abnormalities. *Aquaculture* **232** (1–4): 407–424. DOI: 10.1016/j.aquaculture.2003.08.014



- Sloof W.** 1982. Skeletal anomalies in fish from polluted surface waters. *Aquatic Toxicology* **2** (3): 157–173.  
DOI: 10.1016/0166-445X(82)90013-3
- Yano K.** 1995. Reproductive biology of the black dogfish, *Centroscyllium fabricii*, collected from waters off western Greenland. *Journal of the Marine Biological Association of the United Kingdom*, **75** (2): 285–310.  
DOI: 10.1017/S002531540001818X
- Yano K., Tanaka S.** 1989. Hermaphroditism in the lantern shark *Etmopterus unicolor* (Squalidae, Chondrichthyes). *Japanese Journal of Ichthyology* **36** (3): 338–345.  
DOI: 10.1007/BF02905618

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