

## ΝΕΕΣ ΚΑΤΑΓΡΑΦΕΣ ΤΟΥ ΚΑΡΧΑΡΙΑ *OXYNOTUS CENTRINA* (CHONDRICHTHYES: OXYNOTIDAE) ΣΤΙΣ ΕΛΛΗΝΙΚΕΣ ΘΑΛΑΣΣΕΣ ΚΑΙ ΠΑΡΑΤΗΡΗΣΕΙΣ ΓΙΑ ΤΗΝ ΕΜΒΡΥΪΚΗ ΤΟΥ ΑΝΑΠΤΥΞΗ

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Τέσσερα άτομα ενός σπάνιου και απειλούμενου είδους καρχαρία, του οξύνωτου *Oxynotus centrina* (Linnaeus, 1758), συλλέχθηκαν τυχαία στις ελληνικές θάλασσες. Ένα θηλυκό άτομο, που ζύγιζε 5020 γραμ. και έφτανε στα 790 χιλ. σε ολικό μήκος αλιεύτηκε στον Κορινθιακό Κόλπο και αποτελεί την πρώτη καταγραφή του είδους σε αυτή την περιοχή καθώς και το μεγαλύτερο δείγμα που έχει καταγραφεί μέχρι σήμερα στην ανατολική Μεσόγειο Θάλασσα. Δύο ακόμα θηλυκά άτομα ολικού μήκους 533 και 565 χιλ. αλιεύτηκαν κοντά στα Ψαρά (ΒΑ Αιγαίο), ενώ ένα κυοφορούν θηλυκό άτομο ολικού μήκους 674 χιλ. πιάστηκε κοντά στην Εύβοια (Κεντρικό Αιγαίο). Η μορφομετρία, η γεννητική ωριμότητα και το στομαχικό περιεχόμενο εξετάστηκαν σε κάθε δείγμα. Επιπλέον μελετήθηκε η ανάπτυξη 14 εμβρύων που κυμαίνονταν από 89 σε 105 χιλ. σε ολικό μήκος.

**Λέξεις κλειδιά:** Oxynotidae, *Oxynotus centrina*, Μεσόγειος Θάλασσα.

## NEW RECORDS OF THE SHARK *OXYNOTUS CENTRINA* (CHONDRICHTHYES: OXYNOTIDAE) IN THE GREEK SEAS AND NOTES ON ITS EMBRYONIC DEVELOPMENT

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Four specimens of a rare and threatened shark species, the angular rough shark *Oxynotus centrina* (Linnaeus, 1758), were incidentally caught in the Greek Seas. One female specimen, weighing 5020 g and reaching 790 mm in total length, was captured in the Korinthiakos Gulf, which is actually the first record of the species in this region and at the same time the largest specimen ever recorded in the eastern Mediterranean Sea. Two other females measuring 533 and 565 mm were caught near the island of Psara (NE Aegean Sea), while one gravid female measuring 674 mm was caught near the island of Evia (Central Aegean Sea). The morphometric measurements, sexual maturity and stomach content of each specimen were examined. Moreover, observations on the development of 14 embryos, ranging from 89 to 105 mm in total length were recorded.

**Keywords:** Oxynotidae, *Oxynotus centrina*, Mediterranean Sea.

### 1. Introduction

The angular rough shark, *Oxynotus centrina* (Linnaeus, 1758), is an uncommon, little-known, ovoviviparous species (family: Oxynotidae, order: Squaliformes), which produces litters of 10 to 12 embryos once a year (Capapé *et al.*, 1999) and attains a maximum size of 1500 mm

(Quéro, 1984). It is distributed throughout the entire Mediterranean Sea (Serena, 2005) and Eastern Atlantic inhabiting deep sea bottoms (Compagno, 1984).

In the Mediterranean Sea, the captures of the angular rough shark by the commercial fisheries are sporadic and uncommon (Tortonese, 1956; Bertrand *et al.*, 2000; Golani *et al.*, 2006). Due to the rarity of the species little is known about its distribution and biology within this region. The aim of this paper is to present the morphological and biological characteristics of four new records of the angular rough shark from the Greek Seas and to discuss some aspects of its embryonic development.

## 2. Materials and Methods

Within the period 2006-2011, four angular rough sharks were sampled in various areas of the Greek Seas during seasonal samplings on board fishing vessels and at landings that were carried out in the frame of a research project (Megalofonou, 2008) and a PhD thesis (funded by Heracleitus II, 2010-2013).

In all specimens morphometric measurements were taken to the nearest millimetre (mm), based on Compagno (1984) and all weight measurements were taken to the nearest gram (g). The % ratios of the morphometric measurements in total length were calculated. Sex and sexual maturity was assessed according to Stehmann (1987). Gonadosomatic (GSI) and hepatosomatic (HSI) indexes were calculated. Stomach content was also examined for food remains.

Embryos from a gravid specimen were removed, measured and weighed. The % ratios of the morphometric measurements in total length were calculated. Regression analysis was used to determine length-weight relationships ( $W=aL^b$ ,  $W$ = round weight,  $L$ = total length). The slopes of the regressions were tested against the isometric slope standard of 3 with the Student's t-test. Regression analysis was also used to assess correlations between total length (TL in mm) and yolk sac weight (YSW in g) where it was possible. Image analysis program (Image-Pro<sup>®</sup> Plus, version 6.0) was used to collect photographs of the embryos.

## 3. Results

A total of four angular rough sharks, ranging in total length from 533 to 790 mm were caught incidentally by commercial fishing vessels in the Greek waters. Bottom trawls and bottom longlines were the fishing gears that were used. Two specimens were captured near the island of Psara at depth of 130 m and another near the island of Evia, at depth between 366 and 458 m. One more specimen was captured in Korinthiakos Gulf at depth of 180 m (Fig. 1).

All specimens were females in different stages of maturity. Gonadosomatic index (GSI) ranged from 0.4 (specimen 1) to 8.1 % (specimen 3) while hepatosomatic index (HSI) ranged from 26.6 (specimen 1) to 35.8 % (specimen 3). The examination of stomach content revealed no particular food items in any of the specimens.

A total of 14 embryos, ranging from 89 to 105 mm in total length and from 4 to 8.2 g in weight (without the yolk sac), were counted in the uteri of the gravid specimen. Sex identification

was possible and the ratio of female to male embryos was 1.3:1. Total length and round weight (without the yolk sac) of the 14 embryos were positively correlated. Because the P-value for the slopes was greater than 0.1 ( $P=0.1462$ ), there were not statistically significant differences among the slopes for the right and left uterus. The relationship between embryos' total length (TL in mm) and yolk sac weight (YSW in g) was not highly correlated:  $YSW=0.72TL-41.34$ .

As far as external morphometry is concerned, all embryos had morphological characteristics similar to the adults. However, the mean value of the ratios of the head length (HDL), and eye length (EYL) to the total length were 25 % and 8 % in embryos, while in the case of adults were 18.9 % and 4.1 % respectively (Table 1).

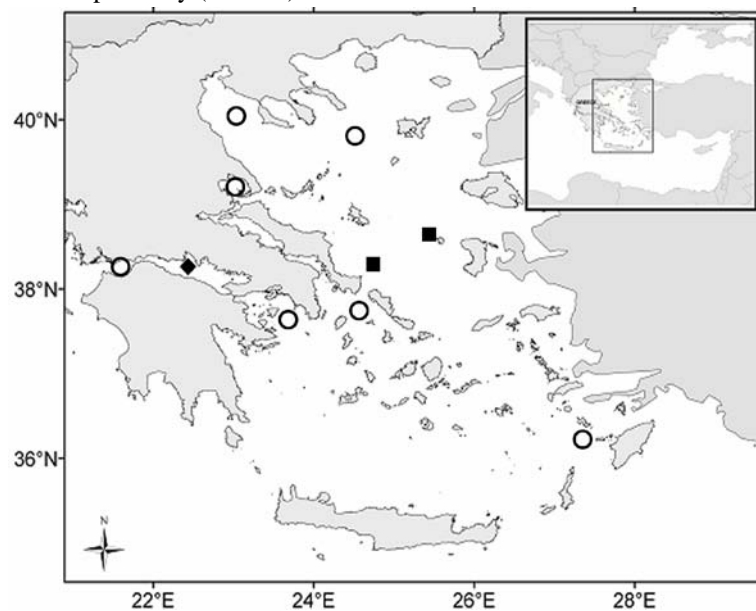


Fig. 1: Map indicating locations where the four angular rough sharks were caught by the bottom longline and trawl fishery and the areas of previous records of the species in the Greek Seas.

■ trawl; ◆ longlines; ○ previous records

Table 1: Morphometric measurements (in mm) and proportional values of the characteristics (expressed as percentage % of total length) for each angular rough shark reported in the present study, along with the mean values.

Morphometric characteristics	Specimen 1		Specimen 2		Specimen 3		Specimen 4		Mean in mm	Mean % TL
	mm	% TL	mm	% TL	mm	% TL	mm	% TL		
<b>PRC</b> (Precaudal length)	420	78.8	465	82.3	556	70.4	534	79.2	493.8	77.7
<b>HDL</b> (Head length)	105	19.7	111	19.6	131	16.6	126	19.5	118.3	18.9
<b>PD1</b> ( Pre-first dorsal length)	118	22.1	122	21.6	142	18.0	166	25.7	137.0	21.8
<b>PD2</b> ( Pre-second dorsal length)	302	56.7	353	62.5	421	53.3	412	63.7	372.0	59.0

<b>PP1</b> (Prepectoral length)	91	17.1	102	18.1	128	16.2	114	17.6	108.8	17.2
<b>PP2</b> (Prepelvic length)	329	61.7	367	65.0	444	56.2	428	66.2	392.0	62.3
<b>D1A</b> (1 <sup>st</sup> dorsal anterior margin)	132	24.8	129	22.8	140	17.7	105	16.2	126.5	20.4
<b>D1H</b> (1 <sup>st</sup> dorsal height)	76	14.3	78	13.8	83	10.5	91	14.1	82.0	13.2
<b>D1P</b> (1 <sup>st</sup> dorsal posterior margin)	81	15.2	87	15.4	99	12.5	118	18.2	96.3	15.3
<b>D1B</b> (1 <sup>st</sup> dorsal base)	95	17.8	102	18.1	138	17.5	102	15.8	109.3	17.3
<b>D2A</b> (2 <sup>nd</sup> dorsal anterior margin)	101	18.9	108	19.1	104	13.2	111	17.2	106.0	17.1
<b>D2H</b> (2 <sup>nd</sup> dorsal height)	44	8.3	64	11.3	66	8.4	62	9.6	59.0	9.4
<b>D2P</b> (2 <sup>nd</sup> dorsal posterior margin)	52	9.8	70	12.4	52	6.6	74	11.4	62.0	10.0
<b>D2B</b> (2 <sup>nd</sup> dorsal base)	62	11.6	79	14.0	86	10.9	78	12.1	76.3	12.1
<b>P1A</b> (Pectoral anterior margin)	102	19.1	104	18.4	105	13.3	108	16.7	104.8	16.9
<b>P1H</b> (Pectoral height)	53	9.9	87	15.4	110	13.9	106	16.4	89.0	13.9
<b>P1P</b> (Pectoral posterior margin)	50	9.4	80	14.2	59	7.5	108	16.7	74.3	11.9
<b>P1B</b> (Pectoral base)	41	7.7	45	8.0	44	5.6	45	7.0	43.8	7.0
<b>P2A</b> (Pelvic anterior margin)	54	10.1	50	8.8	57	7.2	58	9.0	54.8	8.8
<b>P2H</b> (Pelvic height)	37	6.9	42	7.4	55	7.0	65	10.0	49.8	7.8
<b>P2P</b> (Pelvic posterior margin)	42	7.9	58	10.3	54	6.8	55	8.5	52.3	8.4
<b>P2B</b> (Pelvic base)	43	8.1	56	9.9	54	6.8	44	6.8	49.3	7.9
<b>CDM</b> (Dorsal caudal margin)	130	24.4	127	22.5	132	16.7	143	22.1	133.0	21.4
<b>CTR</b> (Terminal caudal margin)	41	7.7	40	7.1	35	4.4	39	6.0	38.8	6.3
<b>CST</b> (Subterminal caudal margin)	13	2.4	12	2.1	13	1.6	14	2.2	13.0	2.1
<b>CPH</b> (Caudal peduncle length)	22	4.1	25	4.4	31	3.9	25	3.9	25.8	4.1
<b>HDH</b> ( Head hight)	65	12.2	93	16.5	89	11.3	90	13.9	84.3	13.5
<b>TRH</b> (Trunk height)	90	16.9	103	18.2	103	13.0	105	16.2	100.3	16.1
<b>ABH</b> (Abdomen height)	92	17.3	122	21.6	146	18.5	140	21.6	125.0	19.7
<b>TAH</b> (Tail hight)	42	7.9	43	7.6	57	7.2	53	8.2	48.8	7.7
<b>EYL</b> (Eye length)	24	4.5	24	4.2	28	3.5	27	4.2	25.8	4.1
<b>EYH</b> (Eye height)	9	1.7	8	1.4	13	1.6	11	1.7	10.3	1.6

#### 4. Discussion

According to the records of *Oxynotus centrina* to date (Papakonstantinou, 1988; Megalofonou and Damalas, 2004; Corsini-Foka, 2009; Kabasakal, 2009; present study) it is shown that this rare species has a wide distribution all over the Aegean Sea (Fig. 1). The examination of size data revealed that the total length of all angular rough sharks caught in the Greek Seas (present study) did not exceed the maximum total length reported previously for the species in the Mediterranean Sea (Capapé *et al.*, 1999; 2001; Dragičević *et al.*, 2009; Kabasakal, 2009; Županovic and Jardas, 1989). Nevertheless, the specimen that was caught in the Korinthiakos Gulf

is the first record of the species in this region, and at the same time it is the largest angular rough shark ever recorded in the Greek waters and generally in the eastern Mediterranean Sea.

Our results showed that the calculated hepatosomatic values were high and in the range of hepatosomatic values found in previous studies (Capapé *et al.*, 1999; 2001, Megalofonou and Damalas, 2004, Dragičević *et al.*, 2009). The high values of the hepatosomatic index could be attributed to the important role that liver plays in buoyancy and movement of sharks (Phleger, 1998). On the other hand, gonadosomatic index had low values in specimens 1 and 2 due to the ovaries with microscopic oocytes (resting phase). Specimen 3 had high gonadosomatic index, due to its large ovaries (vitellogenesis phase). Specimen 4 (gravid female), had ovaries with microscopic oocytes (resting phase) and very low vitellogenetic activity was observed, probably because of the lack of space in the body cavity (Tanaka *et al.*, 1990). This confirms that vitellogenesis does not coincide with gestation period.

There are only few studies regarding the diet of the angular rough shark (Capapé, 2008; Dragičević *et al.*, 2009). In our study the absence of any food item from the stomachs of all specimens could be attributed either to the fact that food content is probably forced out by the pressure of sea water as the specimens are being hauled up from depths (Yano and Tanaka, 1984) or/and to the food preference of the species to worm like preys and consequently to the easily and rapid digestion of polychaetes (Capapé, 2008).

Embryos were described in previous studies (Lo Bianco, 1909; Megalofonou and Damalas, 2004; Capapé *et al.*, 1999; 2001). Our study showed that all embryos were in early stages of development, bearing large yolk sacs and not fully formed external characteristics. For example, in male embryos, a pair of short and flexible claspers could be distinguished, although with great difficulty and only under stereoscopic observation. On the contrary, sex identification was impossible in the 15 embryos recorded by Megalofonou and Damalas (2004) in a female caught in the island of Kea (Central Aegean Sea). Probably this is because the external genital organs in males are very tiny at size of around 90 mm and they can be recognized only under microscopic observation.

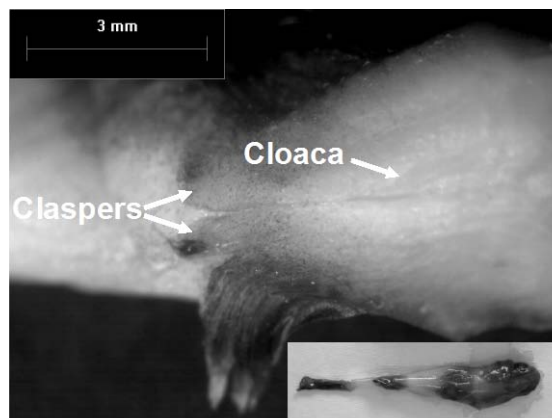


Fig. 2: A pair of claspers reaching 1 mm in length (clasper outer length, CLO), that were distinguished in a male angular rough shark embryo, reaching 91 mm in total length. The figure was captured with Image-Pro® Plus (version 6.0).

In Greece and generally in the whole Mediterranean Sea, *Oxynotus centrina* is listed as critically endangered (Bradaï *et al.*, 2010). In Greek fish markets, the species does not have any economical value. It is generally caught as by-catch and discarded by fishermen at sea. This fact explains why the species is not observed during landings or in fish markets. Therefore angular rough shark is rare to find. Every possible record of the species capture is considered of high importance, due to its vulnerable state, according to IUCN Red List. Further research and systematic monitoring of its captures is needed, in order to assess its population structure and future trends. The development and implementation of management plans are required to facilitate the conservation and sustainable management of all chondrichthyan species.

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