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FIRST RECORD OF *OPHICHTHUS RUFUS* (ACTINOPTERYGII: ANGUILLIFORMES: OPHICHTHIDAE) OFF THE WESTERN IBERIAN COAST: THE NORTHERNMOST OCCURRENCE IN THE EASTERN ATLANTIC

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Abstract. The first record of *Ophichthus rufus* (Rafinesque, 1810) in Portuguese continental waters is reported. In February 2013 two specimens were caught by a commercial bottom trawler on the southwestern Portuguese coast and in August 2019 another specimen was caught at the same location. Analyses of diagnostic morphological characters and morphometric characteristics confirmed the specimens as *Ophichthus rufus*. The distribution of this species has been described in the literature as endemic to the Mediterranean Sea, however other references describe the presence of *O. rufus* in Principe Island, Morocco, and Gulf of Cádiz. The new finding described herewith represents the first record of *O. rufus* for the western Iberian coast and also constitutes the northernmost record of the species.

Keywords: Rufus snake eel, *Ophichthus rufus*, new record, North-east Atlantic Ocean, DNA barcode

INTRODUCTION

The Rufus snake eel, *Ophichthus rufus* (Rafinesque, 1810), belongs to the speciose family Ophichthidae, which comprises 62 genera and 323 species (Froese and Pauly 2018) but only 8 occur in the north-eastern Atlantic Ocean (Bauchot 1986, Quéro et al. 2003, Carneiro et al. 2014). Of the 323 species of Ophichthidae 110 belong to the genus *Ophichthus* Ahl, 1789 (see Froese and Pauly 2018).

Ophichthus rufus has been recognized as endemic and widespread to the Mediterranean Sea (Bauchot 1986, Casadevall et al. 1994, Smith 2014) and has been found within the depth range of 40–660 m (Smith 2014). The most recent presence records, however, extended its known distribution to the Gulf of Cádiz, Spain (Báez et al. 2019), Príncipe Island (Wirtz et al. 2007), the Northern Moroccan Atlantic area (Taï et al. 2015). This eel is known to feed mainly on small shrimp and bony fishes (Casadevall et al. 1994) and has intense nocturnal activity, as observed in the Catalan Sea during the exploration by Bozzano and Sardà (2002). This species has no commercial value and is discarded by commercial fishers (Machias et al. 2001). Even though the impact of such discards is not known, the species has been rated as Least Concern in the Red List of Threatened Species (Smith 2014). *Ophichthus rufus* has been previously described in literature has an elongate, almost cylindrical, snake-like fish (Bauchot 1986). This paper reports the first occurrence of *O. rufus* in Portuguese continental waters.

MATERIAL AND METHODS

Two specimens of *Ophichthus rufus* were caught on 27 February 2013 by a commercial bottom trawler in one bottom trawl haul, in the southwest Portuguese continental slope, targeting the deep-water rose shrimp *Parapenaeus longirostris* at a depth of 292 m (Fig. 1). Again, on 21 August 2019, another specimen of *O. rufus* was caught at the same location, by the same fishing vessel, and using the same fishing gear. In the laboratory, the three specimens were examined for diagnostic morphological and morphometric features following Bauchot (1986) and Casadevall (1991), and head pores (Böhlke 1989, McCosker 2010) (Tables 1 and 2).

All available specimens were photographed and deposited with the respective tissue samples in the zoological collection of the Museu Nacional de História Natural e da Ciência (MUHNAC), University of Lisbon, Portugal. The collection data and numbers are provided in Table 1. The tissue samples were collected to confirm the taxonomic identity of the sampled individuals using DNA barcodes. Each muscle tissue sample from each individual was collected and preserved in 96% ethanol. Total genomic DNA was extracted from muscle tissue and the mitochondrial gene cytochrome c oxidase I (5′-COI) was amplified and sequenced following published protocols (Ivanova et al. 2007). After assembling and editing the bidirectional sequences, a sequence of 652 bp

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fragment was obtained. The haplotypes were deposited in the GenBank (accession numbers MK450529 and MK450530) and in BOLD (process ID IPMAF009-18, IPMAF010-18, and IPMA016-19) and a search for matching sequences of Ophichthidae species available in BOLD and in NCBI BLAST® was performed.

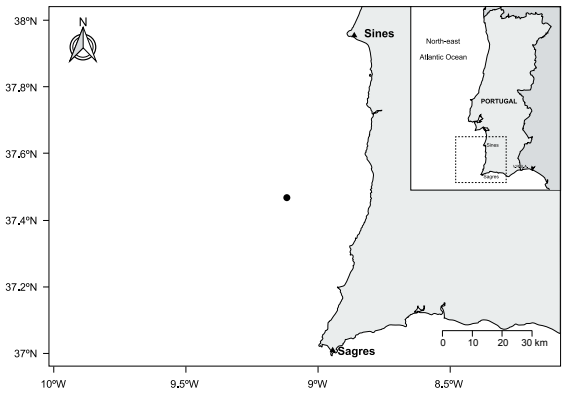

Fig. 1. The sampling site (solid dot) of *Ophichthus rufus* off the Portuguese coast

RESULTS

Family OPHICHTHIDAE

***Ophichthus rufus* (Rafinesque, 1810)**

(Fig. 2; Tables 1, 2)

Material. Specimen 1 (total weight 71.95 g; sample ID MB06-005900; tissue sample ID MB85-017365; 27 February 2013; 37.466667ºN, 009.1167ºW), Specimen 2 (total weight 65.42 g; sample ID MB06-005900; tissue sample ID MB85-017366; 27 February 2013; 37.466667ºN, 009.1167ºW), Specimen 3 (total weight 68.62 g; sample ID MB06-005901; tissue sample ID MB85-017367; 21 August 2019; 37.466667ºN, 009.133333ºW) (sample ID and tissue sample ID refer to specimen deposited at the National Museum of Natural History in Lisbon, Portugal).

Diagnosis. Body elongate, almost cylindrical, snake-like (Fig. 2A); snout short and obtuse; anterior nostrils tubular (Fig. 2B), directed downward, inserted in depression of the upper lip at level of anterior border of eye. Dorsal and anal fins well developed and discontinuous posteriorly; caudal tip hardened and finless (Fig. 2C); pectoral fins well developed (Fig. 2D); pelvic fins absent. Teeth small, conical uni or biserial on both jaws, uniserial on vomer, premaxillary teeth slightly bigger. Gill openings lateral and sub vertical. Coloration almost uniform, brownish, or yellowish. Morphometric characteristics, meristic

Table 1

Morphometric characters of *Ophichthus rufus* specimens collected off the Portuguese coast in 2013 and 2019

Character	Specimen 1			Specimen 2			Specimen 3		
	Absolute value [mm]	$\%L_T$	$\%L_H$	Absolute value [mm]	$\%L_T$	$\%L_H$	Absolute value [mm]	$\%L_T$	$\%L_H$
Total length	548.00	—	—	546.00	—	—	503.50	—	—
Head length	44.99	8.2	—	47.46	8.7	—	44.64	8.9	—
Cephalic width	15.67	—	34.8	13.58	—	28.6	11.65	—	26.1
Snout length	7.23	1.3	16.1	9.14	1.7	19.3	7.73	1.5	17.3
Ocular diameter horizontal	5.26	1.0	11.7	4.89	0.9	10.3	4.78	0.9	10.7
Ocular diameter vertical	4.71	0.9	10.5	4.28	0.8	9.0	3.57	0.7	8.0
Interocular length	7.14	1.3	15.9	8.44	1.5	17.8	5.77	1.1	12.9
Predorsal length	112.00	20.4	—	117.00	21.4	—	94.50	18.8	—
Preanal length	257.00	46.9	—	263.00	48.2	—	227.00	45.1	—
Caudal depth	14.21	2.6	—	12.84	2.4	—	15.25	3.0	—
Postorbital length	32.98	—	73.3	34.70	—	73.1	32.23	—	72.2
Mouth length	14.90	—	33.1	16.78	—	35.4	13.35	—	29.9
Gill slit length	5.39	—	12.0	4.89	—	10.0	4.48	—	10.0
Body depth	19.51	3.6	—	21.04	3.9	—	18.83	3.7	—
Body width	16.15	2.9	—	15.98	2.9	—	13.96	2.8	—
Prepectoral length	45.26	8.3	—	45.67	8.3	—	41.64	8.3	—
Pre anus length	254.00	46.3	—	260.00	47.6	—	223.00	44.3	—
Pre anal-fin length	257.00	46.9	—	263.00	48.2	—	227.00	45.1	—
Dorsal-base length	425.41	77.6	—	422.73	77.4	—	403.50	80.1	—
Anal-base length	284.71	51.9	—	278.30	51.0	—	276.00	54.8	—
Pectoral-fin length	7.95	1.5	—	10.43	1.9	—	9.09	1.8	—

Specimen 1 (total weight 71.95 g; sample ID MB06-005900; tissue sample ID MB85-017365; 27 February 2013; 37.466667ºN, 009.1167ºW), Specimen 2 (total weight 65.42 g; sample ID MB06-005900; tissue sample ID MB85-017366; 27 February 2013; 37.466667ºN, 009.1167ºW), Specimen 3 (total weight 68.62 g; sample ID MB06-005901; tissue sample ID MB85-017367; 21 August 2019; 37.466667ºN, 009.133333ºW); $\%L_T$ = percent of total length, $\%L_H$ = percent of head length; sample ID and tissue sample ID refer to specimen deposited at the National Museum of Natural History in Lisbon, Portugal.

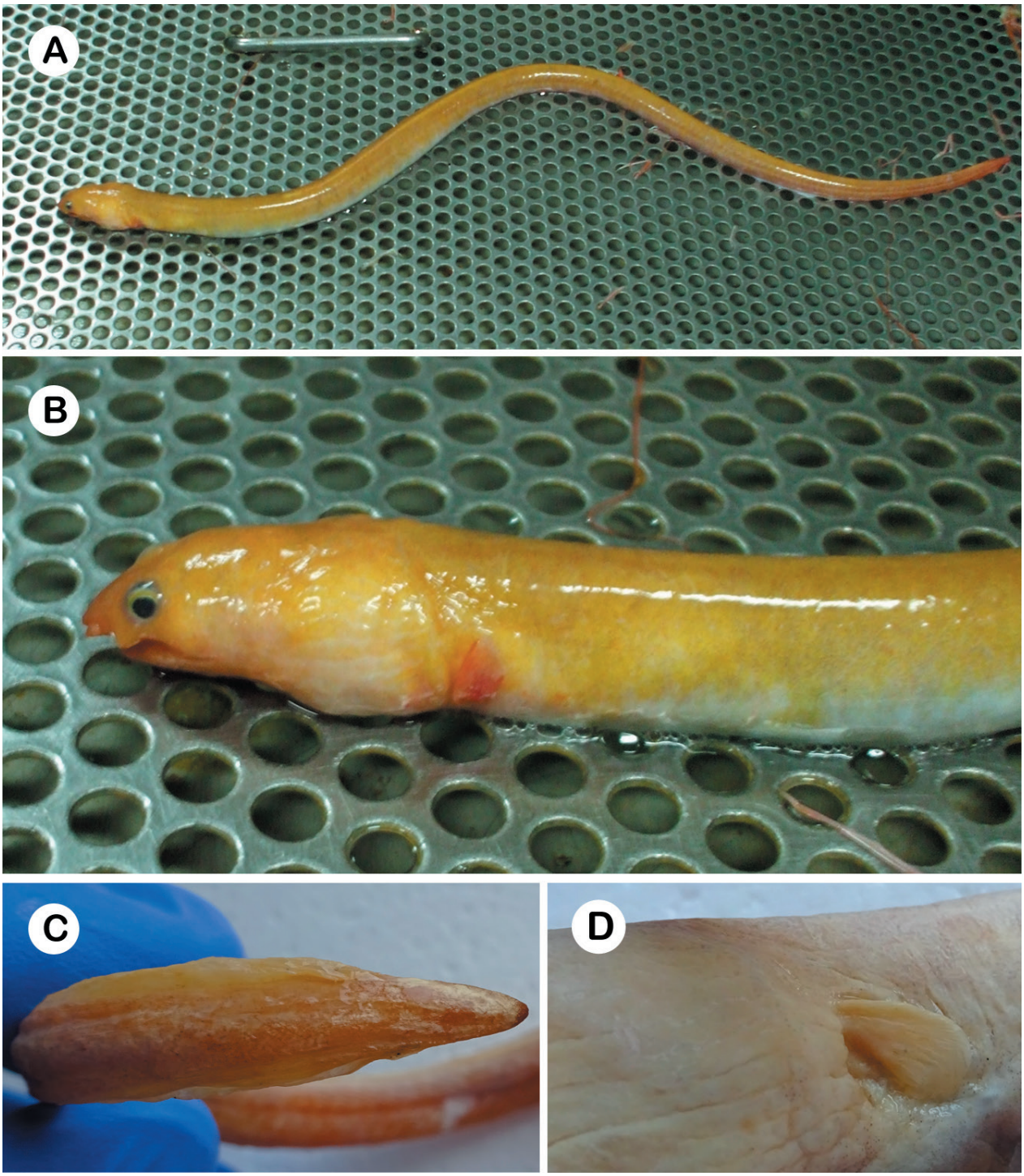

Fig. 2. *Ophichthus rufus*, specimen 1 (548 mm total length and 71.95 g total weight) caught on the Portuguese continental slope in 2013 and 2019; entire specimen (**A**), head (**B**), the finless tip of tail (**C**), pectoral fin (**D**)

counts, pore counts, and body proportions of the sampled specimens are presented in Tables 1 and 2.

No matches were found with sequences of Ophichthidae species available in GenBank or BOLD Systems: of the 323 species described for the family Ophichthidae 101 had public barcodes, of which 27 species belong to the genus *Ophichthus*; of the 8 species of Ophichthidae with known distribution in the northeastern Atlantic 3 had public barcodes namely *Dalophis imberbis* (Delaroche, 1809), *Echelus myrus* (Linnaeus, 1758), and *Ophisurus serpens* (Linnaeus, 1758). No public records were available for *O. rufus*.

A complete match (100%) was found between COI sequences belonging to the three specimens of this study. The public sequences that showed least percentage distance with BLAST (below 10%) were: 8.66% for *Ophichthus apicalis* (Anonymous [Bennett], 1830), 8.81% for *Ophichthus frontalis* Garman, 1899, 9.09% for *Ophichthus rex* Böhlke et Caruso, 1980, 9.71% for *Ophichthus asakusae* Jordan et Snyder, 1901, and 9.86% for *Ophisurus serpens*.

Table 2
Meristic counts of *Ophichthus rufus* specimens collected off the Portuguese coast in 2013 and 2019

Character	Count		
	Specimen 1	Specimen 2	Specimen 1
Pectoral-fin rays	11	11	11
Lateral line prepectoral PNo.	8	8	8
Lateral line preanal PNo.	—	—	61
Ethmoid PNo.	1	1	1
Frontal PNo.	1	1	1
Interorbital PNo.	2	2	2
Supraorbital PNo.	4	4	4
Postorbital PNo.	2	2	2
Infraorbital PNo.	7	7	7
Mandibular PNo.	6	6	6
Preoperculomandibular PNo.	8	8	8
Supratemporal PNo.	2	2	2

PNo. = pore number; the specimen information as in Table 1.

DISCUSSION

The diagnostic morphological characters and morphometrics matched with the previous descriptions of Bauchot (1986) and Casadevall (1991). The morphology of the three examined specimens was consistent with the previous description of the species namely concerning: the tubular anterior nostrils (Fig. 2B), the short and obtuse snout (Fig. 2B), the hardened and finless caudal fin tip (Fig. 2C), the presence of a pectoral fin (Fig. 2D) and the yellowish or brownish almost uniform coloration (Fig. 2A). A comparison of genetic data with individuals from the Mediterranean Sea was not possible due to a lack of data from public libraries. However, the genetic analysis conducted allowed to exclude the 101 species of the family Ophichthidae that occur worldwide and have available public DNA barcodes (based on mitochondrial DNA gene cytochrome c oxidase I (5′-COI)), including the 27 species of the same genus (*Ophichthus*) and the three species of Ophichthidae with occurrence in the Northeast Atlantic Ocean. The bibliographic references point to a first record of *Ophichthus rufus* for Portuguese continental waters (Carneiro et al. 2014) and the first record for the species in the western Iberian Coast, which represents the northernmost record for the species.

In the western Iberian coast (Galicia), two other species of Ophichthidae have also been recorded recently for the first time to the north of their known geographical distribution areas, viz., *Pisodonophis semicinctus* (Richardson 1848) and *Ophisurus serpens* (see Bañon et al. 2002, 2011).

These new records may be due to recent movement of these species northwards of the previously known range. There are pieces of evidence of a process tropicalization of fish assemblage structures within temperate transition zone along the Portuguese west coast motivated by more frequent warming events in the last decades (Horta e Costa et al. 2014). Another hypothesis for these new records of Ophichthidae is species misidentification in the past, but these hypotheses remain to be investigated.

Attention should be paid to the catches of Ophichthidae in the study area and future studies should compare the genetics of individuals identified as *O. rufus* from the different areas (Mediterranean, North-eastern Atlantic, and eastern central Atlantic).

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