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ORIGINAL SCIENTIFIC PAPER

Occurrence of two rare species from order *Lampriformes*: Crestfish *Lophotus lacepede* (Giorna, 1809) and scalloped ribbonfish *Zu cristatus* (Bonelli, 1819) in the northern coast of Sicily, Italy

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The bony fish Lophotus lacepede *(Giorna, 1809) and* Zu cristatus *(Bonelli, 1819) are the two species rarely recorded within the Mediterranean basin, usually reported as accidentally captured in depth (mesopelagic) fishing operations. In the current work, we present the first record of* L. lacepede *and* Z. cristatus *in fishing catches from southwestern Tyrrhenian Sea. Moreover, in order to improve existent biological/ecological knowledge, some bio-related aspects such as feeding aspect, sexual maturity and age estimate have been discussed.*

Key words: crestfish, scalloped ribbonfish, meristic features, vertebrae, growth ring

INTRODUCTION

The target species of this study (*Lophotus lacepede* and *Zu cristatus*) belong to Lophotidae (Bonaparte, 1845) and Trachipteridae (Swainson, 1839) families respectively, including the Lampriformes order (consisted of 7 families).

L. lacepede (largely referred to as crestfish) is a pan-oceanic species, which can reach up to 200 cm as maximum total length (TL). Despite its wide distribution, it is rare to find and its catches appear to be widely separated from each other by either space or time (GASTON, 1994). Being the only Mediterranean representative species of Lophotidae family, the *L. lacepede* inhabits the epipelagic zone, although it could also be recorded in most oceans from the surface up to 1000 m depth (HEEMSTRA, 1986; PALMER, 1986; OLNEY, 1999). First record of this species in the Mediterranean Basin was from the Southern Adriatic Sea (KOLOMBATOVIĆ, 1890) and afterwards it was observed in other places, ranging from the Aegean Sea to the Spanish coast (MINOS *et al.,* 2015), as well as, off the coast of Algeria (BACHOUCHE *et al.,* 2016). Essentially, this species derives its name from the occipital adipose crest situated on top of the head holding up vertically to the first ray of dorsal fins

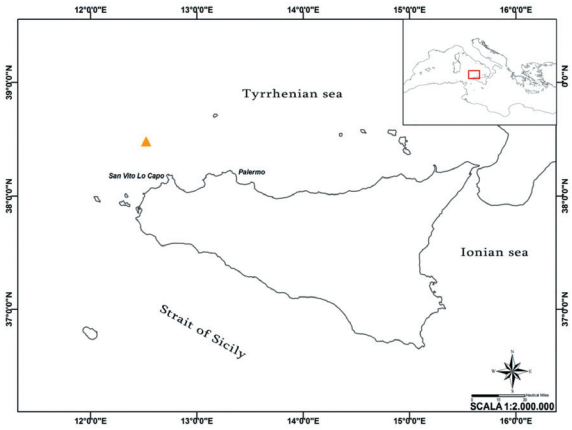

Fig. 1. Map of southwestern Tyrrhenian Sea location (full orange triangle) sampling of L. lacepede *and* Z.cristatus

(JARDAS, 1996). Besides, juveniles of this species feed on plankton while adults feed on either fish and/or squids (REY, 1983; MINOS *et al.,* 2015).

On the other hand, Trachipteridae family includes three genera *Desmodema* (Walters & Fitch, 1960) *Trachipterus* (Goüan, 1770) and *Zu* (Walters & Fitch, 1960). *Z. cristatus* (also called scalloped ribbonfish), well-known due to its particular face-up swimming (BIANCHI *et al.,* 1999), seems to be the only Mediterranean species from its genus. Furthermore, it is a cosmopolitan species, since it occupies ocean waters from tropical to temperate latitudes (FROESE & PAULY, 2005). Regarding the bathymetric distribution, it might be considered as mesopelagic, given its existence in wider depths of up to 800 m. Mostly, scalloped ribbonfish adults tend to feed on small fish and cephalopods (PALMER, 1986). In the Mediterranean basin, records of *Z. cristatus* are relatively rare (BIANCO *et al.,* 2006) and its capture has long been seen to mostly concur with the principal spawning period within its seasonal life cycle (SPARTA, 1956). In particular, the occurrence of *Z. cristatus* has been reported in the Adriatic and Ligurian Sea, central and south-eastern Tyrrhenian Sea, off the coasts of Spain and Algeria and in the Gulf of Tunis (north of Tunisia) (FISCHER, *et al*., 1987; PAPACOSTANTINOU, 1988; QUIGNARD & TOMASINI, 2000; GOLANI *et al.,* 2006; ZENETOS *et al.,* 2015).

In the current work, an unexpected catch of *L. lacepede* and *Z. cristatus* species at southwestern Tyrrhenian Sea has been described, together with some aspects of the species biology such as feeding, sexual maturity and age estimation.

MATERIAL AND METHODS

During the summer 2015 season, two fish specimens from order Lampriformes, (*L. lacepede* and *Z. cristatus*) were caught using a long line drifting 20 miles off San Vito Lo Capo, Sicily (38°29'00''N, 12° 31' 24''E). Afterwards, samples were transported to the IAMC-CNR laboratory in Mazara del Vallo where individuals were examined and biometric and meristic data were collected. Biometrics included various lengths, widths and weights of different fish body parts. Meristic data was referred to numerical counts of various fins, vertebrae, teeth and gill rakers. All measurements were performed by visual inspection using available expertize. Collected data was expressed in terms of millimeter (mm) and subsequently as percentage (%) of standard length (SL) while all weights were measured with an accuracy of 0.1 g.

The use of photographs was employed to supplement all observed data. This was performed prior to and after dissections, which were intended to establish features such as age estimations, sex of fish, contents of the stomach, as well as internal organs. For instance, to estimate the age, two independent experts identified and counted the accretion bands (annual growth rings that allow for age estimation) by means of hard structures. To further support age estimation, the second vertebra has been used at both species adding the first dorsal ray (*L. lacepede*) and otolith (*Z. cristatus*). To define the sexual maturity (SM), the MEDITS (International Bottom Trawl Survey in the Mediterranean) approach has been employed by way of visual inspection of gonads. In particular, sexual maturity has been classified as follows: Stage 0 - undetermined; Stage 1 - immature; Stage 2a - virgin-developing; Stage 2b - recovering; Stage 2c - maturing; Stage 3 - mature/spawner; Stage 4a - spent; as well as Stage 4b - resting (BERTRAND *et al.*, 2007). All measurements were performed using preserved specimens.

In order to perform robust comparisons of our current data, we used comparable data records of these species already reported in other Mediterranean areas such as the Strait of Sicily (RAGONESE *et al.,* 1997), Adriatic Sea (ŠPREM *et al.,* 2014; DULČIĆ, 2002) and marine waters of Algeria (BACHOUCHE *et al.,* 2016) for *L. lacepede*, while the Ligurian Sea (TORTONESE, 1958; PSOMADAKIS *et al.,* 2007) and the Iberian Sea (ROIG DEMESTRE, 1982) for *Z. cristatus*.

RESULTS AND DISCUSSION

The biometric data obtained during the study were similar to those previously reported by other authors (Table 1) (BACHOUCHE *et al.,* 2016; TORTONESE, 1958; RAGONESE *et al.,* 1997; ŠPREM *et al.,* 2014; PSOMADAKIS *et al.,* 2007; ROIG & DEMESTRE, 1982).

Regarding *L. lacepede*, only the operculum height resulted higher compared to the data reported by RAGONESE *et al.* (1997), 74.8% and 62.8% of the SL respectively. Concerning *Z. cristatus*, just the dorsal fin maximum height was higher in comparison to the data recorded by PSOMADAKIS *et al.* (2007), 12.5 % and 6.6% of the SL respectively. To our best knowledge, in the Mediterranean Sea, information regarding the operculum thickness, gonad length, as well as weights of stomach content/empty, intestine, and gonad, ink gland/duct of *L. lacepede* was not available in the literature. Similarly, specific data on weights of stomach content/empty, liver and gonad, as well as other measurements such as operculum thickness/heights, dorsal fin (maximum length), base pectoral fin (width), gonad length, number of vertebra, and teeth (lower/

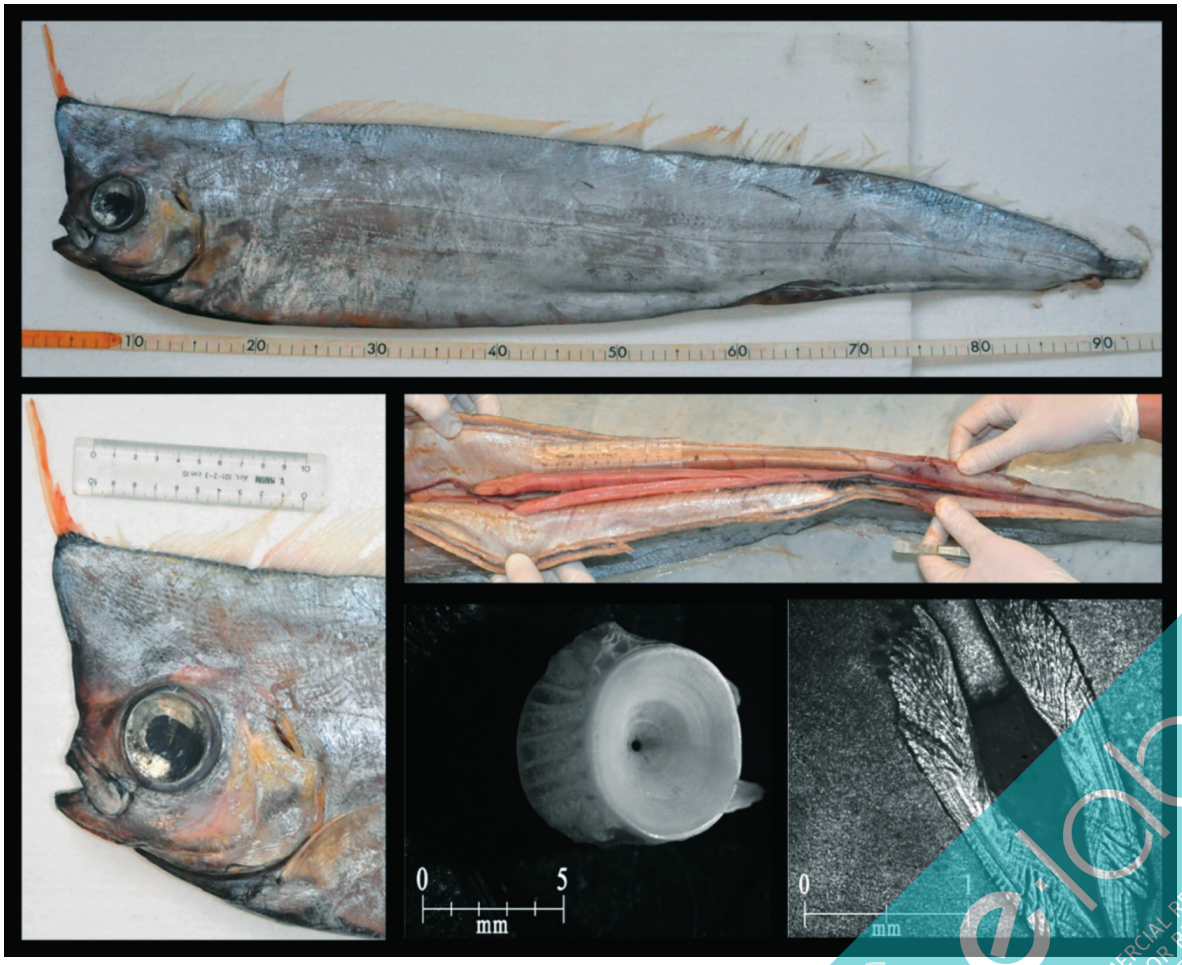

Fig. 2. Images of the whole, head, gonad, one vertebra specimen and transverse section of first fin dorsalray for L. lacepede

Table 1 (a, b). Biometric and meristic measurements of sampled individuals compared to extant literature of L. lacepede *and* Z. cristatus

	Lophotus lacepede					*Zu cristatus*				
a) BIOMETRIC	Present note		Strait of Sicily[1]	Croatian coast[2]	Algerianccoast[3]	Present note		Ligurian sea[4]	Ligurian sea[5]	Iberian sea[6]
	(mm)		**(mm)**	**(mm)**	**(mm)**	**(mm)**		**(mm)**	**(mm)**	**(mm)**
Total length (TL)	915.0		1470	1390	132	876.0		1219.0	1105.0	1115.0
		% TL	**% TL**	**% TL**	**% TL**		**% TL**	**% TL**	**% TL**	**% TL**
Standard length (SL)	893.0	97.6	97.5	96.8	97.0	733.0	83.7	90.6	88.7	89.7
		% SL	**% SL**	**% SL**	**% SL**		**% SL**	**% SL**	**% SL**	**% SL**
Head length	119.8	13.4	15.6	13.4	13.0	128.0	17.5	17.3	16.3	16.5
Preorbital length	31.8	3.6	3.2		4.4	39.6	5.4	5.6	5.6	5.0
Postorbital length	46.5	5.2	6.1		5.2					
Longitudinal eye diameter	39.4	4.4	3.8	4.1	4.5	47.8	6.5	6.2	5.8	
Length upper jaw	39.2	4.4	4.3			53.7	7.3			
Lower jaw length						75.3	10.3	9.2		
Crest-anus projection length	834.0	93.4	93.7	93.7						
Anus-caudal peduncle length	59.3	6.6	6.4							
Eye-crest length	89.3	10.0	9.0							
Maximum height of the body	166.0	18.6	17.3	17.1	16.8					
Operculum height	161.2	18.1	17.1			146.2	19.9			
Operculum thick	43.2	4.8				36.8	5.0			
Dorsal fin max heigth						91.3	12.5	6.6	7.1	
Pectoral fin length	57.0	6.4	5.9	5.9		47.7	6.5	6.1	6.6	7.0
Base pectoral fin width	15.4	1.7	1.5			10.0	1.4			
Base anal fin width	19.7	2.2	2.0	2.2						
Caudal fin length						130.2	17.3	10.3	12.8	11.5
Gonad length	613.0	68.6				145.6	19.9			
Ink gland length	668.0	74.8	62.8							
	(g)		**(g)**			**(g)**		**(g)**	**(g)**	**(g)**
Total weight (TW)	2426.0		9800 g			1301.0		4400	2800	2160
		% TW	**% TW**				**% TW**			
Stomach contents weight	22.0					16.4	1.3			
Empty stomach	31.4	1.3				32.4	2.5			
Intestine weight	10.7	0.4								
Liver weight	29.0	1.2	2.0			7.7	0.6			
Gonad weight	42.2	1.7				3.1	0.2			
Ink gland weight	38.4	1.6								
Ink duct weight	15.6	0.6								

b) MERISTIC (COUNTS)	*Lophotus lacepede*			*Zu cristatus*			
	Present note	Strait of Sicily[1]	Algerianccoast[3]	Present note	Ligurian sea[4]	Ligurian sea[5]	Iberian sea[6]
Number rays dorsal fin	236	248	228	126	130	125	117
Number rays pectoral fin	17	16	15	11	11	10	11
Number rays anal fin	17	20	20				
Number rays caudal fin		18	19	9	9	9+1	9+4
Number vertebrae	136	140		62			
Gill rakers ***				3+8	3+8	2+9	10
Teeth upper jaw				18	21		
Teeth lower jaw				12	10		
Palatin teeth				4	4		
Vomerin teeth				3	4		

[1] Literature from RAGONESE *et al..,* 1997; [2] Literature from ŠPREM *et al.,* 2014; [3] Literature from BACHOUCHE *et al.,* 2016; [4] Literature from PSOMADAKIS *et al..,* 2007; [5] Literature from TORTONESE 1958; [6] Literature from ROIG & DEMESTRE 1982.

% SL was referred as a percentage of the standard length; **% TL** was referred as a percentage of the total length; **% TW** was referred as a percentage of the total weight

*** The first number was referred to the epibranchial and the second number to ceratobranchial (first left gill arch)

upper jaw/palate/vomer) of *Z. cristatus* have not been earlier reported.

In addition, a thorough visual inspection of samples' anato-morphological features was conducted. Images of the whole, head, gonad, one vertebra specimen and a transverse section of first fin dorsal ray for *L. lacepede* are depicted in Fig. 2. Also, different pictures of the whole, head, gonad, one vertebra specimen and transverse section of otolith for *Z. cristatus* are included in Fig. 3.

The diagnostic identification, based on visual observations, showed that *L. lacepede* sample was a female whereas *Z. cristatus* was a male. Thereafter, both specimens were dissected to allow for further analyses. For *L. lacepede*, the gonad length and weight were ≈ 613 mm and 42 g, respectively. The ovaries seemed "Y" shaped and were well developed at maturity stage 3 (gonads occupied more than two-thirds of the abdominal cavity), indicating that it was a mature female. The calculated Gonadosomatic Index (GSI), which represents gonad as the proportion to fish body mass widely believed to express the fish maturity associative of development of ovary/testes, has been estimated at 1.77. For *Z. cristatus*, the testicles length and weight were ≈ 146 mm and 3 g respectively, which seemed well developed at maturity stage 3. However, the GSI was 0.24 that it is a low value if compared to the recognized maturity stage. This information on gonads (ovaries/testes) and the period of capture, may offer some insights about the reproduction of inspected samples. In the present study, in agreement with previous literature, the spawning period of *L. lacepede* seemed related to the summer season (MINOS *et al.,* 2015; SANZO 1940; SPARTÀ 1954). However, DULČIĆ & SOLDO (2008), found a mature spawner male during the winter period. Regarding *Z. cristatus*, previous studies reported that the spawning period of this species usually takes place between spring and summer seasons (DULČIĆ, 2002; PSOMADAKIS *et al.,* 2007, BRADAI & OUAER, 2012); nevertheless, *Z. cristatus* eggs have been collected during summer–fall period at Middle Atlantic Bight (OLNEY, J.E. & A. NAPLIN 1980). Notably, DULČIĆ (2002) reported that the preferred spawning ground of *Z. cristatus* was related to low salinity environments. However, the current study may suggest that these species would tolerate wider salinity ranges since

Fig. 3. Images of the whole, head, gonad, one vertebra specimen and transverse section of otolith for Z. cristatus

examined specimens were collected at open sea (38‰). At the light of this, additional information would be necessary to better understand the factors influencing the spawning period of these species.

To estimate the age of *L. lacepede*, seven accretion rings were counted from both vertebrae and dorsal ray sections, while for *Z. cristatus*, eleven accretion rings were counted from otolith transverse section and vertebrae. Whilst accretion rings fundamentally accord with the age of fish (PANFILI *et al.,* 2002; PRINCE & PULOS, 1983) and although observations herein have been performed based on one specimen, this age estimation together with the maturity stage further indicates that the studied samples corresponded with adult individuals. Heretofore, this should represent the first attempt to estimate the age of these species within the Mediterranean basin.

The total stomach contents of *L. lacepede* were also analyzed. We found (a) five specimens of *Scaeurgus unicirrhus* (Delle Chiaje [in Férussac & d'Orbigny], 1841) (b) one specimen of *Sepietta oweniana* d'Orbigny, 1841(c) thirteen cephalopods since twenty-five mandibles were counted, (d) remains of Portunidae paws and (e) remains of skeleton and scales fish. It thereafter allowed for a classification, namely: 93.3% of Cephalopoda class (a, b, c respectively), 1.4% of Malacostraca class (d) and 5.3% of Osteichthyes class (e). Possibly, *L. lacepede* diet has been mainly based on cephalopods followed by bony fish and crustaceans somewhat in agreement with MINOS *et al.* (2015). The stomach of *Z. cristatus* contained only the head of Scombridae fish, which probably was used as the bait of long-line fishery.

CONCLUSIONS

To the best of our knowledge, this is the first report about *L. lacepede* and *Z. cristatus* species unexpectedly caught off the southwestern Tyrrhenian Sea. Previous authors such as TORTONESE (1958) described these species as rarely captured probably because of reduced fishing activity that took place at mesopelagic habitats at those times. The present study contributes to improving the extant biological knowledge, such as the feeding aspect, sexual maturity and age estimation of these species in the Mediterranean basin. Finally, we would like to point out that further investigation should be conducted to better understand the biology and life cycle of these rare species.

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Pojava dviju rijetkih vrsta iz reda *Lampriformes*: britke jedroglavke *Lophotus lacepede* (Giorna, 1809) i vlasuljke *Zu cristatus* (Bonelli, 1819) kod sjeverne obale Sicilije, Italija

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SAŽETAK

Koštunjičave ribe *Lophotus lacepede* (Giorna, 1809) i *Zu cristatus* (Bonelli, 1819) dvije su vrste koje se rijetko nalaze u Sredozemnom moru i najčešće su zabilježene kao slučajni ulov pri ribolovu dubinskim alatima (mezopelagijal). U ovom radu predstavljamo prvi zapis britke jedroglavke i vlasuljke koje su uhvaćene tijekom ribolova u jugozapadnom dijelu Tirenskog mora. Štoviše, kako bi se poboljšalo postojeće znanje o biologiji i ekologiji, u radu se raspravlja o nekim biološkim određenim aspektima kao što su prehrana, spolna zrelost i procjena starosti.

Ključne riječi: jedroglavka, vlasuljka, meristička obilježja, kralješci, naraštajni prstenovi