Journal of Threatened Taxa

Building evidence for conservation globally

www.threatenedtaxa.org

ISSN 0974-7907 (Online) | ISSN 0974-7893 (Print)

Communication

On the taxonomy of the first record of rare deep-water rough shark species of Oxynotidae (Chondrichthyes: Squaliformes) in the western Indian Ocean

Sarah Viana & Mark W. Lisher

26 May 2018 | Vol. 10 | No. 6 | Pages: 11732–11742
10.11609/jott.3916.10.6.11732-11742

COMMUNICATION

Journal of Threatened Taxa | www.threatenedtaxa.org | 26 May 2018 | 10(6): 11732–11742

ISSN 0974-7907 (Online)
ISSN 0974-7893 (Print)

OPEN ACCESS

On the taxonomy of the first record of rare deep-water rough shark species of Oxynotidae (Chondrichthyes: Squaliformes) in the western Indian Ocean

Sarah Viana [1] & **Mark W. Lisher** [2]

[1] South African Institute for Aquatic Biodiversity, Private Bag 1015, Grahamstown, 6140, South Africa
[2] The Scottish Association for Marine Science, Scottish Marine Institute, Dunbeg, Oban, Argyll, Scotland, PA37 1QA, United Kingdom
[1] stviana@gmail.com (corresponding author), [2] lishermw@gmail.com

Abstract: An immature female specimen of rough shark was collected south of Reunion Island in the Madagascar Basin in 2009 aboard R/V Dr. Fridtjof Nansen, representing the first official record of the family Oxynotidae in the western Indian Ocean. The specimen is herein identified as *Oxynotus* sp. due to morphological differences with its closely similar congeners *O. centrina* and *O. bruniensis* regarding morphometrics, shape of dorsal, pectoral and caudal fins, shape of the head and colouration, refuting the hypothesis of occurrence of these two species in the region. These results indicate that *Oxynotus* sp. is possibly an undescribed species. A general description of the external morphology, external morphometrics and photographs of *Oxynotus* sp. are provided. The specimen has a hepatosomatic index of 36.33% which reveals that it was possibly approaching maturation, suggesting that a viable population of *Oxynotus* sp. exists in the western Indian Ocean. Intraspecific variations in *O. centrina* from the Mediterranean Sea and eastern Atlantic Ocean are also noticed, requiring further taxonomic scrutiny.

Keywords: Madagascar Basin, morphology, *Oxynotus*, rough sharks, taxonomy, western Indian Ocean.

DOI: http://doi.org/10.11609/jott.3916.10.6.11732-11742 | **ZooBank:** urn:lsid:zoobank.org:pub:FFDA138B-7CB7-4A5B-ACE5-D8E46772CAE3

Editor: E. Vivekanandan, Central Marine Fisheries Research Institute, Chennai, India. **Date of publication:** 26 May 2018 (online & print)

Manuscript details: Ms # 3916 | Received 26 November 2017 | Final received 03 April 2018 | Finally accepted 22 April 2018

Citation: Viana, S. & M.W. Lisher (2018). On the taxonomy of the first record of rare deep-water rough shark species of Oxynotidae (Chondrichthyes: Squaliformes) in the western Indian Ocean. *Journal of Threatened Taxa* 10(6): 11732–11742; http://doi.org/10.11609/jott.3916.10.6.11732-11742

Funding: None.

Competing interests: The authors declare no competing interests.

Author Details: Sarah Viana is a research associate at the South African Institute for Aquatic Biodiversity with expertise in taxonomy, phylogeny and biogeography of Chondrichthyes, especially Squaliformes. Her currently interests are conservation genetics and molecular phylogeography of southern African endemic species. Mark W. Lisher worked for several years in the field of collection management and biodiversity data in South Africa. Currently, he is a MSc scholar at The Scottish Association for Marine Science. His interests are ichthyology, biodiversity, and taxonomy of marine fishes.

Author Contribution: SV and MWL contributed equally in the conceptualization, collection and analysis of data, discussion of the results and writing up of this manuscript.

Acknowledgements: The authors thank O. Gon, A. Whitfield, R. Bills, B. Konqobe and N. Mazungula (SAIAB), and E. Mitchell (SAMS) for curatorial and technical assistance. Special thanks to A. Hay and M. McGrouther (AMS) for providing information on comparative material, and A. Orlov (VNIRO) for helping with acquisition of original descriptions. The first author was supported by the South African Institute for Aquatic Biodiversity.

INTRODUCTION

Oxynotidae is a monotypic family of small to medium sized rare deep-water rough sharks with endemic regional geographical distributions on continental and insular shelves and upper continental slopes of the Atlantic and Pacific Oceans (Ebert et al. 2013). The occurrence of Oxynotidae and records of its representatives in the western Indian Ocean were speculative (e.g., Ebert 2013, 2015; Ebert & van Hees 2015; Compagno 2016; Weigmann 2016) till recently in Fricke et al. (2018). Members of Oxynotidae are characterized by having a body triangular in cross-section, conspicuously deep, arched dorsally and flattened ventrally at trunk, rough skin with large dermal denticles, head small and wide, snout blunt at tip and short with fringed anterior margin of nostrils, mouth circular with papillose lips and ventrally located, eyes rounded and conspicuously large, located laterally, spiracles large and crescent, located behind eyes, dorsal fins sail-like, conspicuously upright and tall, dorsal-fin spines conical, thick and markedly small, located prior to each dorsal fin and never transcending the fin apex, pectoral fins leaf-like, pointed distally at apex, and inconspicuous free-rear tips, lateral ridges prominent at trunk, caudal fin small and broadly sub-triangular with inconspicuous lower caudal lobe and evident subterminal notch. It bears teeth dissimilar in both jaws, upper teeth smaller than lower teeth, upper teeth thin and lanceolate, lower teeth broad and blade-like (Compagno 1999).

Oxynotus Rafinesque, 1810 currently comprises five valid species: *O. centrina* (Linnaeus, 1758), type-species, originally from the Mediterranean Sea; *O. paradoxus* Frade, 1929 from the northeastern Atlantic Ocean, ranging from Morocco to Senegal; *O. caribbeaus* Cervigon, 1961 from the Caribbean; *O. bruniensis* (Ogilby, 1893) from the southwestern Pacific Ocean, particularly Australia and New Zealand; *O. japonicus* Yano & Murofishi, 1985 from Japanese and Taiwanese coasts (Ho & Nakaya 2016). Little is known about their biological and ecological traits, including population size, distribution and life history, and studies regularly focus on reproductive biology and feeding of *O. centrina* (e.g., Capapé et al. 1999; Capapé 2008; Guallart et al. 2015; Kousteni & Megalofonou 2016). Currently, these species are listed as Data Deficient in the IUCN Red List of Threatened Species (Francis 2003; Leandro 2004; Yano 2004; Soldo & Freitas 2009), with the exception of *O. centrina*, which is considered Vulnerable (Bradaï et al. 2007).

Oxynotus centrina is usually distinguished from its congeners by having grey or brownish grey body with broad dark brown blotches dorsal-laterally, eyes with heavy supra-ocular ridge and knobs, spiracles large and vertical (Compagno 2016), and few proportional external measurements (e.g., dorsal fin-spines and first dorsal-fin apex, precaudal length and origin of first dorsal fin spine) (Yano & Matsuura 2002). It inhabits muddy and coralline algal bottoms of continental and insular shelves and upper continental slopes between 40–800 m depth, and is occasionally caught as bycatch during trawls and longlining (Ebert & Stehmann 2013; Ragonese et al. 2013; Compagno 2016). This species occurs throughout the Eastern Atlantic Ocean from Norway to the western coast of South Africa (Bass et al. 1976; Cadenat & Blache 1981; Ebert & Stehmann 2013; Ebert 2015; Compagno 2016). According to Ebert & Stehmann (2013), Compagno et al. (2015), Ebert (2015) and Compagno (2016), *O. centrina* or a separate similar species possibly occurs in Mozambique, or off Madagascar (Ebert & van Hees 2015). Ebert (2013) and Weigmann (2016) later listed *O. centrina* in the western Indian Ocean although without scrutiny, indicating that the identification of this species or any other member of Oxynotidae in the region is uncertain. Fricke et al. (2018) inaccurately listed this species as from off northern Madagascar, representing the first official record of Oxynotidae in the region, but again without detailed taxonomic information. The present study thus aimed to provide a general morphological description, external morphometrics, details of the collection and biological data of this specimen, and to clarify the occurrence of Oxynotidae in the western Indian Ocean. Taxonomic problems on species of *Oxynotus* are also discussed herein.

MATERIAL AND METHODS

The southern Indian Ocean seamounts cruise expedition was undertaken aboard the R/V Dr. Fridtjof Nansen along the southwestern Indian Ridge between 12 November and 19 December 2009. During this cruise, a single specimen of *Oxynotus* sp. was captured on 14 November 2009 during Trawl 1, Station 2, Madagascar Basin, south of Reunion Island, Event 7, at a maximum depth of 600m using a pelagic Åkra trawl net fitted with a multisampler. The Åkra trawl net used was a Flytetrål 152 MSK x 3200mm, with a 20m net mouth opening (Rogers et al. 2010). Prior to each trawl, ice-trays and labels were prepared for sorting. Once on deck, samples were emptied into large trays containing ice. A small

amount of seawater was added to the trays to prevent the samples freezing to the ice. Specimen of *Oxynotus* sp. was labelled by tying a label to the fish using string, then either fixed in a 4% formalin solution or frozen (Rogers et al. 2010). This specimen was later donated and logged at the South African Institute for Aquatic Biodiversity (SAIAB) where further curatorial procedures such as identification and cataloguing took place, and put through a series of 10% and 50% ethanol solutions, before finally being preserved in 70% ethanol solution.

External measurements were obtained from a specimen preserved in 70% ethanol using a digital calliper and metric tape for measurements greater than 150mm. Measurements follow Last et al. (2007) and Ebert et al. (2013), and are expressed as percentage of total length (% TL). Morphometric data of *O. centrina* recorded elsewhere were compiled from Yano & Murofushi (1985), Barrull & Mate (2001), Yano & Matsuura (2002), Megalofonou & Damalas (2004), Dragicervic et al. (2009), Moftah et al. (2011), Kousteni & Megalofonou (2016), and Yigin et al. (2016) for comparisons. Terminology of general external morphology, dermal denticles and colouration in description follows Yano & Murofushi (1985), Garrick (1960) and Compagno (2016), and for dentition follows Herman et al. (2005). Colouration is based on specimen preserved in 70% ethanol. Maturation was based on Capapé et al. (1999). Skin sample measuring 1cm^2 was taken from below first dorsal fin (right side) for analysis of dermal denticles. Liver weight and conditions follow Capapé et al. (1999). Hepatosomatic index (HIS) was calculated using the formula HSI (%) = liver weight (g) / dressed weight (g) X 100. Specimen was photographed in dorsal, lateral, and ventral views as well as individual body parts (e.g., fins, liver) using digital camera. Photographs of dermal denticles were taken using stereoscope microscope attached to digital camera at the Scottish Association for Marine Science. Map of collecting locality of examined specimen was generated using QGIS 2.14.2 Essen (QGIS Development Team, QGIS Geographic Information System, Open Source Geospatial Foundation Project; http://qgis.osgeo.org/) and Google Earth (http://www.google.co.uk/intl/en_uk/earth). Institutional abbreviations are in accordance to Sabaj (2016).

TAXONOMY

Family Oxynotidae Gill, 1863
Genus *Oxynotus* Rafinesque, 1810
***Oxynotus* sp.**
Images 1–6, Table 1

Material examined: SAIAB 192249, juvenile female, 519mm TL, south of Reunion Island, Madagascar Basin,

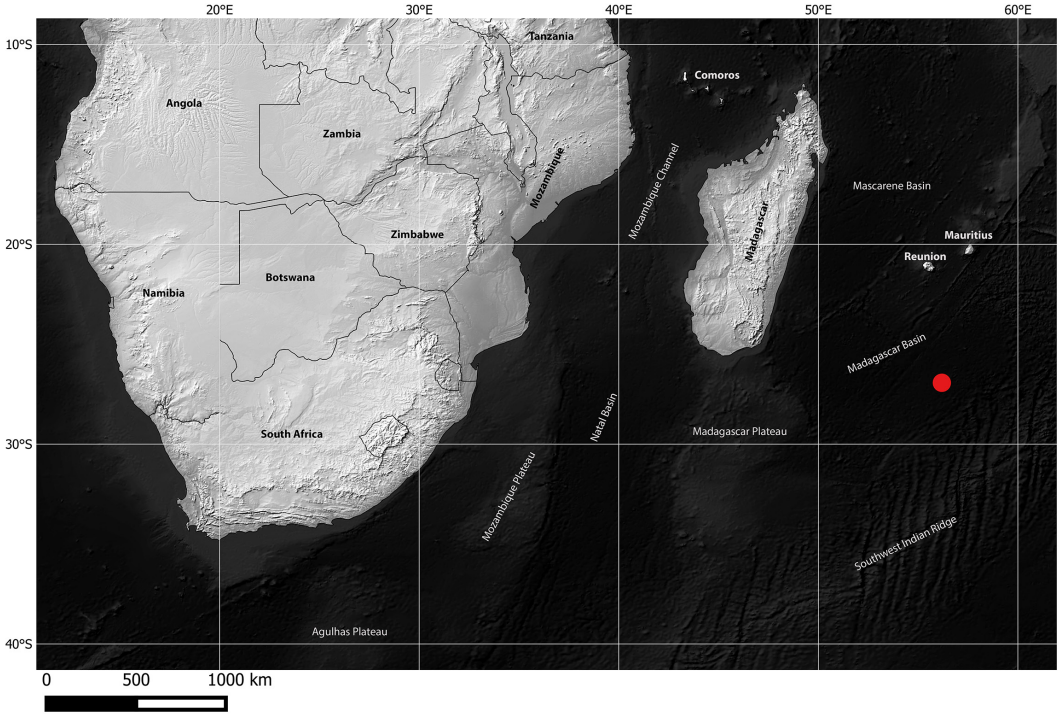

Image 1. Map of southern Africa region, showing the collection locality (red dot) of *Oxynotus* sp. in the Madagascar Basin, western Indian Ocean.

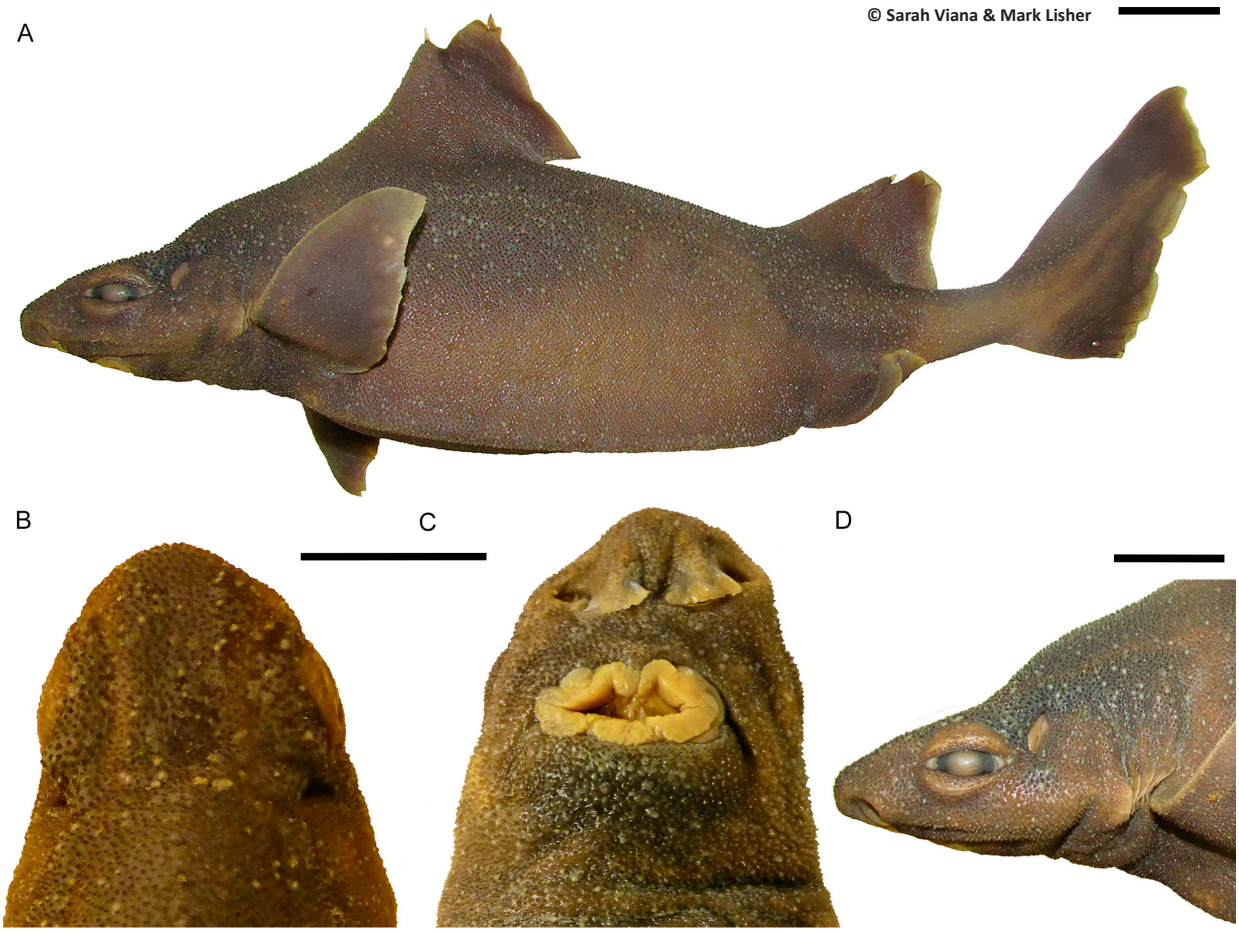

Image 2. Specimen of *Oxynotus* sp., SAIAB 192249, juvenile female, 519mm TL in lateral view (A), and detail of head in dorsal (B), ventral (C), and lateral (D) views. Scale bars: 50mm.

26.93125^{0}S & 56.1894833^{0}E, Trawl 1, Station 2, Event 7, 600m depth, trawled on 14.xi.2009 aboard R/V Dr. Fridtjof Nansen, coll. K.M. Kemp, P.H. Boersch-Supan, O. Alvheim, D. Benivary, V. Mangar, N. Mazungula, T.B. Letessier and A.D. Rogers.

General description of external morphology: External measurements for *Oxynotus* sp. are provided in Table 1. Body robust and triangular in cross-section, conspicuously deep at trunk and abdomen, and thin at precaudal peduncle; body arched dorsally from head to abdomen, flattened ventrally at trunk with lateral ridges prominent at trunk; body wide from head to abdomen and narrow at precaudal penduncle. Head small, narrow anteriorly and wide posteriorly, markedly arched anterior-dorsally. Snout blunt at tip and short with nostrils broad and horizontal with anterior margin of nostrils elongated, wide and fringed distally. Eyes elliptical horizontally and conspicuously large, located laterally with prominent supraorbital and infraorbital ridges and inconspicuous knob. Spiracles large, subcrescent, thin and vertical, situated posterior to eyes. Mouth large and transverse, constricted and circular with papillose and fleshy lips, located ventrally; preoral cleft elongate, thick, distally rounded, situated medially in the upper lip. Upper teeth smaller and thinner than lower teeth; upper teeth compressed and triangular, conspicuously slender at crown and crown vertically elongated, unicuspid with pointed cusp, mesial and distal cutting edges straight; upper teeth irregularly distributed in mouth; lower teeth compressed and interlocked, broadly triangular at crown, crown vertically low, unicuspid with small serrations in the blades, mesial and distal cutting edges sigmoid. Gill slits markedly tall and vertical. Dorsal fins sail-like and triangular, conspicuously upright, tall and broad at fin web; anterior and posterior margins of first and second dorsal fins straight; apex and free rear tips of first and second dorsal fins pointed. Dorsal-fin spines conical, thick and markedly small, located prior to each dorsal fin and never transcending the fin apex; first dorsal-fin spine directed forwardly and

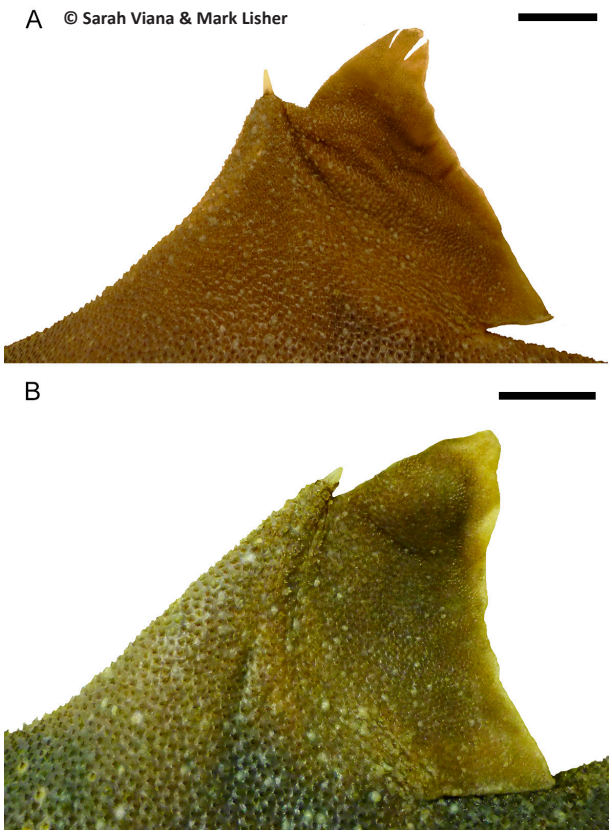

Image 3. Dorsal fins of *Oxynotus* sp., SAIAB 192249, juvenile female, 519mm TL. A: first dorsal fin; B: second dorsal fin. Scale bars: 20mm.

second dorsal-fin spine directed backwardly. Pectoral fins leaf-like and wide, placed laterally; pectoral-fin anterior and inner margins markedly convex; pectoral-fin posterior margin somewhat straight and slightly concave distally; pectoral-fin apex pointed distally; pectoral-fin free-rear tips inconspicuous. Pelvic fins sub-quadrangular and wide, located ventrally just prior to caudal fin; pelvic-fin margins straight; pelvic-fin apex and free rear tips rounded. Caudal fin small and sub-triangular with inconspicuous lower caudal lobe and evident subterminal notch; caudal fork inconspicuous; dorsal caudal margin straight; preventral caudal margin somewhat convex; terminal caudal margin straight; postventral caudal margins straight; posterior, ventral and subterminal caudal tips rounded.

Dermal denticles markedly large, measuring 1mm width across tips of lateral cusps. Denticles heavy, sparsely distributed with different sizes throughout, and positioned in right angle to the longitudinal body axis. Denticles crown-like with four pointed cusps distally, including two lateral cusps and two median cusps. Median cusps comprised of one anterior cusp and one posterior cusp. Anterior median cusp much more elongate than remaining cusps. Posterior median cusp small and hook-like. Large denticles with three thin anterior ridges, although a single anterior ridge is shown in small denticles. Lateral ridges thin and small. Crown base of denticles conspicuously broad.

Body brownish laterally and ventrally with large black blotches dorso-laterally throughout head, trunk and tail; black botches also found ventrally at head posterior to mouth till vertical traced at insertion of pectoral fins. Dorsal fins brownish, dorsal-fins posterior margin and free rear tips white. Pectoral fins brown dorsally and blackish ventrally with pectoral-fin anterior and posterior margins broadly white. Pelvic fins dark brown with black blotch ventrally; pelvic-fin anterior and posterior margins whitish. Caudal fin dark brown with postventral caudal margins slightly white, black caudal strip prominent and black caudal blotch evident in the preventral caudal margin.

Biological traits. The specimen weighed a total of 1.944kg. The liver is markedly heavy with total

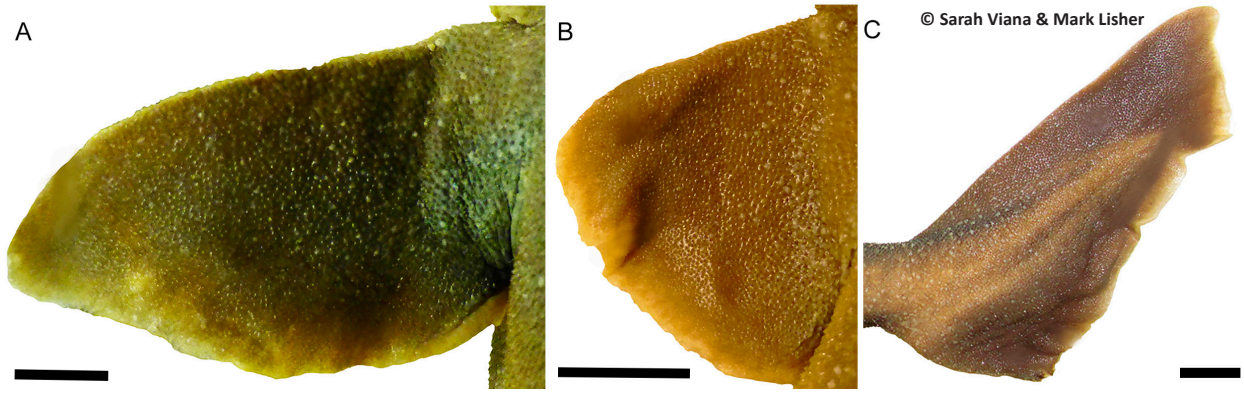

Image 4. Pectoral (A) and pelvic (B) fins in dorsal view, and caudal fin (C) of *Oxynotus* sp. (SAIAB 192249, juvenile female, 519mm TL). Scale bars: 20mm.

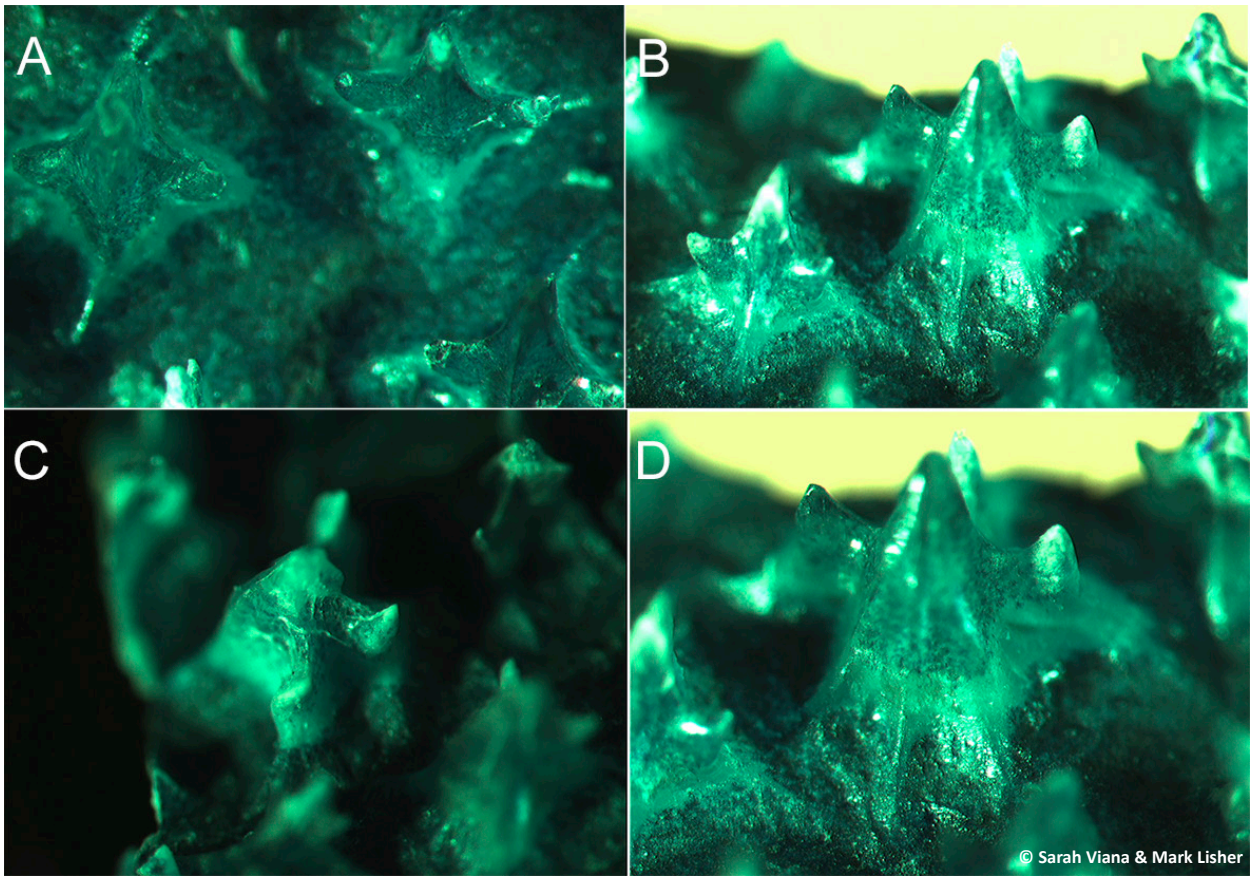

Image 5. Dermal denticles of *Oxynotus* sp. (SAIAB 192249, juvenile female, 519mm TL) taken from below first dorsal fin. A: dorsal view; B: anterior view; C: posterior view, showing posterior median cusp; D: anterior view of a large denticle.

weight of 518g, entirely occupying the abdominal cavity. It comprises two asymmetrical lobes, somewhat cylindrical, triangular in cross-section, pointed distally and convex proximally. Liver lobes are conspicuously elongate with right lobe measuring 275mm and left lobe 262mm in length. The hepatosomatic index (HSI) for the specimen is 36.33%. According to Capapé et al. (1999) adult females show HSI ranging from 23%–42% while Megalofanou & Damalas (2004) noticed 18.8% HSI for a gravid female of *O. centrina*, supporting that HSI considerably decreases in breeding females. The hepatosomatic index in the immature female of *Oxynotus* sp. comprises twice that of gravid females of *O. centrina*. Capapé et al. (1999) stated that the HSI of *O. centrina* increases as juveniles approach maturation, taking this into account the high HSI of *Oxynotus* sp. indicates that the specimen was possibly approaching maturation at the time of capture. Thus, a viable population of *Oxynotus* sp. may exist within the Madagascar Basin, although this is the only official record of this species and family from the region suggesting that the population is rather small and vulnerable.

DISCUSSION

The *Oxynotus* specimen from the western Indian Ocean is herein identified as *Oxynotus* sp. due to inherent differentiation in external morphology and morphometrics with specimens of *O. centrina* and *O. bruniensis*. *Oxynotus* sp. is distinct from *O. centrina* from the Mediterranean Sea and northeastern Atlantic Ocean by having body much more robust and deeper from head to tail with heights of head, trunk, tail and caudal peduncle greater in length than in *O. centrina* (*vs*. body slender and low in *O. centrina*), knob behind eyes inconspicuous (vs. conspicuous in *O. centrina*), dorsal fins with posterior margin straight and apex directed upwardly (vs. conspicuously concave and apex directed posteriorly in *O. centrina*), pectoral fins broad with apex slightly pointed (vs. thin with apex conspicuously pointed and thin in *O. centrina*), and caudal fin with lower caudal lobe inconspicuous or small (*vs*. lower caudal lobe conspicuous in *O. centrina*). *Oxynotus* sp. also differs by having smaller dorsal-caudal space than those of *O. centrina*, and body brownish with many black blotches

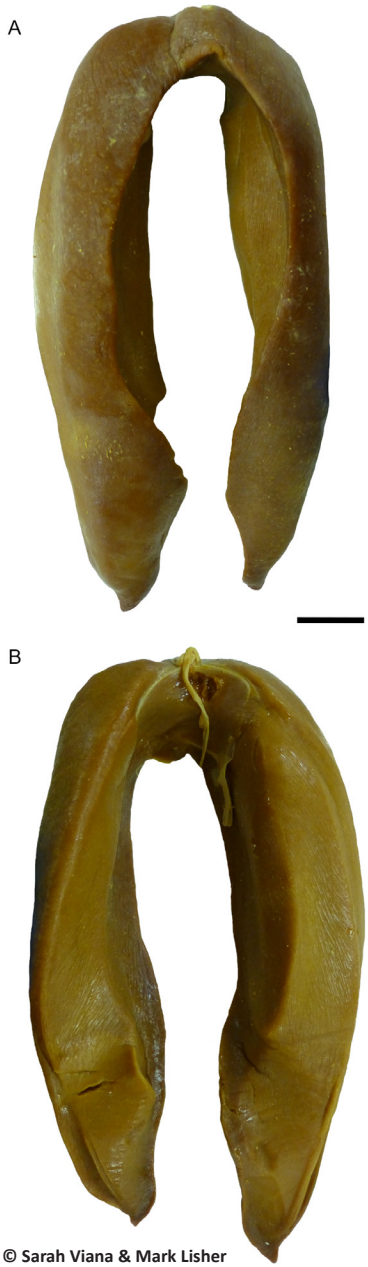

Image 6. Liver of *Oxynotus* sp. (SAIAB 192249, juvenile female, 519mm TL) in dorsal (A) and ventral (B) views, showing asymmetrical lobes. Scale bar: 30mm.

throughout the body dorsal, lateral and ventrally (vs. body greyish-white with brown or reddish-brown blotches throughout the body in *O. centrina*). *Oxynotus* sp. has head, preorbital, pre-branchial, prespiracular and prepelvic lengths greater than in *O. centrina*. The former species also shows pre-vent length, pelvic-caudal space, trunk width, interorbital space, postventral caudal margin length much greater than in *O. centrina*. Other differences in external measurements between *Oxynotus* sp. and *O. centrina* are noticed for preoral length, height of fifth gill slit, length of first dorsal-fin anterior and posterior margins, height of pelvic fin, dorsal-caudal and pectoral-pelvic space, height of eyes.

Bass et al. (1976) stated that the interdorsal space as percentage of precaudal length in specimens from the southeastern Atlantic Ocean (e.g., Angola, Namibia and South Africa) is smaller than those from the northeastern Atlantic Ocean and Mediterranean Sea. According to Yano & Matusuura (2002), interdorsal space as percentage of precaudal length overlaps in *O. centrina* and the specimen of *Oxynotus* from Namibia (29.1%–34.6% PCL vs. 30.1% PCL). *Oxynotus* sp. from the western Indian Ocean shows a much smaller interdorsal space, corresponding to 25.8% PCL, which is in accordance to the results of Bass et al. (1976) and against those of Yano & Matusuura (2002). It is important to notice, however, that the measurement provided in Yano & Matusuura (2002) for the Namibian specimen was calculated from the illustration taken from Bass et al. (1976), which might have interfered in their results. When the interdorsal space is calculated as percentage of total length, *Oxynotus* sp. (20.7% TL) and *O. caribbaeus* (19.2% TL) taken from Yano & Matsuura (2002) overlap with those of *O. centrina* (18.0%–21.0% TL). Interdorsal space in *Oxynotus* sp. clearly differs from those of *O. bruniensis* (12.7% TL), *O. japonicus* (16.7% TL) and *O. paradoxus* (21.9% TL) taken from Yano & Matsuura (2002).

Besides interdorsal space, *Oxynotus* sp. is separated from *O. bruniensis* sensu Ogilby (1893), Cadenat & Blache (1981), Last & Stevens (2009) and Ebert (2013) by having body dark brown with black blotches present from head to tail (*vs*. body sandy light brown with no evident black blotches in *O. bruniensis*), supraorbital and infraorbital ridges conspicuous (vs. inconspicuous in *O. bruniensis*), head markedly convex anterior-dorsally (vs. markedly concave anterior-dorsally in *O. bruniensis*), spiracles vertical (vs. spiracles rounded in *O. bruniensis*), and dorsal fin with apex pointed (*vs*. apex rounded in *O. bruniensis*). It is further distinct from *O. bruniensis* by having interdorsal space 1.67 times second dorsal-fin base length (vs. interdorsal space 0.93 times second dorsal-fin base length in *O. bruniensis*, taken from Yano & Matsuura 2002). These findings support that *O. bruniensis* recognized in the Eastern Indian Ocean in Ebert (2013) and Weigmann (2016) has no occurrence in the western Indian Ocean.

Oxynotus sp. may represent a species distinct from the Mediterranean *O. centrina* and possibly an undescribed species. The present study clarifies that this species occurs in the Madagascar Basin from off south Reunion Island

Table 1. External measurements for *Oxynotus* sp. (SAIAB 192249) expressed as percentage of the total length (% TL). TL is given in millimeter. Morphometrics of *O. centrina* are summarized as mean values for comparisons.

	Oxynotus sp.		*Oxynotus centrina*							
	SAIAB 192249		Yano & Murofushi (1985)	Barrull & Mate (2001)	Yano & Matsuura (2002)	Megalofonou & Damalas (2004)	Dragičević et al. (2009)	Moftah et al. (2011)	Kousteni & Megalofonou (2016)	Yigin et al. (2016)
	n=1		n=5	n=2	n=8	n=1	n=1	n=1	n=4	n=1
Total length (mm)	519		440–545	555	210–545	690	800	–	533–790	651
	mm	%TL	Mean %TL							
Precaudal length	417.00	80.35	80.24	80	78.8	81	79	78.49	77.68	80.18
Pre-first dorsal length	131.20	25.28	29.24	19.25	15.7	24	22	22.38	21.85	23.81
Pre-second dorsal length	325.00	62.62	65.57	58.15	57.6	62	60		59.05	64.82
Head length	107.75	20.76				15	15	17.56	18.85	18.13
Prebranchial length	91.96	17.72	15.69		15.4				15.03	
Prespiracular length	60.02	11.56	8.96	9.65	8.6				9.48	
Preorbital length	37.17	7.16	3.66	6	3.3				4.75	
Pre-pectoral length	103.58	19.96	19.64	18.55	19.7	15	16	17.21	17.25	18.43
Pre-pelvic length	330.00	63.58	62.57	61.55	61.7			59.55	62.28	
Pre-vent length	372.00	71.68	66.46		65.5					
Interdorsal space	107.68	20.75	19.36		19.7	21	18		18.93	20.43
Dorsal-caudal space	45.80	8.82	10.42		10				9.15	
Pectoral-pelvic space	190.00	36.61			37.2				39.68	
Pelvic-caudal space	52.63	10.14	9.19		9.4					
Head width	94.28	18.17								
Trunk width	98.03	18.89	15.69		16					
Head height	98.95	19.07				8	9		13.48	13.67
Trunk height	120.42	23.20	17.37		18	18	20	16.35	16.08	16.9
Tail height	44.68	8.61							7.73	
Caudal peduncle height	25.62	4.94				4	4		4.08	4.15
Eye length	20.36	3.92	4.52	4.05	4.5	4	3		4.1	3.69
Eye height	7.18	1.38		2.05	1.5				1.6	
Interorbital space	60.34	11.63	9.75		9.4				7.5	
Spiracle length	16.83	3.24	2.92		3				3.1	
Nostril width	17.64	3.40		2.8						
Internarial space	7.91	1.52	1.13	1.8	1.2				2.85	
Mouth width	32.76	6.31	5.78	4.4	5.6				7.5	
Prenarial length	13.35	2.57	1.56	2.8	1.5				1.68	
Preoral length	30.60	5.90	4.79	4.7	4.8				5.25	
First gill slit height	8.27	1.59	1.25	1.5	1.4				1.8	
Fifth gill slit height	11.94	2.30	1.46	1.5	1.6				1.85	
Intergill length	19.61	3.78		4.55					4.43	
First dorsal fin anterior margin length	112.13	21.61				19	21		20.38	18.89
First dorsal fin height	66.29	12.77	14.46	12.35	14.5	14	13		13.18	12.29
First dorsal fin inner margin length	18.82	3.63		4.15						
First dorsal fin posterior margin length	76.50	14.74			15.4				15.33	

	Oxynotus sp.		*Oxynotus centrina*							
	SAIAB 192249		Yano & Murofushi (1985)	Barrull & Mate (2001)	Yano & Matsuura (2002)	Megalofonou & Damalas (2004)	Dragičević et al. (2009)	Moftah et al. (2011)	Kousteni & Megalofonou (2016)	Yigin et al. (2016)
	n=1		n=5	n=2	n=8	n=1	n=1	n=1	n=4	n=1
First dorsal fin base length	96.00	18.50		19.9	24.4	12	18		17.3	12.6
First dorsal fin length	114.48	22.06		24.05	27.3					
First dorsal-fin spine length	6.70	1.29			0.9					
Second dorsal fin anterior margin length	87.43	16.85				15	16		17.1	15.05
Second dorsal fin height	57.57	11.09	11.02	10.45	11.1	16	10		9.4	10.14
Second dorsal fin inner margin length	19.10	3.68		3.8						
Second dorsal fin posterior margin length	55.80	10.75			10.8	10	12		10.05	8.6
Second dorsal fin base length	64.48	12.42	11.95	11.05	12	9	12		12.15	9.98
Second dorsal fin length	81.38	15.68		14.85	15.9					
Second dorsal-fin spine length	3.98	0.77			0.9					
Pectoral-fin anterior margin length	88.33	17.02	17.79	15.75	17.8	19	16		16.88	17.2
Pectoral-fin inner margin length	17.79	3.43		3.5						
Pectoral-fin posterior margin length	77.38	14.91		14.2	11.6				11.95	
Pelvic-fin anterior margin length	51.15	9.86	9.79	6.4	9.8	10	10		8.78	8.29
Pelvic fin height	49.55	9.55				9	8		7.83	6.91
Pelvic-fin posterior margin length	54.88	10.57				11	13		8.38	9.52
Dorsal caudal margin length	112.44	21.66	21.09	20.55	21.5	17	18		21.43	18.74
Terminal caudal margin length	31.05	5.98				6	6		6.3	5.22
Preventral caudal margin length	64.07	12.34		11.7		11	11		12.8	11.52

(not northern Madagascar as seen in Fricke et al. 2018) and speculative records elsewhere (e.g., Mozambique and Madagascar) requires future scientific expeditions in the region. To elucidate the taxonomic status of this species an ongoing taxonomic investigation on species of the genus is being undertaken (Viana & Lisher in prep.) by integrating molecular analysis of the preserved specimen and comparative morphological examination of material from the Eastern Atlantic Ocean, particularly specimens from South African and Namibian waters, as well as congeners described elsewhere. Elucidation of the taxonomic status of other available nominal species is also essential such as *O. shubnikovi* Myagkovi, 1986 from off Kunene River in Namibia. This species is considered junior synonym of *O. centrina* in Yano & Matsuura (2002), Compagno (2016), and Weigmann (2016) due to overlapping of external morphological characters and interdorsal space. Vasil'eva et al. (2001), however, considers *O. shubnikovi* as valid following earlier assumptions of Bass et al. (1976), Myagkov (1986), and Compagno et al. (1991).

Preliminary comparative morphological observations in *O. centrina* reveal strong intraspecific variations between specimens from the eastern and western Mediterranean Sea as well as northeastern Atlantic Ocean regarding shape of dorsal and pectoral fins, body colouration and body depth. External measurements also vary for trunk height, interorbital and internarial spaces, mouth width, preoral length and heights of first and fifth gill slits, length of first dorsal-fin base, and length of second dorsal-fin posterior margin (see Table 1). These variations possibly represent the existence

of another nominal species distinct from *O. centrina* in this region as well. *Oxynotus salviani* Risso, 1827 described from Nice, France has been in synonymy with *O. centrina* without detailed taxonomic examination in Krefft & Tortonese (1973), demanding verification. Divergences on the morphometric methodology applied in earlier accounts on species of *Oxynotus* (e.g., Yano & Murofushi 1985; Myagkov 1986; Yano & Matsuura 2002; Kousteni & Megalofonou 2016) and the present study exist, and may have interfered in the assumptions pointed out in the present study, indicating that a standardization of external measurements for *Oxynotus* species is essential for future comparative purposes. The differences and intraspecific variations observed in the external morphology among species of the genus, however, denote that the taxonomy of the group is more complex than previously noticed. Re-evaluation of these morphological aspects combined with molecular analysis of species of *Oxynotus,* especially *Oxynotus* sp. and *O. centrina*, is urgently required in order to elucidate if *Oxynotus* sp. is a valid species and if *O. centrina* comprises a species with broad geographical distribution and strong intraspecific variations or if it has been misidentified with other regional congeners (e.g., *O. paradoxus*).

Oxynotus sp. is a rare deep-water species, possibly comprising a small and vulnerable population with scattered endemic distribution in the western Indian Ocean. Fishery trends are currently shifting from targeting coastal habitats to abyssal basins where fish stocks are still widely available for exploitation, including the Madagascar Basin where this species occurs. Thus, it is assumed that *Oxynotus* sp. may occasionally be caught as by-catch during bottom trawls by commercial vessels in this region, as it is noticed for its congeners elsewhere, including *O. centrina, O. bruniensis*, and *O. japonicus* (Francis 2003; Yano 2004; Bradaï et al. 2007). Moreover, the high HSI of this species provided in this study indicates that the population of *Oxynotus* sp. is approaching the breeding stage of the life cycle, making this species even more vulnerable to fishing threats. It is of urgent conservation concern to consider *Oxynotus* sp. as a species vulnerable to overfishing, even though fisheries have no apparent economic interest in rough sharks.

Comparative material

Oxynotus centrina (five specimens): AMS I.1752, adult female, 635mm TL, Mediterranean Sea (stuffed specimen, destroyed); CAS 234693, 195mm TL, neonate male, Guiné-Bissau; RMNH.PISC. 4248, Cantraine; RMNH.PISC. 17805, 20 miles from Barra Nova; RMNH. PISC. 34809, 20 miles from Barra Nova.

REFERENCES

Barrull, J. & I. Mate (2001). First confirmed record of angular roughshark *Oxynotus centrina* (Linnaeus, 1758) predation on shark egg case of small-spotted catshark *Scyliorhinus canicular* (Linnaeus, 1758) in Mediterranean waters. *Annales Series Historia Naturalis* 11: 23–28.

Bass, A.J., J.D. D'Aubrey & N. Kistnasamy (1976). Sharks of the east coast of southern Africa. VI. The families Oxynotidae, Squalidae, Dalatiidae and Echinorhinidae. *Investigational Report, Oceanographic Research Institute, Durban* 45(1): 1–103.

Bradaï, M.N., F. Serena, I. Bianchi & D.A. Ebert (2007). *Oxynotus centrina*. The IUCN Red List of Threatened Species 2007: e.T63141A12622296. Downloaded on 7 June 2017; http://doi.org/10.2305/IUCN.UK.2007.RLTS.T63141A12622296.en

Cadenat, J. & J. Blache (1981). *Requins de Méditerranée et d'Atlantique (plus particulierment de La Côte Ocidentale d'Afrique).* Colletion Fauna Tropicale XXI. ORSTOM, Paris, 330pp.

Capapé, C. (2008). Diet of the Angular Rough Shark *Oxynotus centrina* (Chondrichthyes: Oxynotidae) off the Languedocian Coast (Southern France, North-Western Mediterranean). *Viet et Milieu - Life and Environment* 58(1): 57–61.

Capapé, C., A.A. Seck & J.P. Quignard (1999). Observations on the reproductive biology of the Angular Rough Shark, *Oxynotus centrina* (Oxynotidae). *Cybium* 23(3): 259–271.

Compagno, L.J.V. (1999). Checklist of living elasmobranchs, pp. 471–498. In: Hamlett, W.C. (ed.). *Sharks, Skates, and Rays. The biology of elasmobranch fishes*. John Hopkins University Press, Baltimore and London, 528pp.

Compagno, L.J.V. (2016). Sharks, pp. 1123–1336. In: Carpenter, K.E. & N. De Angelis (eds.). *FAO Species Identification Guide for Fisheries Purpose. The Living Marine Resources for Eastern Central Atlantic. Volume 2: Bivalves, gastropods, hagfishes, sharks, batoid fishes, and chimaeras*. FAO Species Identification Guide for Fishery Purposes, Rome, pp. 665-1509.

Compagno, L.J.V., D. A. Ebert & P.D. Cowley (1991). Distribution of offshore demersal cartilaginous fish (Class Chondrichthyes) off the West coast of Southern Africa, with notes on their systematics. *South African Journal of Marine Science* 11 (1): 43–139; http://doi.org/10.2989/025776191784287664

Compagno, L.J.V., M. Dando & S. Fowler (2005). *Sharks of the World*. Princeton University Press, New Jersey, 368pp.

Dragičević, B., J. Dulčić & C. Capapé (2009). Capture of a rare shark, *Oxynotus centrina* (Chondrichthyes: Oxynotidae) in the eastern Adriatic Sea. *Journal of Applied Ichthyology* 25(1): 56–59; http://doi.org/10.1111/j.1439-0426.2009.01265.x

Ebert, D.A. (2013). *Deep-sea cartilaginous fishes of the Indian Ocean. Volume 1: Sharks.* FAO Species Catalogue for Fisheries Purposes No. 8, Rome, 256pp.

Ebert, D.A. (2015). *Deep–Sea Cartilaginous Fishes of the Southeastern Atlantic Ocean.* FAO Species Catalogue for Fishery Purposes, No. 9, Rome, 251pp.

Ebert, D.A. & K.E. Van Hees (2015). Beyond Jaws: rediscovering the 'lost sharks' of southern Africa. *African Journal of Marine Science* 37(3): 141–156; http://doi.org/10.2989/1814232X.2015.1048730

Ebert, D.A., S. Fowler & L.J.V. Compagno (2013). *Sharks of the World: A Fully Illustrated Guide*. Wild Nature Press, London, 528pp.

Ebert, D.A. & M.F.W. Stehmann (2013). *Sharks, batoids and chimaeras from the North Atlantic.* FAO Species Catalogue for Fisheries Purposes, No.7, Rome, 523pp.

Francis, M.P. (2003). *Oxynotus bruniensis.* The IUCN Red List of Threatened Species 2003: e.T41840A10578144. Downloaded on 7 June 2017; http://doi.org/10.2305/IUCN.UK.2003.RLTS.

T41840A10578144.en

Fricke, R., J. Mahafina, F. Behivoke, H. Jaonalison, M. Léopold & D. Ponton (2018). Annotated checklist of the fishes of Madagascar, southWestern Indian Ocean, with 158 new records. *Fishtaxa* 3(1): 1–432.

Garrick, J.A.F. (1960). Studies on New Zealand Elasmobranchii PartXI. Squaloids of the genera *Deania*, *Etmopterus*, *Oxynotus* and *Dalatias* in New Zealand waters. *Transactions of the Royal Society of New Zealand* 88(3): 489–517.

Guallart, J., P. Garcia-Salinas, A.E. Ahuir-Baraja, M. Guimerans, J.R. Ellis & M. Roche (2015). Angular roughshark *Oxynotus centrina* (Squaliformes: Oxynotidae) in captivity feeding exclusively on elasmobranch eggs: an overlooked feeding niche or a matter of individual taste? *Journal of Fish Biology* 87(4): 1072–1079; http://doi.org/10.1111/jfb.12761

Herman, J., M. Hovestadt-Euler & D.C. Hovestadt (2005). Contributions to the odontological study of living Chondrichthyes. 2. The genus *Oxynotus* Rafinesque, 1810. *Bulletin de L'Institut Royal Des Sciences Naturelles de Belgique, Biologie* 75: 5–20.

Ho, H-C. & K. Nakaya (2016). New record of the Japanese Roughshark, *Oxynotus japonicus* Yano & Murofushi, 1985 (Elasmobranchii: Squaliformes: Oxynotidae) in Taiwan. *Acta Ichthyologica et Piscatoria* 46(4): 357–360; http://doi.org/10.3750/AIP2016.46.4.08

Krefft, G. & E. Tortonese (1973). Oxynotidae, pp. 35–36. In: Hureau, J.C. & T. Monod (eds.). *Check-list of the Fishes of the North-eastern Atlantic and of the Mediterranean*. CLOFNAM Unesco, Paris, 683pp.

Kousteni, V. & P. Megalofonou (2016). Observations on the biological traits of the rare shark *Oxynotus centrina* (Chondrichthyes: Oxynotidae) in the Hellenic Seas. *Journal of Fish Biology* 89(3): 1880–1888; http://doi.org/ 10.1111/jfb.13077

Last, P.R. & J.D. Stevens (2009). *Sharks and Rays of Australia*, 2nd Edition. Harvard University Press, Cambridge, 644pp.

Last, P.R., W.T. White, J.J. Pogonoski, D.C. Gledhill, G.K. Yearsleay & R.D. Ward (2007). Part 1 – Application of a rapid taxonomic approach to the genus *Squalus*, pp. 1–10. In: Last, P.R., W.T. White & J.J. Pogonoski (eds.). *Descriptions of new dogfishes of the genus Squalus (Squaloidea: Squalidae)*. CSIRO Marine and Atmospheric Research Paper 014, Hobart, 130pp.

Leandro, L. (2004). *Oxynotus caribbaeus*. The IUCN Red List of Threatened Species 2004: e.T44568A10907800. Downloaded on 7 June 2017; http://doi.org/10.2305/IUCN.UK.2004.RLTS.T44568A10907800.en

Megalofonou, P. & D. Damalas (2004). Morphological and biological characteristics of a gravid angular rough shark (*Oxynotus centrina*) and its embryos from the Eastern Mediterranean Sea. *Cybium* 28(2): 105–110.

Moftah, M., S.H. Abdel Aziz, S. Elramah & A. Favereaux (2011). Classification of Sharks in the Egyptian Mediterranean Waters Using Morphological and DNA Barcoding Approaches. *PLoS ONE* 6(11): e27001; http://doi.org/10.1371/journal.pone.0027001

Myagkov, N.A. (1986). Oxynotidae, pp. 168–173. In: Gubanov, E.P., V.V. Kondyurin & N.A. Myagkov, (eds.). *Sharks of the World Ocean: Identification handbook. [=Akuly Mirovogo okeana: Spravochnik-opredelitel']*. Agropromizdat, Moscow, 272pp.

Ogilby, J.D. (1893). Description of a New Shark from the Tasmanian Coast. *Records of the Australian Museum* 2(5): 62–63; http://doi.org/10.3853/j.0067-1975.2.1893.1194

Ragonese, S., S. Vitale, M. Dimech & S. Mazzola (2013). Abundances of Demersal Sharks and Chimaera from 1994-2009 Scientific Surveys in the Central Mediterranean Sea. *PLoS ONE* 8(9): e74865; http://doi.org/10.1371/journal.pone.0074865

Rogers, A.D., O. Alvheim, E. Bemanaja, D. Benivary, P.H. Boersch-Supan, T. Bornman, R. Cedras, N. Du Plessis, S. Gotheil, A. Hoines, K. Kemp, J. Kristiansen, T. Letessier, V. Mangar, N. Mazungula, T. Mørk, P. Pinet, J. Read & T. Sonnekus (2010). Cruise report "Dr. Fridtjof Nansen". Southern Indian Ocean Seamounts. IUCN/ GEF/ UNDP/ ZSL/ ASCLME/ NERC/ EAF Nansen Project/ ECOMAR/ ACEP 2009 Cruise 410, 182pp.

Sabaj, M.H. (2016). Standard symbolic codes for institutional resource collections in herpetology and ichthyology: an Online Reference. In: American Society of Ichthyologists and Herpetologists, Washington, DC., Version 6.5 (16 August 2016), http://www.asih.org. Downloaded on 2 September 2016.

Soldo, A. & M. Freitas (2009). *Oxynotus paradoxus.* The IUCN Red List of Threatened Species 2009: e.T161361A5406422. Downloaded on 7 June 2017; http://doi.org/10.2305/IUCN.UK.2009-2.RLTS.T161361A5406422.en

Vasil'eva, E.D., N.N. Sazonov & I.A. Verigina. (2001). *Types of Vertebrates in the Zoological Museum of Moscow University*. Moscow University Publisher, Moscow, 250pp.

Yano, K. (2004). *Oxynotus japonicus.* The IUCN Red List of Threatened Species 2004: e.T44206A10870794. Downloaded on 7 June 2017; http://doi.org/10.2305/IUCN.UK.2004.RLTS.T44206A10870794.en

Yano, K. & M. Murofushi (1985). A New Prickly Dogfish, *Oxynotus japonicus*, from Japan. *Japanese Journal of Ichthyology* 32(2): 129–135.

Yano, K. & K. Matsuura (2002). A Review of the Genus *Oxynotus* (Squaliformes, Oxynotidae). *Bulletin of the National Science Museum, Tokyo, Series A* 28(2): 109–117.

Yigin, C.C., A. Ismen & U. Onal (2016). Occurrence of a rare shark, *Oxynotus centrina* (Chondrichthyes: Oxynotidae), from Saros Bay, North Aegean Sea, Turkey. *Journal of the Black Sea/Mediterranean Environment* 22(1): 103–109.

Weigmann, S. (2016). Annotated checklist of the living sharks, batoids and chimaeras (Chondrichthyes) of the world, with a focus on biogeographical diversity, *Journal of Fish Biology* 88(3): 837–1037; http://doi.org/10.1111/jfb.12874

Journal of Threatened Taxa

www.threatenedtaxa.org

ISSN 0974-7907 (Online); ISSN 0974-7893 (Print)

May 2018 | Vol. 10 | No. 6 | Pages: 11703–11830
Date of Publication: 26 May 2018 (Online & Print)
DOI: 10.11609/jott.2018.10.6.11703-11830