

# Preliminary observations of the reproductive biology and diet for the Norwegian skate *Dipturus nidarosiensis* (Rajidae) from the Central Western Mediterranean Sea

by

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**ABSTRACT.** - Twenty-three *Dipturus nidarosiensis* (Collett, 1880) (Elasmobranchii: Rajidae) were collected off the coasts of Sardinia between 550 m and 1688 m of depth in 2005-2011. A first description of some biological aspects as the vertical distribution, the reproduction and the diet of the Norwegian skate from the Central Western Mediterranean is provided. Females attained a greater length than males, they mature at larger sizes and were found mature always at depths of 550-600 m in the same area of the Southern coast of Sardinia. The diet of *D. nidarosiensis* was based almost entirely on decapod crustaceans and completed by bony fish.

**RÉSUMÉ.** - Observations biologiques chez le pocheteau de Norvège, *Dipturus nidarosiensis* (Elasmobranchii: Rajidae) dans le centre de la Méditerranée occidentale.

Vingt-trois *Dipturus nidarosiensis* (Collett, 1880) ont été collectés entre 2005 et 2011 au large des côtes de la Sardaigne à des profondeurs comprises entre 550 et 1688 m. Une première description de certains aspects de la distribution verticale, de la biologie de la reproduction et de l'alimentation de *D. nidarosiensis* dans le centre de la Méditerranée occidentale est fournie. Les femelles atteignent une plus grande longueur et mûrissent à des tailles plus grandes que les mâles. Elles ont toujours été trouvées à des profondeurs de 550-600 m et dans la même zone de la côte sud de la Sardaigne. Le régime alimentaire de *D. nidarosiensis* est presque entièrement basé sur les crustacés décapodes et complété par des poissons osseux.

Key words. - Rajidae - *Dipturus nidarosiensis* - Skates - Mediterranean - Reproduction - Diet.

The genus *Dipturus* Rafinesque, 1810 is a eurybathic taxon occurring worldwide and comprises at least 29 nominal species with 14 or more undescribed species (Ebert and Compagno, 2007; Last *et al.*, 2008). The genus is still under revision and the species identification might change in the near future. According to the European Register of Marine Species (Van der Land *et al.*, 2001), four species belonging to the genus *Dipturus* occur in the North-eastern Atlantic region: the common skate *D. batis* (Linnaeus, 1758), the long-nosed skate *D. oxyrinchus* (Linnaeus, 1758), the sailray *D. linteus* (Fries, 1838) and the Norwegian skate *D. nidarosiensis* (Collett, 1880). Up to 2010, only two species have been reported in the Mediterranean Sea (Bauchot, 1987; Serena, 2005): *Dipturus batis* (depth range 10-600 m) and *D. oxyrinchus* (depth range 90-900 m). *Dipturus nidarosiensis*, known as the only species of *Dipturus* endemic to the NE Atlantic area, has been found mainly in the slopes of the Eastern Atlantic from the fjords of Central and Southern Norway to Southern Iceland, around Rockall Trough in Ireland and in Northern Mauritania (Boeseman, 1967; Stehmann and Bürkel, 1984; Stehmann, 2008; Wil-

liams *et al.*, 2008; Iglésias *et al.*, 2010; Priede *et al.*, 2010). From 2005 to 2008, fourteen specimens of the Norwegian skate were caught off the Sardinian coasts (Central Western Mediterranean Sea) (Follesa *et al.*, 2010). Their identification has been confirmed by the analysis of three mtDNA regions, compared with that of the three species of *Dipturus* (*D. batis*, *D. oxyrinchus* and *D. nidarosiensis*) from the Mediterranean Sea and North-Eastern Atlantic (Cannas *et al.*, 2010). The molecular data have been also complemented by morphological analyses.

Given the general lack of biological data on this species, the aim of this paper is to gather preliminary information on the life history of *D. nidarosiensis* from the study of specimens caught off Sardinia's coast. Actually, biological data on *D. nidarosiensis* are extremely limited and refers to a few studies describing the egg case morphology and the diet (Boeseman, 1967; Lacourt, 1979; Gordon and Ducan, 1989; Ebert and Bizzarro, 2007). Considering that this species is listed in the IUCN Red List as Near Threatened (Stehmann, 2008), any deepening of knowledge is of priority importance.

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**MATERIALS AND METHODS**

Twenty-three *D. nidarosiensis* specimens were collected on compact mud bottoms off the coasts of Sardinia (Central Western Mediterranean) from 2005 to 2011 by otter trawl nets. Five specimens were captured during commercial prawn hauls performed at a mean depth of 600 m in the South of Sardinia and seventeen specimens were caught during deep experimental trawl surveys performed along the South-Eastern coast of Sardinia at between depths of 800 and 1688 m (duration of hauls 49-164 minutes). Only one individual was caught in the North-Western coast during the MEDITS survey (MEDiterranean International Trawl Survey; Bertrand *et al.*, 2002) at the mean depth of 550 m (Fig. 1). Table I summarizes the positive hauls by month, depth range (m), number of specimens collected and catch values in terms of biomass standardized to a 1-h haul (kg h<sup>-1</sup>).

The individuals were measured (total length, TL and disc width, DW in mm) and weighed (total weight, TW in g) on board, then were sent to the laboratory for further measurements and analyses. Linear regression analysis between TL and DW was performed separately for both sexes and ANOVA was used to test for differences between slopes (Zar, 1996).

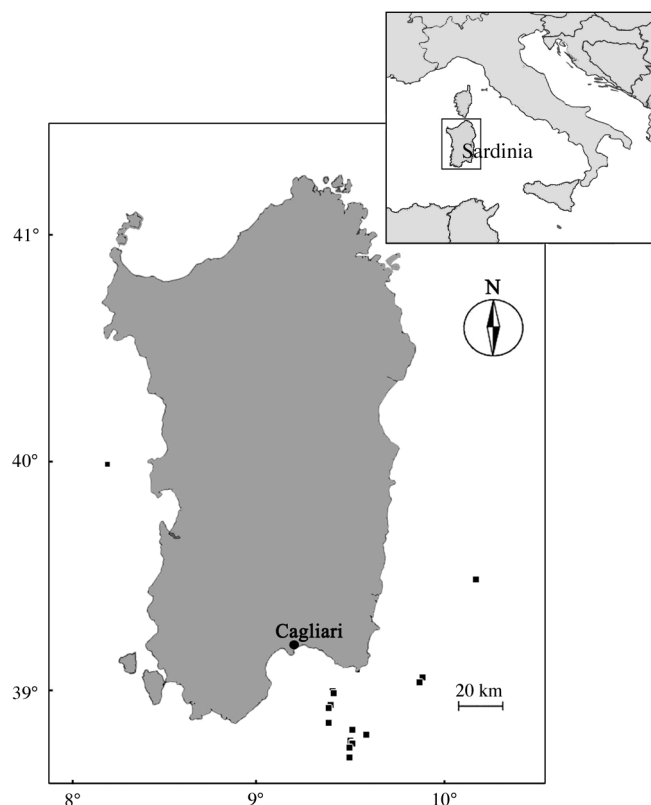


Figure 1. - Map of the study area and position of trawl stations (black squares) off the coasts of Sardinia where the specimens of *Dipturus nidarosiensis* were caught.

The skates were sexed following the maturity scales for oviparous elasmobranchs reported in Stehmann (2002). To determine the onset of sexual maturity in males, the length (CL, mm) and the consistency of the claspers and the development of sperm ducts and gonads were recorded. In females, the oviducal gland width (OGW, mm), the condition of the oviducts and the number and diameter (mm) of the yolked follicles in each ovary were registered. Histological assays of female and male reproductive tracts were performed to verify macroscopic maturity stages. A piece of tissue from the middle region of the gonad was cut, preserved in 5% formol saline, stored in 70% ethanol and subsequently processed to observe the process of gonadal development. Transverse sections of 3.5 μm (glycol-methacrylate method) were stained with Harris hematoxylin and counterstained with eosin (Mazzi, 1977).

For the dietary analysis, the digestive processes were interrupted by an injection of 5% formol saline in the abdominal cavity, right after capture. Gut contents were analyzed to the lowest taxonomic level possible. Each prey was identified and counted after removing the excess of moisture. In order to analyze the dietary composition, calculations were carried out for the percentage frequency (% F = percentage of the stomachs containing a specific prey item or category).

Table I. - Indication of the positive hauls for *Dipturus nidarosiensis* by month, mean depth (m), number and kg/h.

Haul	Month	Mean depth (m)	Number of specimens	kg h <sup>-1</sup>
1PSP06	January	1147	1	0.0216
1PSP11	January	1005	1	6.461124
2PSP11	January	1200	1	4.437273
4PSP11				
4PSP11	January	1120	1	1.68949
7PSP11	February	1570	1	0.556861
1GIS08	March	600	1	no data
7PSP07	April	1115	1	0.0369
1GIS10	May	600	1	no data
7PSP06	May	1163	1	6.05292
9PSP06	May	1037	1	4.0976
10PSP06	May	946	1	7.0376
11PSP05	May	1145	1	5.3684
12PSP05	May	1188	1	3.1899
52MED09	June	600	1	no data
14PSP06	July	600	2	12.17
5PSP09	August	1420	1	2.4265
1GIS07	September	650	1	no data
6PSP09	September	1688	1	0.2301
9PSP07	September	1420	1	1.92
31GIS06	September	550	1	no data
1GIS09	December	600	1	no data

Table II. - Reproductive data for *Dipturus nidarosiensis*.

Sex	N of specimens	Maturity stage	TL range (mm)	Gonad weight range (g)	Oviducal gland width (mm) / Clasper length (mm)	Egg size (mm)
Females	6	Immature	247-1235	13.15-40.00	10.00-20.00	
	4	Maturing	1288-1365	52.00-131.00	36.50-56.80	
	4	Mature	1270-1482	237.80-420.00	62.80-67.00	22-42
Males	5	Immature	240-733	0.03-2.60	8.10-32.00	
	3	Maturing	1020-1070	11.20-12.74	93.00-110.00	
	1	Mature	1180	25.00	240.00	

ry) and percentage abundance (% Cn = percentage of the number of specific prey item or category on that of prey item found). Because of the paucity of data, it was not possible to calculate the index of the relative importance (IRI).

**RESULTS**

Among the 23 individuals caught, 14 were females and 9 were males. Females attained greater length and weight than males, ranging from 247 to 1482 mm in TL (mean ± SD: 1194 ± 294.9 mm) and from 20.12 to 13783 g in TW (mean ± SD: 8692.7 ± 3483.1). Males ranged from 240 to 1180 mm in TL (mean ± SD: 721.1 ± 389.3 mm) and from 27.7 to 6948 g in TW (mean ± SD: 2501.9 ± 2766). The regression slopes between sexes for the TL and DW (ANOVA, F-ratio = 4.08; p-value > 0.05) did not differ significantly.

Even though there was some overlap in lengths among the adjacent maturity stages in females, a clear increment in

lengths with the evolution of the maturity stage (Tab. II) has been identified.

Among the 9 males (found at depth upper than 1115 m), the immature individuals, caught in January (n = 2), February (n = 1), April (n = 1) and September (n = 1), had short and uncalcified claspers, thin duct deferens and small testis with spermatogonia in a peripheral position in the spermatocyst. The maturing males, captured in May (n = 1), July (n = 1) and August (n = 1), had claspers longer than the length of the pelvic fins, and testes enlarged with lobules clearly visible but not occupying the whole surface. In this stage, by the histological point of view, the testis contained spermatocysts in all spermatogenesis stages (mainly spermatocytes). The only mature specimen, collected in May, presented long and calcified claspers, testes greatly enlarged filled with developed lobules. The epididymides were filled with numerous mature spermatozoa.

The TL and CL values showed a clear relationship in immature, maturing and mature males (Tab. II). All the females had both functional and symmetrical ovaries. The

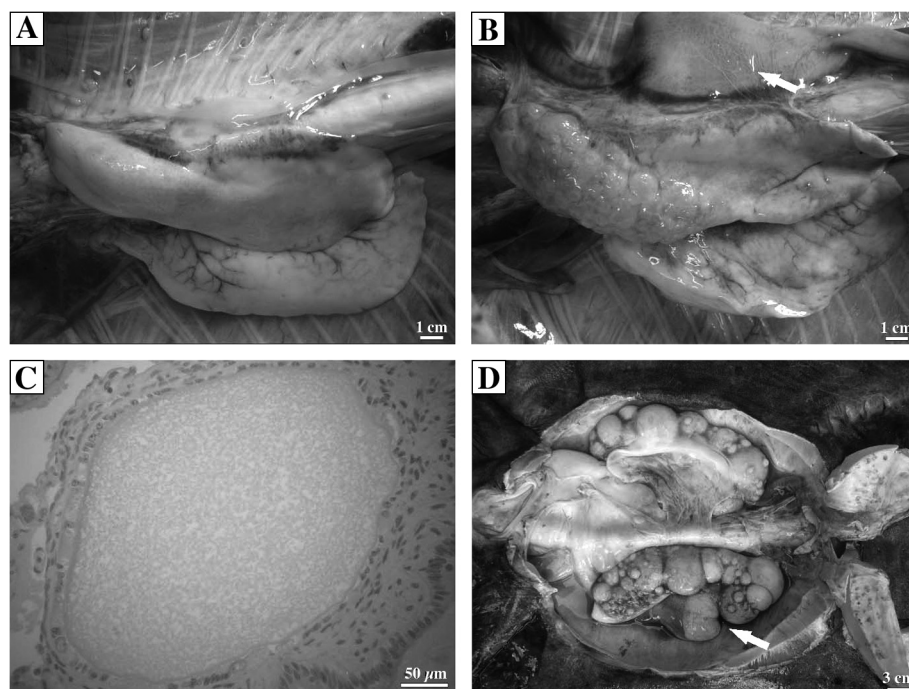


Figure 2. - Maturity stages in females of *Dipturus nidarosiensis*. A: Immature ovaries; B: Maturing ovaries; C: Traverse section of previtellogenic oocytes; D: Mature ovaries. White arrow indicates the oviducal gland.

immature females, caught in January (n = 2), May (n = 2), June (n = 1) and September (n = 1), had translucent and isodiametric follicles in the ovaries (Fig. 2A) and small oviducal glands, while the maturing females collected in May (n = 3) and July (n = 1) had oviducal glands fully developed and follicles white in colour (previtellogenic and vitellogenic follicles, some of which large) (Fig. 2B, 2C). All the immature and maturing females were caught in a wide bathymetric range, while all the mature females (with large oviducal glands and fully developed oviducts) were caught in March (n = 1), September (n = 2) and December (n = 1) at depths between 550 and 600 m. In these individuals, large yolked ovarian follicles were between 6 and 10 in number on each ovary (Fig. 2D) (Tab. II). No differences between the number of yolked follicles in the right and left ovaries were observed. The relationship between oviducal gland width (OGW) and TL increased with the evolution of maturity stage.

Among the 19 stomachs analyzed, all except one belonging to adult specimens, only three were empty. Five broad prey groups were identified in *D. nidarosiensis* stomachs. Decapod crustaceans were the most important preys, found in 13 stomachs on 16 (% F = 81.25 and %Cn = 70.37). The food spectrum was completed by bony fishes (found in 6 stomachs), while cephalopods, elasmobranchs and polychaetes seemed to be accidental preys. The unique juvenile specimen analyzed (TL = 242 mm) showed one polychaete and one unknown decapod crustacean in the stomach.

## DISCUSSION

The females of *Dipturus nidarosiensis* were larger than males, with the largest female (1480 mm of TL) 300 mm greater than the largest male (1180 mm of TL). The occurrence of sexual differences in growth is known in *Dipturus oxyrinchus* and *D. pullupunctata* (Walmsley-Hart *et al.*, 1999; Yigin and Ismen, 2010), and it is also well documented in other elasmobranchs.

The females of *D. nidarosiensis* mature at larger sizes (TL 1270-1420 mm) than males (1180 mm TL). This characteristic has been also observed in other Rajidae species such as *Raja clavata* (Follesa *et al.*, 2003) and *R. brachyura* (Porcu *et al.*, 2010). Mature females of the Norwegian skate were exclusively caught at depths of 550-600 m and always in the same area, located in the Southern coast of Sardinia, probably attesting there the occurrence of a specific reproductive habitat for the species. Furthermore, the occurrence of mature females over a long period (March, September and December) suggests that they are continuous breeders.

The feeding habits of the Norwegian skates from Central Western Mediterranean sea suggest that *D. nidarosiensis* is a crustacean specialist, its diet is dominated mainly by brachy-

urans and appeared different from that reported for the same species in the Atlantic (Rockall Trough) (Gordon and Duncan, 1989).

This study, although based on limited number of specimens analyzed, does provide new information on the reproductive biology and diet of *D. nidarosiensis* from Central Western Mediterranean. In spite of the effort done to broaden the knowledge many aspects of the life history of this species are still unknown. In order to fully understand the impact of fisheries on the species and to make reliable estimates of fishing and discard mortality, more data on the spatial distribution, biology (e.g. reproductive grounds, nursery areas) and landing effort from the entire area of distribution of *D. nidarosiensis* should be gathered in the future.

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