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Occurrence of a blind *Lophius budegassa* in the Mediterranean Sea

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Abstract: The first specimen of a blind *Lophius budegassa* found in the Mediterranean Sea was caught during the scientific survey "COMSOM" conducted in June 2009 in the fishing grounds off Cap de Creus (NW Mediterranean Sea) with an experimental beam trawl at 90 m depth. The individual is described, and biometric measurements and meristic data provided. The presence of the microsporidian parasite *Spraguea lophii* was also observed.

Résumé : *Sur la présence d'un spécimen aveugle de* Lophius budegassa *en Méditerranée.* Le premier spécimen d'un *Lophius budegassa* aveugle trouvé en Méditerranée a été capturé pendant la mission scientifique "COMSOM" réalisée en juin 2009 dans les zones de pêche au large du Cap de Creus (Mer Méditerranée nord-ouest) avec un chalut à perche expérimentale à 90 m de profondeur. L'individu est décrit, les mesures biométriques et méristiques sont fournies. La présence du parasite microsporidie *Spraguea lophii* a également été observée.

Keywords: Blindness ● Morphological abnormalities ● Teratologies ● Anglerfish ● NW Mediterranean Sea ● *Spraguea lophii*

Introduction

The genus *Lophius* is represented in the Mediterranean Sea by two species: the black anglerfish *Lophius budegassa* Spinola, 1807, and the white anglerfish *Lophius piscatorius* Linnaeus, 1758. Both species are very similar, being distinguished by the colour of the peritoneum and by the number of rays in the second dorsal fin: *L. budegassa*, black peritoneum and 9-10 rays, *L. piscatorius*, white peritoneum and 11-12 rays (Caruso, 1986).

L. budegassa is a demersal fish living in sandy, muddy and rocky bottoms that has an important role in the fisheries economy of the NW Mediterranean Sea. According to official data, total landings of Mediterranean lophiids in this area have increased over the past 10 years reaching 5,450 t, with a value of 37 million of Euros (Unpublished data from the Directorate of Fishing and Maritime Affaires, Government of Catalonia). *L. budegassa* is distributed in the Mediterranean Sea as well as in the eastern North

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Atlantic from British Isles to Senegal at depths up to 800 m (Carlucci et al., 2009) and cohabits on the continental shelf with *L. piscatorius*. Despite the overlapping distribution of both species Colmenero et al. (2010) concluded that no ecological competition exists between them due to a temporal segregation in their daily biorhythms.

The presence of specimens showing morphological anomalies has already been reported in the literature; blindness, body pigmentation and albinism for the North Atlantic (Cendrero & de Cárdenas, 1979; Fariña & Fernández, 1981; Alonso-Allende, 1983; Bucke et al., 1994; Pereda & Gancedo, 1994; Landa et al., 1998 & 2007; Bañón & Armesto, 2004) and body pigmentation anomalies for the Mediterranean Sea (Allué & Sánchez, 1986; Ragonese & Giusto, 2006; Arculeo et al., 2010). However, a blind anglerfish has never been described in the Mediterranean Sea.

This study reports the occurrence of the first blind *L. budegassa* in the Mediterranean Sea.

Materials and Methods

During the scientific survey "COMSOM" conducted in June 2009 along the Mediterranean Sea a *L. budegassa* with no anatomical eye (absence of eyeball) was captured with an experimental 2 m beam trawl named "rastell" (de Juan et al., 2007) in the NW Mediterranean Sea (Fig. 1) in the fishing grounds off Cap de Creus (42.24873ºN-3.29568'E, 42.26257'N-3.30403'E) at 90 m depth on sandy-mud bottoms.

The specimen was exhaustively studied, biometric measurements were taken using a calliper to the nearest 0.01 mm and meristic data were obtained and compared with previous works (Alonso-Allende, 1983; Landa et al., 1998) in order to discover more abnormalities. It was also dissected, gonads removed, sex determined and maturity assigned according to the 5 maturity phases described in Colmenero et al. (2013).

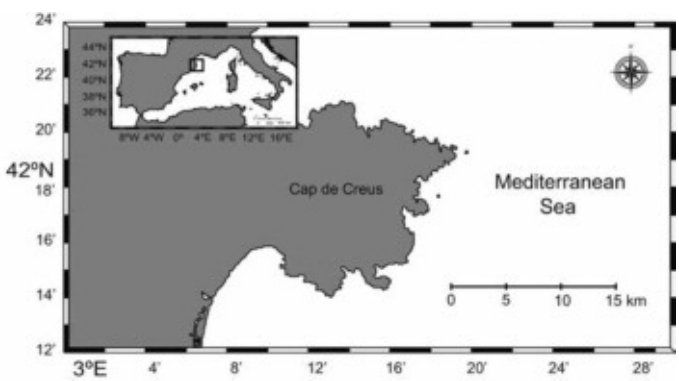

Figure 1. Map of the collection site

The specimen was donated to the Biological Reference Collections of the Institute of Marine Sciences in Barcelona and it can be found under the catalogue number ICMP000005.

Results

The blind specimen of *L. budegassa* was completely absent of external eye ball (Fig. 2A & B). However, a rudimentary and deformed sclera with degenerate retinal tissue was found under the dermis (Fig. 2C). A reduced optic nerve was also observed (Fig. 2D). Its first dorsal fin presented only 5 external rays instead of 6; although the 6th one was found under the epidermis. Three of the remaining rays had part of them below the skin making the 1st dorsal fin not completely mobile. Its body coloration was dark-brown and the peritoneum was black as normal in *L. budegassa*. The individual was a male in immature condition (Phase I). The presence of the microsporidian parasite *Spraguea lophii* (Doflein, 1898) Vávra & Sprague, 1976 was observed in this specimen. *S. lophii* is a well-known parasite of the genus *Lophius* that infects its peripheral nervous system and shows one of the most striking host cell manipulations, converting host nervous tissue into spore-filled formations termed xenomas (Weissenberg, 1976; Campbell et al., 2013). Once the parasite enters to the host by direct ingestion of the spores (Stentiford et al., 2013) or by vertical transmission of the host to its offspring (Galbreath et al., 2004), injects the germplasm contained in the spore into the host cell. In some cases, mature spores are found in eggs although the sporoplasms infecting germinal cells usually postpone their development to the beginning of embryogenesis (Phelps & Goodwin, 2008). As the spores and cyst structures (xenomas) found in the studied *L. budegassa* were located in the vagal nerves near to the kidneys, along the length of the vertebral column, on the trigeminal nerve (Fig. 2D) and on the medulla oblongata of the brain, probably transmission of the parasite took place vertically and the infection could affect its eye development during embryogenesis. Measurements and meristic counts are presented in table 1.

Discussion

Blindness in *Lophius* species has been always described in albino individuals or with pale body coloration (Alonso-Allende, 1983; Bucke et al., 1994; Landa et al., 1998). In the literature both anomalies have been linked together; however, the blind anglerfish described in this study had dark-brown body colouration; similar to other *Lophius* species, and therefore this connection between these anomalies

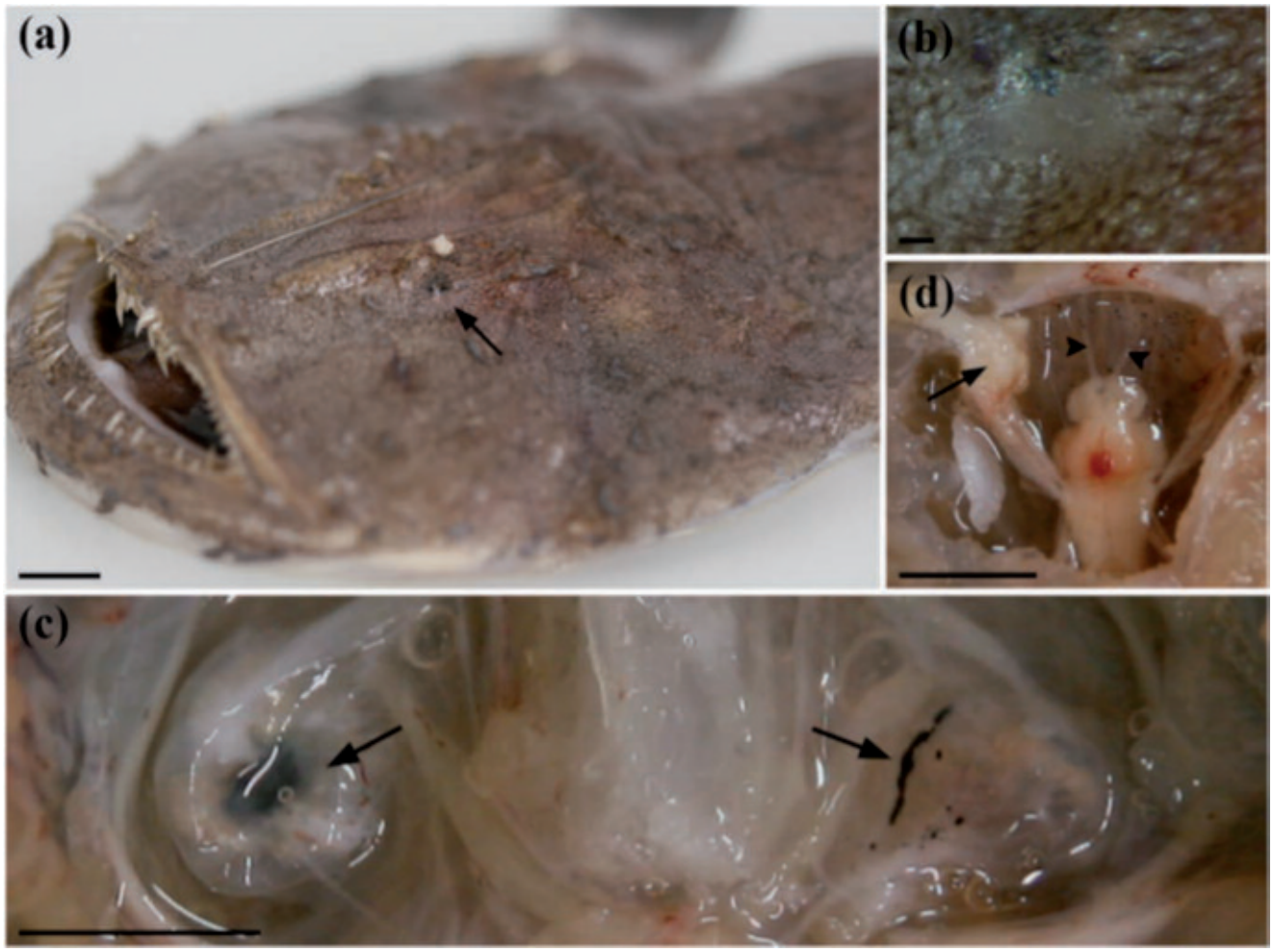

Figure 2. Blind specimen of *Lophius budegassa*. **A.** General view revealing the absence of eye (arrow) (scale bar = 1 cm). **B.** Close-up of the ocular region showing a depigmented area with no anatomical eye (scale bar = 1 mm). **C.** Ventral view revealing microsporidian xenomas in the trigeminal nerve (arrow) and a reduced optic nerve (arrowheads) (scale bar = 1 cm). **D.** Deformed sclera and degenerate retinal tissue (arrows) (scale bar = 1 cm).

does not exist in our specimen. The abnormality found in our individual show a different pattern of the ones described until now and it was the presence of a reduced optic nerve which could be related with the no eye development.

Besides the absence of the external part of the 6th ray of the first dorsal fin, the specimen studied had all the characters associated with the species (Wheeler et al., 1974). This aberration was previously described by Landa et al. (1998) who suggested the possibility to be associated with albinism and/or blindness.

Despite the lack of anatomical eye, the studied *L. budegassa* reached a considerable size and age; almost 2 years (García-Rodríguez et al., 2005). This could be explained for the presence of the sensory units of the lateral system freely exposed to the environment as papillae which allow them detect and localize preys and predators (Marshall, 1971).

The causes of blindness in *Lophius* species are currently unknown. Alonso-Allende (1983) consider the possibility of a genetic alteration during the embryonic development of the eye as some cave-dwelling species which had a normal eye development during the early stages although afterwards turn into a rudimentary eye located under the dermis (Peters & Peters, 1973). Parasitism was taking into consideration as another cause of blindness. Bucke et al. (1994) studied several specimens of blind *L. budegassa* in the Celtic Sea and did not found any relationship between this anomaly and genetic alterations or pollution effects; however, the microsporidian parasite *S. lophii* was also found affecting their nervous system and concluded that severe infections could be associated with anatomical anomalies such as eye deformities. The most frequently way for microsporidia to infect the host is horizontally by

Table 1. *Lophius budegassa.* Biometric measurements and meristic counts of this atypical specimen.

Weights	**g**
Gutted weight	130
Gonad weight	0.65
Liver weight	1.55
Biometrics	**mm**
Total length	233
Standard length	188
Body depth	74.44
Head length	72.40
Head depth	87.28
Preorbital length	42.87
Postorbital length	46.96
Interorbital space	26.30
Horizontal depigmented area (ocular region)	4.09
Vertical depigmented area (ocular region)	1.59
Predorsal length	21.71
First dorsal fin base length	62.68
1st dorsal fin 1st ray length (*illicium*)	41.07
1st dorsal fin 2nd ray length	32.11
1st dorsal fin 3d ray length	14.94
1st dorsal fin 4d ray length	11.33
1st dorsal fin 5d ray length	5.74
1st dorsal fin 6d ray length	-
Interdorsal space	29.54
Second dorsal fin base length	52.53
2nd dorsal fin 1st ray length	16.70
Prepectoral length	80.72
Pectoral fin length	34.47
Prepelvic length	48.42
Pelvic fin length	26.45
Preanal length	126.29
Anal fin base length	44.55
Caudal fin length	42.70
Meristic counts	
First dorsal fin rays	V
Second dorsal fin rays	IX
Caudal fin rays	VIII
Pelvic fin rays	V
Pectoral fin rays	XXIII
Anal fin rays	IX

spores that are acquired from the environment. Alternatively, infection occurs vertically by transovarial transmission when sporoplasms are injected into germinal cells of the gonads inside the parental organism (Vávra & Lukes, 2013). The infection of our blind specimen of *L. budegassa* probably took place vertically through its parents. Most likely, during embryogenesis sporoplams attached to neurofibrils in the epithelial or muscular layer or in the connective tissue which were assembled into a nerve fibre from where microsporidia might migrate in the direction of the central nervous system and reached its ganglion cells where a colony (xenomas) became established (Weissenberg, 1976). Since the eye and the retina is an extension of the central nervous system, which is attached to the brain via the optic nerve (Fritzsch, 1991), the presence of the parasite *S. lophii* could affect its development.

Although infections of *S. lophii* are not usually pathogenic (Freeman et al., 2011) and they have been described in not deformed specimens (Maillo et al., 1998; Cañas et al., 2010; Mansour et al., 2013), physiological weakening of the host's immune defences may lead to explosive colonisation of the host by the parasite with pathogenicity consequences (Vávra & Lukes, 2013).

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