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REVIEWING THE INVASION HISTORY OF THE BLUE CRAB *CALLINECTES SAPIDUS* (PORTUNIDAE) IN SICILY (CENTRAL MEDITERRANEAN): AN UNDERESTIMATED ALIEN SPECIES

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ABSTRACT

The alien blue crab Callinectes sapidus*, a species native to the western Atlantic coasts, has long invaded the Mediterranean, including the Italian seas. It is listed among the 100 worst invasive alien species in the Mediterranean and is presumed to exert an impact on biodiversity and fishing activities. To date, a small number of individuals of this species has been reported from Sicily. This note updates the status of the species in Sicilian seas by means of an analysis of records from various sources, and adds further records. The analysis shows that the distribution of the species in Sicily has so far been underestimated both in terms of abundance and frequency of occurrence.*

Key words: citizen science, non-indigenous, Decapoda, Brachyura, waterways, lagoons

RILEGGERE LA STORIA DELL'INVASIONE DEL GRANCHIO BLU *CALLINECTES SAPIDUS* (PORTUNIDAE) IN SICILIA (MEDITERRANEO CENTRALE): UNA SPECIE ALIENA SOTTOSTIMATA

SINTESI

Il granchio blu alieno Callinectes sapidus*, una specie originaria delle coste dell'Atlantico occidentale, ha invaso da tempo il Mediterraneo, compresi i mari italiani. È elencata tra le 100 peggiori specie esotiche invasive del Mediterraneo e si presume abbia un impatto sulla biodiversità e sulle attività di pesca. Ad oggi, solo di pochi individui è stata documentata la presenza in Sicilia. Questa nota aggiorna lo stato della specie nei mari siciliani mediante un'analisi delle segnalazioni provenienti da varie fonti e aggiunge ulteriori ritrovamenti. L'analisi mostra che la distribuzione delle specie in Sicilia è stata finora sottostimata sia in termini di abbondanza che di frequenza di ritrovamento.*

Parole chiave: scienza dei cittadini, specie non indigene, decapodi, brachiuri, corsi d'acqua, lagune

INTRODUCTION

The blue crab *Callinectes sapidus* Rathbun, 1896 is a shelf-estuarine species native to the western Atlantic coasts, ranging from Nova Scotia in Canada down to northern Argentina, including Bermuda and the Antilles (Williams, 1974). This species started invading the European Atlantic coasts in 1900 (Nehring, 2011 and literature therein) and was probably introduced in the Mediterranean Sea through maritime traffic. Although mistaken in the past for the Lessepsian crab *Portunus segnis* (Forskål, 1775), its first occurrence in the Mediterranean can safely be dated to 1949, when a specimen, currently preserved in the zoological collection of the Museum of Natural History of Venice, was caught in the northern Adriatic Sea (Mizzan, 1993; Castriota *et al.*, 2012). Currently, this species has spread to many areas of the Mediterranean Sea, probably owing to its tolerance to environmental changes, high fecundity, strong swimming ability, and pugnacious nature (Williams, 1974). Included among the 100 worst invasive alien species in the Mediterranean Sea (Streftaris & Zenetos, 2006), it is presumed to exert an impact on benthic communities at multiple trophic levels and to have considerable negative effects on fishing activities; on the other hand, this alien species is already a high--value resource in some fisheries of the eastern Mediterranean (Mancinelli *et al.*, 2017). The first occurrence of *C. sapidus* in Sicilian waters dates back to 1970 when one specimen was collected in the Strait of Messina, followed by another specimen caught in 1972 in the same area (Cavaliere & Berdar, 1975). However, these occurrences have been questioned by some authors and rather attributed to misidentification of *P. segnis* (Lipej *et al.*, 2017). Recently, Falsone *et al.* (2020) reported new records of *C. sapidus* in the Strait of Sicily and provided an updated distribution map of this species' records in the Mediterranean suggesting its successful settlement in the Strait of Sicily, despite the scarcity of valid supporting records. However, new reports originating from online sources (i.e., magazines) and those reported directly to the scientists, suggest that the distribution of this species in Sicilian seas as reported in the literature does not reflect the current situation but seems to be underestimated.

This note aims to update the distribution of *C. sapidus* in Sicilian waters through the addition of several new records in new locations, since tracing the spread of invasive species may be useful for controlling and preventing the potential adverse effects on local ecosystems.

MATERIAL AND METHODS

An analysis of both scientific and grey literature as well as that of other sources (i.e., online magazines, observations reported directly to scientists) was carried out in order to revise the invasion history of *Callinectes sapidus* in Sicilian waters and to update the knowledge on its current distribution in Sicily. Records were reported in chronological order on a map (Fig. 1). Published records that did not provide detailed photos or descriptions of specimens were considered unconfirmed. Citizen reports were collected by ISPRA (Italian Institute for Environmental Protection and Research) researchers through both personal contacts and the dedicated institutional email alien@isprambiente.it. This email address was launched in 2013 with the aim of collecting records of marine alien species in the national territory from citizens. These records were considered valid only when the reports contained details on the capture/sighting of blue crabs along with photos of the

Fig. 1: Map of Sicily indicating the distribution of *Callinectes sapidus* ***by chronological order of occurrence, with enlargement of the south-eastern area. 1, 2: Lipej*** *et al.*, ***2017; 3: Guadagnino, 2016; 4–6: Katsanevakis*** *et al.*, ***2020; 7–8: Falsone*** *et al.*, ***2020; 9: Giacobbe*** *et al.*, ***2019; 10–12: Katsanevakis*** *et al.*, ***2020; 13: Pipitone*** *et al.*, ***2020; 14: Falsone*** *et al.*, ***2020; 15: Pipitone*** *et al.*, ***2020; 16: www.oggimilazzo.it 2020; 17: present paper; 18: www.tp24.it 2020; 19: Sercia & Innocenti, 2020; 20–24: present paper. Blue points are records from literature; red points are records from other sources.***

Sl. 1: Razširjenost modre rakovice *(Callinectes sapidus)* ***na podlagi zapisov v časovnem zaporedju na zemljevidu Sicilije, z razširjenim jugovzhodnim predelom. 1, 2: Lipej*** *et al.*, ***2017; 3: Guadagnino, 2016; 4–6: Katsanevakis*** *et al.*, ***2020; 7–8: Falsone*** *et al.*, ***2020; 9: Giacobbe*** *et al.*, ***2019; 10–12: Katsanevakis*** *et al.*, ***2020; 13: Pipitone*** *et al.*, ***2020; 14: Falsone*** *et al.*, ***2020; 15: Pipitone*** *et al.*, ***2020; 16: www.oggimilazzo.it 2020; 17: to delo; 18: www.tp24.it 2020; 19: Sercia & Innocenti, 2020; 20–24: to delo. Modre točke so podatki iz literature, rdeči pa podatki iz drugih virov.***

Tab. 1: Records of** Callinectes sapidus **collected from online sources and citizen reports.
Tab. 1: Podatki o vrsti** Callinectes sapidus**, zbrani iz spletnih virov in virov, povezanih z ljubiteljsko znanostjo.

Record number (Fig. 1)	Observation date	Location	Coordinates (DD)	Substratum	Depth	Sex	Number of specimens
16	24/02/2020	Milazzo	38.2384°N 15.2397°E	sand-gravel bottom	0-10 m	male	1
17	31/03/2020	Porto Empedocle	37.231006°N 13.622655°E	rocky bottom with sand	4 m	immature female	1
18	01/06/2020	Stagnone di Marsala	37.8572°N 12.4595°E	sand with seagrass	0-2 m	-	many
20	22/08/2020	Sampieri	36.720000°N 14.737306°E	sand with rocks	10-15 cm	-	1
21	20/09/2020	Oasi del Simeto	37.387223°N 15.082757°E	-	-	-	5
22	18/10/2020	Sampieri quagmire	36.719778°N 14.750889°E	-	0-10 cm	-	1
23	19/10/2020	Marina di Modica quagmire	36.709833°N 14.782472°E	-	-	-	3
24	17/12/2020	Sciacca	37.517078°N 12.986948°E	sandy bottom	7-8 m	-	1

specimens that allowed the identification of the species. Records from online magazines were validated through analyses of the photo/video documentation referring to the reports and directly provided by the Authors/Editors. The specimens recorded were identified to species level on the base of the presence of two large and obtuse teeth on the frontal margin, which distinguish *C. sapidus* from *P. segnis*, another exotic crab reported in the Mediterranean (Williams, 1974; Mizzan, 1993; Lai *et al*., 2010), which also occurs in Sicily either reported as *P. pelagicus* or misidentified as *C. sapidus* (Ariani & Serra, 1969). *P. segnis* also bears a prominent spine on the internal margin of the cheliped carpus (Lai *et al*., 2010), which is missing in *C. sapidus*. In addition, *P. segnis* exhibits many pale white spots on the carapace surface, particularly posteriorly and anterolaterally (Lai *et al*., 2010), which are absent in *C. sapidus*.

In some cases, it was also possible to determine the sex and maturity stage through an analysis of abdomen morphology according to Williams (1974). The approximate size of the individuals was also recorded, estimated by the person who reported them.

RESULTS

Literature analysis yielded 16 valid records of at least 50 individuals of *Callinectes sapidus* from 12 Sicilian localities (Lipej *et al*., 2017; Giacobbe *et al*., 2019; Falsone *et al*., 2020; Katsanevakis *et al*., 2020; Pipitone *et al*., 2020; Sercia & Innocenti, 2020), plus 3 unconfirmed records from 2 localities (Cavaliere & Berdar, 1975; Franceschini *et al*., 1993). Additionally, eighth records in as many locations were extracted from other sources (Tab. 1). Three of these records were retrieved through online magazines and consist of: i) one specimen spotted in November 2016 in the southwestern Sicilian coast (Guadagnino, 2016), subsequently also reported in the literature (Katsanevakis *et al*., 2020), ii) one specimen recorded in February 2020 in the northeastern coast (www.oggimilazzo.it, 2020), and iii) dozens of individuals reported in June 2020 in the Stagnone di Marsala Lagoon (west coast) (www.tp24.it, 2020).

Two records were personally reported to ISPRA researchers by two professional fishermen. The first fisherman reported the capture of one specimen (Fig. 2) caught on 31 March 2020, by trammel net targeting cuttlefish *Sepia officinalis*, on a mixed rocky-sandy bottom at 4 m depth, 300 m far from the mouth of the Naro River in the southwestern coast of Sicily (Porto Empedocle). Upon photographing the specimen, the fisherman released it alive back into the sea. It was an immature female, as shown by the triangular poorly expanded abdomen (Williams, 1974), and measured about 12 cm in carapace width. At the moment of capture it exhibited the following colours: brownish green dorsally with whitish scattered dots anteriorly, white ventrally, chelipeds orange with blue anterior sides, merus of chelipeds bearing three white spines with dark brown extremities, legs light blue. The fisherman reported damages to the net the meshes of which were cut by the crab's claws.

The second fisherman reported the capture of one specimen of about 20 cm in carapace width, caught on 17 December 2020, by trammel net on a sandy bottom at 7-8 m depth in the locality of Sciacca (southwestern coast of Sicily). This record was validated based on an analysis of a video made by the fisherman.

Additional four records were reported to ISPRA researchers by email: on 22 August 2020, an adult specimen measuring about 20 cm in width was caught by hand net on the seashore, on a sandy bottom with rocks, in the south-eastern coast of Sicily (Sampieri), and photographed; in September 2020, six specimens (Fig. 3) were poached in inland waters within the Oriented Nature Reserve Simeto Oasis in eastern Sicily, subsequently seized and photographed by the staff of the Reserve; on 18 October 2020, an individual of about 13 cm in carapace width was photographed at the depth of 10-15 cm on the bank of the Sampieri quagmire, south-eastern Sicily; on 19 October 2020, three individuals of different sizes, the largest of which measured about 20 cm in carapace width, were spotted in the marsh of Marina di Modica, south-eastern Sicily, and photographed.

DISCUSSION

The history of the invasion by *Callinectes sapidus* in Sicily begins with the record of a female of this species collected in the Strait of Messina in 1970, followed by the capture of another female in 1972 in the same area (Cavaliere & Berdar, 1975). These two specimens were later attributed to *Portunus segnis* (Lipej *et al.*, 2017), but they are to be re-examined at the University of Messina, where they are currently preserved and waiting to be inventoried (Giacobbe *et al.*, 2019). We have classified these individuals as unconfirmed until proven otherwise, as we did with the record from eastern Sicily, no longer verifiable, reported by Franceschini *et al.* (1993) in a species checklist from trawl surveys. If we exclude these unconfirmed records, the first validated record of *C. sapidus* in Sicily is the specimen caught in October 2016 outside the harbour of Licata (southern coast) on sandy-muddy bottom, followed by a further capture of two individuals in the same locality ten days later (Lipej *et al.*, 2017) (Fig. 1, nos. 1, 2). About a month later, another individual was reported on a sandy bottom of the Sicilian southwestern coast (Selinunte), at about 110 km west from the first record site (Guadagnino, 2016) (Fig. 1, n. 3). No additional records were reported until May 2018 when this species reappeared in a few localities of the southeastern Sicilian coast (Fig. 1, nos. 4, 5), on both muddy bottoms and sandy bottoms with sparse seagrass *Posidonia oceanica*; an exceptional capture of 20 individuals was reported on muddy bottoms near a river mouth on the eastern coast (Fig. 1, no. 6) (Katsanevakis *et al.*, 2020). Subsequently, the species reappeared in some locations where it had already been recorded (Falsone *et al.*, 2020; Katsanevakis *et al.*, 2020) (Fig. 1, nos. 7, 8, 10, 11) and appeared for the first time in

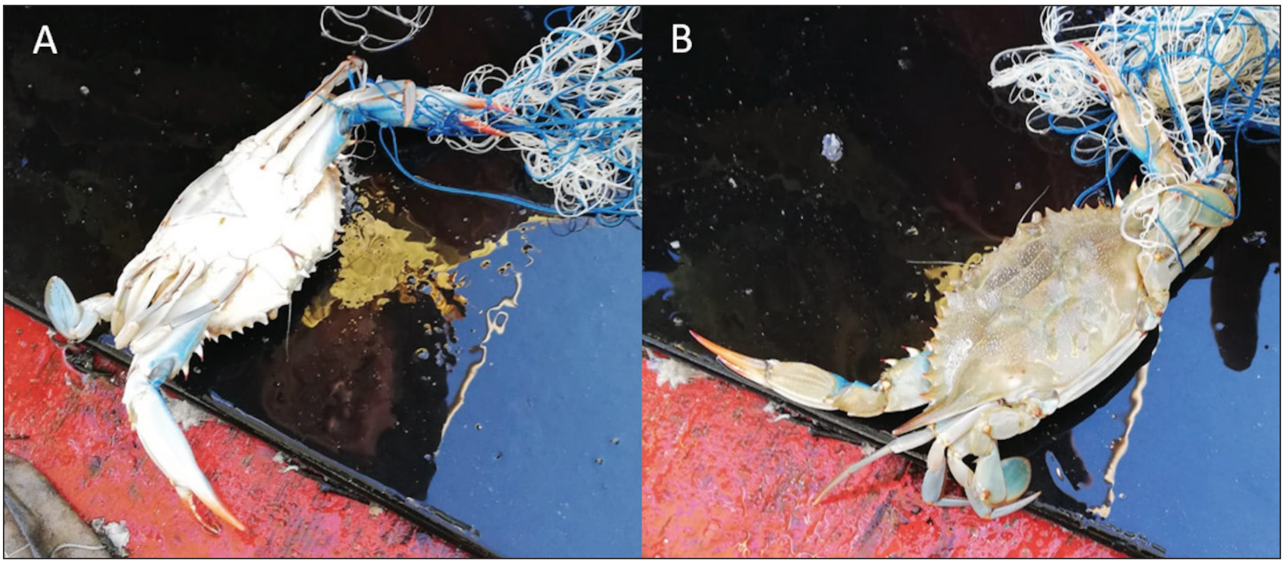

Fig. 2: Specimen of *Callinectes sapidus* ***caught at Porto Empedocle (Sicily) on 31 March 2020 (A: ventral view, B: dorsal view).***
Sl. 2: Primerek modre rakovice (*Callinectes sapidus****), ujete pri Portu Empedocle (Sicilija) 31. marca 2020 (A: trebušna stran; B: hrbtna stran).***

Fig. 3: Specimens of *Callinectes sapidus* ***poached within the Oriented Nature Reserve Simeto Oasis in September 2020.***
Sl. 3: Primerki modre rakovice (*Callinectes sapidus****), ulovljeni v Naravnem rezervatu Simeto Oasis v septembru 2020.***

new Sicilian areas such as the northeastern (Giacobbe *et al*., 2019) (Fig. 1, n. 9) and northwestern coasts (Katsanevakis *et al*., 2020; Pipitone *et al*., 2020) (Fig. 1, nos. 12, 13). Additional records were reported in 2020, some of them in already mentioned sites (Falsone *et al*., 2020; Pipitone *et al*., 2020; present paper) (Fig. 1, n. 14, 15, 20-23), others from new Sicilian areas (Sercia & Innocenti, 2020; present paper) (Fig. 1, nos. 16–19). The occurrence of *C. sapidus* in some of these localities was also confirmed by the results of an online questionnaire administered to recreational fishers (Cerri *et al*. 2020). From our revision, this species spread to almost the entire coast of Sicily over a period of four years (2016–2020), first colonising the southern coasts and then extending its distribution in other areas, without showing a well-traced path. Such a rapid spread could be related to the presence in Sicily of several lagoons and waterways connected to the sea where *C. sapidus* spends some phases of its life cycle. As known, *C. sapidus* specimens migrate from seawater to rivers, and vice versa, at different stages of their life cycle. In particular, after mating in estuarine brackish waters females migrate to higher salinity coastal waters to lay eggs and then tend to remain there, or rather move to close-by sea waters while males prefer to remain in low salinity areas (Van Engel, 1958; Williams, 1965). Larval stages complete their development in coastal waters and re-enter brackish habitats at the stage of post-larva up to reach the juvenile stage; both juvenile and adult stages can be found in freshwater areas as well as highly saline habitats (Hines *et al*., 2008; Mancinelli *et al*., 2013; Cilenti *et al*., 2015). According to collected data, this species in Sicilian waters predominates on soft bottoms, mainly in proximity of river mouths or inland channels, but also in coastal lagoons and near ports, in different periods of the year, and in shallow waters. The occurrence of several *C. sapidus* records in the vicinity of Sicilian brackish water bodies suggests these places to be potential areas of establishment, as observed in other Mediterranean estuaries and lagoons where established populations occurred with numerous specimens at different life stages (Beqiraj & Kashta, 2010; Dulčić *et al*., 2011; Mancinelli *et al*., 2013). For this reason, it is important to monitor estuarine and lagoon areas and consider them for management purposes in order to contain the invasion by this species and to mitigate possible impacts on biodiversity and fishing activity. *C. sapidus* would in fact interfere with fishing activities, on the one hand, by damaging the nets with its claws (Beqiraj & Kashta, 2010), on the other, by representing a valuable commercial resource for its highly appreciated meat, although in Sicily the species has not yet been introduced in local markets. The fishermen from our study confirmed the damage to the nets caused by the crab and pointed out the need to receive guidelines of good practices for the management of this species. The several records reported by fishermen stress the importance of their cooperation as sentinels for the detection of invasive species. In this process, the voluntary help offered by citizens in informing scientists about the presence of alien species should not be underestimated. The wide response on social pages dedicated to the knowledge of marine life is proof of this and could constitute in the next future a valid tool to support the monitoring of alien species.

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REVIZIJA ZGODOVINE INVAZIJE MODRE RAKOVICE *CALLINECTES SAPIDUS* (PORTUNIDAE) NA SICILIJI (OSREDNJE SREDOZEMSKO MORJE): PODCENJENA TUJERODNA VRSTA

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POVZETEK

*Tujerodna modra rakovica (*Callinectes sapidus*), ki izvira iz vzhodne atlantske obale, že dlje časa naseljuje Sredozemsko morje, vključno z italijanskimi morji. Je na seznamu stoterice najbolj nevarnih invazivnih vrst v Sredozemskem morju in domnevajo, da povzroča posledice na biodiverziteti in ribištvu. Do danes je bilo le manjše število primerkov te vrste potrjenih za Sicilijo. V tem zapisu avtorja poročata o statusu modre rakovice v morju okoli Sicilije na podlagi analize potrjenih zapisov iz raznih virov in dodajata nove primere pojavljanja. Analiza kaže, da so bili doslej podatki o razširjenosti te vrste podcenjeni tako glede abundance kot tudi frekvence pojavljanja.*

Ključne besede: ljubiteljska znanost, tujerodne vrste, Decapoda, Brachyura, vodne poti, lagune

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FIRST RECORD OF THE FLAT NEEDLEFISH, *ABLENNES HIANS* (BELONIDAE) IN CENTRAL MEDITERRANEAN WATERS (WESTERN IONIAN SEA)

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ABSTRACT

Two specimens of Ablennes hians *(Valenciennes, 1846) were collected between 2018 and 2020 in nearshore waters off the island of Malta. The first occurrence of the flat needlefish in the central Mediterranean, almost contemporary to its first record in the eastern Levantine Sea, is briefly discussed.*

Key words: Malta, *Ablennes hians*, non-indigenous fish, Mediterranean Sea

PRIMO RITROVAMENTO DI *ABLENNES HIANS* (BELONIDAE) IN MEDITERRANEO CENTRALE (MAR IONIO OCCIDENTALE)

SINTESI

Due esemplari di Ablennes hians *(Valenciennes, 1846) sono stati catturati tra il 2018 e il 2020 nelle acque costiere dell'isola di Malta. La prima segnalazione della specie nel Mediterraneo centrale, quasi contemporanea a quella documentata per il Mar di Levante orientale, è brevemente discussa.*

Parole chiave: Malta, pesci non-indigeni, Mediterraneo

INTRODUCTION

The flat needlefish *Ablennes hians* (Valenciennes, 1846) is one of the 47 species comprised in the ten genera of the family Belonidae (Froese & Pauly, 2021). It has a widespread distribution, being known from tropical and subtropical waters of the eastern and western Atlantic Ocean, as well as from eastern and western Pacific and Indian Oceans, as far as the Red Sea and the Gulf of Aqaba (Collette, 1999, 2016; Golani & Fricke, 2018; Golani, 2019; Collette & Bemis, 2019; Alshawy *et al.*, 2019). While the species is not listed among the ichthyofauna of the Gulf of Suez (Golani & Fricke, 2018), it is found among the belonids of the Suez Canal (Sabrah *et al.*, 2018). The flat needlefish is reported in by-catch communities of the pelagic ecosystem in the tropical tuna purse seine fishery of the Eastern Atlantic and Western Indian Oceans (Lezama-Ochoa *et al.*, 2015, 2018). This pelagic fish reaches over 120 cm in standard length, inhabits offshore surface waters, but also coastal waters, is often found near islands, and in estuaries; it occurs both as a solitary and schooling fish; its diet consists mainly of small fishes, such as Atherinidae; the deposited eggs may be found attached to objects in the water using filaments on their surface (Fishelson, 1975; Collette, 1986, 2016; Froese & Pauly, 2021; Golani, 2019).

In the Mediterranean, the first specimen of *A. hians* was collected in September 2018 off the coasts of Israel by trammel net at a depth of 20–30 m (Golani, 2019). A few months later, in February 2019, two specimens were caught off the coasts of Syria in a gill net (Alshawy *et al.*, 2019), and another one, in March 2019, along the coasts of Israel, by purse seine (Tadmor-Levi *et al.*, 2020). These recently documented records of *A. hians* in the Levantine Sea increase to six the number of belonid species known in the Mediterranean. The five previously known species include the native *Belone belone* (Linnaeus, 1761), *Belone svetovidovi* Collette & Parin, 1970, *Tylosurus acus acus* (Lacépède, 1803), and *Tylosurus acus imperialis* (Rafinesque, 1810), as well as the rare non-indigenous species of Indo-Pacific origin *Tylosurus choram* (Rüppell, 1837) (Froese & Pauly, 2021; Galil *et al.*, 2021). Although listed in Zenetos *et al.* (2010, 2018), the non-indigenous *Tylosurus crocodilus* (Péron & Le Sueur, 1821) is not included because the single specimen from Hellenic Aegean waters (Sinis, 2005) was probably a misidentified co-generic Mediterranean species.

This study documents the first record of *A. hians* in the coastal waters off the island of Malta and in the central Mediterranean, offering some considerations about the possible introduction pathways for this species.

MATERIAL AND METHODS

On 1 December 2020, one specimen of *A. hians* (specimen *a*) was caught off the southern coast of the island of Malta (35.808434°N, 14.537536°E), by means of a kayak fishing rod, at a depth of 10 m, over a rocky seabed. The bait was sliced fragments of *Arenicola* sp. (Polychaeta). The fisher reported the capture through social media (*Spot the Alien Fish* campaign Facebook page, https://www.facebook.com/aliensmalta). The *Spot the Alien Fish* citizen science campaign was launched by the University of Malta in 2017 to collate a national database of all records made by different sea users in relation to non-indigenous species (NIS) of fish within Maltese waters. Reports to the campaign can be submitted through a dedicated web portal (https://www.um.edu.mt/newspoint/news/2020/06/spot-alien-website-launched), as well as through the corresponding campaign social media page and email address.

Upon capture, the fisher noted unusual evident black bars/markings in the posterior part of the fish, which led him to promptly sketch and submit a drawing of the same markings (Fig. 1A) to the citizen science campaign's social media platform. Specimen *a* was not preserved by the fisher, who did, however, take photographs (Fig. 1B, C). Its length was measured using a plastic bottle; the bottle having a known length of 20.5 cm, it was placed alongside the fish and included in the original photograph. In Fig. 1C, the bar corresponds to the length of the bottle.

Two months after the submission of the above *A. hians* photo to social media, the fishery community of the island was alerted about it by one of the authors (AD) and the photo of another specimen (specimen *b*) emerged on the mentioned platform (Fig. 2). Specimen *b* had been caught two years earlier, on 22 September 2018, in a location off the south-eastern coast of the island of Malta (35.819001°N, 14.559989°E), using a rod fishing technique known as 'spinning' from land. This sample was not preserved by the recreational fisher, so the only morphometric attribute that could be inferred from the corresponding photo was the total length.

RESULTS

Both specimens of *A. hians* (specimen *a*: 61.5 cm total length, 57.5 cm standard length, 330 g approximate weight; specimen *b*: 75.0 cm estimated total length) were identified based on the submitted photographs and drawing/sketch, following the descriptions by Collette & Parin (1970), Collette (1999, 2016), Collette & Bemis (2019), Golani (2019), and Alshawy *et al.* (2019). Body elongate and laterally compressed. Upper and lower jaws greatly elon-

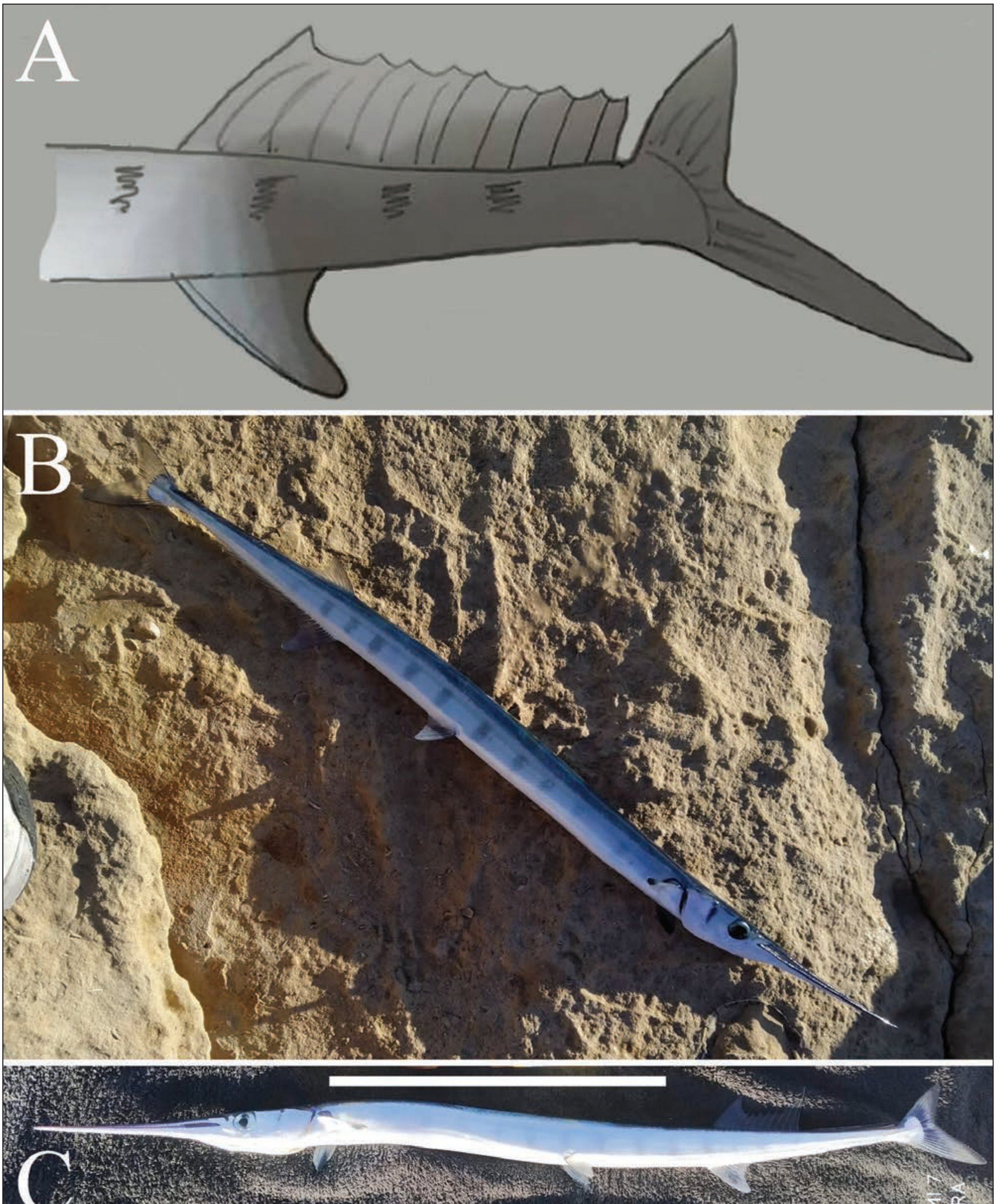

Fig. 1: *Ablennes hians* **(specimen a) caught in December 2020 off Malta (A, drawing made on board; B, immediately upon landing; C, a few minutes after landing, white bar 20.5 cm, details in Material and Methods (Drawing and photographs by L. Saliba).**
Sl. 1: *Ablennes hians* **(primerek a), ujet decembra 2020 pri Malti (A, risba na tablici; B, ravnokar ujet; C, nekaj minut po ulovu, bela črta 20,5 cm, detajli v poglavju Materiali in metode (Slika in fotografije: L. Saliba).**

gate, with small sharp teeth. Apparently, there were no lateral keels on the caudal peduncle. Dorsal and anal fins opposite, their anterior parts presenting moderately falcate lobes; caudal fin deeply forked, lower lobe longer than upper. Colour: bluish-green back, light blue flanks, white ventral surface; pelvic fins whitish, other fins appearing darker, posterior lobe of dorsal fin black (Fig. 2); a series of at least 13 dark vertical bars on the body along the sides (Figs. 1B-C, 2). In Fig. 1C, the vertical bars appear slightly faded compared to Fig. 1B, probably due to different light exposure values of the two photographs. Jaws pinkish.

DISCUSSION

The presumed arrival in 2020 of *A. hians* in Maltese waters led us initially to hypothesise a rapid spread of this newly introduced fish from the Levantine basin (Golani, 2019; Alshawy *et al.*, 2019) to the central Mediterranean, as it was reminiscent of the exceptional spread rate of *Fistularia commersonii* Rüppell, 1838 within the Mediterranean observed two decades ago. In fact, in only two years since its first record in the basin in 2000, off the Mediterranean coasts of Israel (Golani, 2000), that Lessepsian migrant extended its distribution range by over 2500 km, as far as the Italian island of Lampedusa in the central parts of the basin (Azzurro *et al.*, 2004), earning the species the title of 'Lessepsian sprinter' (Karachle *et al.*, 2004). Golani (2019) underlined the uncertainty of the origin of the first *A. hians* specimen found in Israel, but since the Suez Canal was included in the distribution range of the flat needlefish (Sabrah *et al.*, 2018), a tentative introduction into the Mediterranean via the Suez Canal (Lessepsian migration) was initially hypothesised, and this main route of introduction was also ascribed to the *A. hians* specimens from Syrian waters (Alshawy *et al.*, 2019). However, recent molecular analysis of *A. hians* samples collected from a broad geographical range revealed that within *A. hians*, previously considered a single circumtropical species, there may be several cryptic taxa (Tadmor-Levi *et al.*, 2020). Given the genetic differences between Red Sea specimens and the specimen sampled from Israel (Mediterranean Sea), the Lessepsian migration theory for the introduction of *A. hians* into the Mediterranean appears less probable, albeit not impossible; further studies are required to verify the introduction pathway for the species into the basin (Tadmor-Levi *et al.*, 2020).

The unexpected emergence of an even earlier record of *A. hians* (dating back to September 2018) from Maltese waters and the subsequent finding of the same species in 2020 within the same waters may further substantiate the hypothesised improbability of the arrival of the species in the Mediterranean through Lessepsian migration, in agreement with Tadmor-Levi *et al.* (2020). The outcomes of our study, in fact, suggest that a different route of introduction of the species into the Mediterranean should be considered. The Strait of Sicily, east of which the Malta archipelago is located, is an ecological corridor for the east-west and west-east dispersion of exotic species within the Mediterranean basin,

Fig. 2: *Ablennes hians* ***(specimen b) caught off Malta in September 2018 (Photograph by M. Caruana, submitted to social media in February 2021).***
Sl. 2: *Ablennes hians* ***(primerek b) ujet pri Malti septembra 2018 (Fotografija: M. Caruana, objavljen v socialnih medijih februarja 2021).***

i.e., a biogeographical crossroads between the two parts of the basin (Guidetti *et al*., 2010; Azzurro *et al*., 2014; Insacco & Zava, 2017; Deidun *et al*., 2021). As a result, an Atlantic origin of *A. hians* inhabiting the Mediterranean cannot be completely discounted. Although Moroccan Atlantic waters are not included in the Atlantic distribution range of the flat needlefish by Collette & Bemis (2019), the latter is listed as an unexploited species of Morocco that could acquire economic and commercial value (Menioui, 2009). Given the pelagic character of *A. hians*, a passive (not mediated by human agency) range expansion from the tropical east Atlantic into the Mediterranean via the Strait of Gibraltar could be speculated, analogously to an increasing number of non-native species within the basin (Essl *et al*., 2019). This hypothesis, however, is not supported by any records of the species from the western basin of the Mediterranean, which is anomalous for a putative range-expanding species of Atlantic origin.

Given that the Sicily Channel is a busy shipping lane, alternative vectors linked with maritime transport, including vessel ballast water and oil platforms, could also be responsible for introducing the species into the central Mediterranean, as has been documented in previous studies (e.g., Pajuelo *et al*., 2016; Insacco & Zava, 2017). Based on the records of *A. hians* from a wide geographical range within the basin, multiple instances of introduction of the species into the same basin are plausible; however, as suggested by Tadmor-Levi *et al*. (2020); a larger sample size is necessary in any future genetic investigation in order to ascertain the origin of the flat needlefish in the Mediterranean.

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PRVI ZAPIS O POJAVLJANJU PLOŠČATE MORSKE IGLE, *ABLENNES HIANS* (BELONIDAE) V VODAH OSREDNJEGA SREDOZEMSKEGA MORJA (ZAHODNO JONSKO MORJE)

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POVZETEK

Dva primerka ploščate morske igle, Ablennes hians *(Valenciennes, 1846), sta bila ujeta med 2018 in 2020 v obalnih vodah Malte. Avtorji razpravljajo o prvem pojavljanju ploščate morske igle v osrednjem Sredozemskem morju, ki časovno sovpada s prvim zapisom o pojavljanju te vrste v vzhodnem Levantskem morju.*

Ključne besede: Malta, *Ablennes hians*, tujerodna vrsta, Sredozemsko morje

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OCCURRENCE OF RETICULATED LEATHERJACKET *STEPHANOLEPIS DIASPROS* (MONACANTHIDAE) IN THE CENTRAL MEDITERRANEAN SEA, AND A NEW RECORD FROM THE TUNISIAN COAST

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ABSTRACT

The authors describe and comment the capture of a specimen of reticulated leatherjacket Stephanolepis diaspros *Fraser-Brünner, 1940. This is the first capture for this species made in the Gulf of Hammamet in eastern Tunisia. Such a record also fills the gap in the distribution of the species in Tunisian waters, which could be considered as the core of the species in the central Mediterranean Sea and perhaps in the entire Mediterranean.*

Key words: *Stephanolepis diaspros*, extension range, Gulf of Hammamet, eastern Tunisia

PRESENZA DI MONACANTO RETICOLATO *STEPHANOLEPIS DIASPROS* (MONACANTHIDAE) NEL MEDITERRANEO CENTRALE E NUOVA CATTURA IN TUNISIA

SINTESI

Gli autori descrivono e commentano la cattura di un esemplare di monacanto reticolato Stephanolepis diaspros *Fraser-Brünner, 1940. L'evento rappresenta la prima cattura della specie nel Golfo di Hammamet, nella Tunisia orientale. Il ritrovamento aiuta a riempire le lacune inerenti la distribuzione della specie nelle acque tunisine, che potrebbero venir considerate come il centro della presenza della specie nel Mediterraneo centrale e forse in tutto il Mediterraneo.*

Parole chiave: *Stephanolepis diaspros,* range di estensione, Golfo di Hammamet, Tunisia orientale

INTRODUCTION

Since its first record from the Levant Basin (Steinitz, 1927), the Lessepsian migrant reticulated leatherjacket *Stephanolepis diaspros* Fraser-Brünner, 1940 has progressively migrated toward western areas (Golani, 1998). Viable populations are successfully established in the central Mediterranean Sea (Tortonese, 1986) and in Turkish waters (Taskavak & Bilecenoglu, 2001).

In the former area, *S. diaspros* found favourable environmental parameters for reproduction and development, especially in Tunisian waters, for example, in the Gulf of Gabès in the south (Zouari-Ktari *et al.*, 2008; Zouari-Ktari & Bradaï, 2011), and northwards, off Bizerte and in the Lagoon of Bizerte (Bdioui *et al.*, 2004; Shaiek *et al.*, 2019). Additionally, the northernmost extension range of the species reached the area off Tabarka, close to the Algerian border (Ben Amor & Capapé, 2008).

Recent investigations conducted off the eastern Tunisian coast, mainly in the Gulf of Hammamet, supported by the assistance of fishermen aware of fishing grounds, allowed the collection of the specimen of *S. diaspros* described in the present paper.

MATERIAL AND METHODS

The specimen was caught by trawl with 40 mm stretched mesh size on 30 January 2021, in the Bay of Monastir, the Gulf of Hammamet, eastern Tunisia (35°46′36.94″ N and 10°51′12.75″ E; Fig. 1). The capture occurred at a depth between 30 and 35 m, on sandy-muddy bottom partially covered by seagrass and algae. The *S. diaspros* was caught together with cephalopod species, such as the common octopus *Octopus vulgaris* Cuvier, 1797, and teleost species, including the European seabass *Dicentrarchus labrax* (Linnaeus, 1758), the red mullet *Mullus barbatus* Linnaeus, 1758, the salema *Sarpa salpa* (Linnaeus, 1758), and the red scorpionfish *Scorpaena scrofa* Linnaeus, 1758. Abundant samples of ocean grass-wrack *Posidonia oceanica* (L.) Delille, 1813 were also collected during the trawls carried out in the Gulf of Hammamet. The recorded morphometric measurements, length measured to the nearest millimetre following Ben Amor & Capapé (2008), weight to the nearest gram, and meristic counts are summarised in Table 1. The specimen was fixed in 10% buffered formalin, preserved in 75% ethanol, and deposited in the Ichthyological Collection of the Institut National des Sciences et Techniques de la Mer of Tunis (Tunisia) under catalogue number INSTM-Stedia 01.

RESULTS AND DISCUSSION

The studied specimen was identified as *Stephanolepis diaspros* following previous descriptions by Tortonese (1967, 1986), Golani *et al.* (2017), Dulčić & Pallaoro (2003), Bdioui *et al.* (2004), and Shaiek *et al.* (2019). It displayed a brown-to-grey colour, with dark posterior areas and sinuous grey lines on the sides, while dark bands in the caudal fin were not visible (Fig. 2).

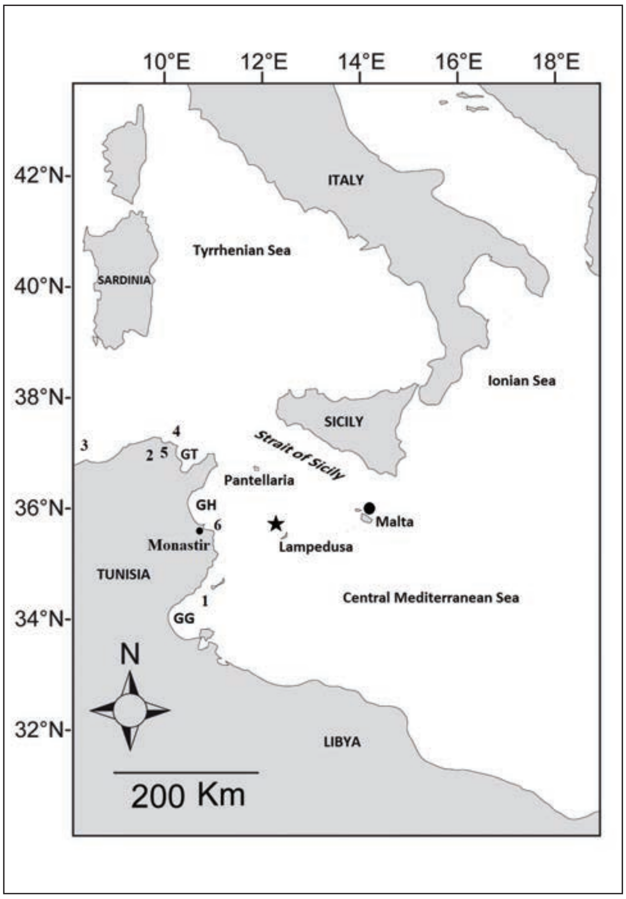

Fig. 1: Capture sites of *Stephanolepis diaspros* ***in the central Mediterranean Sea. 1. Gulf of Gabès (Chakroun, 1966). 2. Lagoon of Bizerte (Bdioui*** *et al.*, ***2004). 3. Off Tabarka (Ben Amor & Capapé, 2008). 4. Off Bizerte (Shaiek*** *et al.*, ***2019). 5. Lagoon of Bizerte (Shaiek*** *et al.*, ***2019). 6. Bay of Monastir, Gulf of Hammamet (this study). The black star and black circle indicate the captures of the species in waters surrounding the Island of Lampedusa and the Island of Malta, respectively (Deidun*** *et al.*, ***2015).***

Sl. 1: Zemljevid lokalitet, kjer so bili ujeti primerki vrste *Stephanolepis diaspros* ***v osrednjem Sredozemskem morju. 1. Zaliv Gabès (Chakroun, 1966). 2. Laguna v Bizerti (Bdioui*** *et al.*, ***2004). 3. Tabarka (Ben Amor & Capapé, 2008). 4. Bizerta (Shaiek*** *et al.*, ***2019). 5. Laguna v Bizertie (Shaiek*** *et al.*, ***2019). 6. Zaliv Monastir v zalivu Hammamet (ta raziskava). Črna zvezdica in črni krog kažeta lokaliteti, kjer so bili ujeti primerki v okolici Lampeduse in Malte (Deidun et al., 2015).***

Tab. 1: Comparison of morphometric measurements, meristic counts, and total body weight recorded in the specimens of* Stephanolepis diaspros*, collected in the Bay of Monastir, Gulf of Hammamet (ref. INSTM-Ste-dia-01), northern Tunisian coast (FST-STE-diasp1), and the Lagoon of Bizerte (ISPAB-Ste-dia-01).

Tab. 1: Primerjava morfometričnih meritev, merističnega štetja in skupne telesne mase, zabeleženih pri osebkih* Stephanolepis diaspros*, ujetih v Monastirju v zalivu Hammamet (ref. INSTM-Ste-dia-01), ob severni tunizijski obali (FST-STE-diasp1) in v Laguni Bizerte (ISPAB-Ste-dia-01).

References	**INSTM-Ste-dia 01**		**FST-STE-diasp1**		**FSB-Ste-dia-01**	
Measurements	**mm**	**%TL**	**mm**	**%TL**	**mm**	**%TL**
Total length (TL)	125	100.0	154	100	215	100
Standard length (SL)	104	83.2	125	81.2	185	86.05
Head length	27	21.6	34	22.1	55	25.6
First predorsal length	32	25.9	41.1	26.6	49	22.6
Second predorsal length	58	46.2	72.4	47.01	95	43.9
Preanal length	59	47.5	74.3	48.2	97	45.4
Prepectoral length	34	27.1	42.9	27.8	49	23.0
First dorsal fin length	6	4.9	7.6	4.9	13	6.3
Second dorsal fin length	41	32.9	51.8	33.6	73	34.2
Anal fin length	37	29.8	47.2	30.6	66	30.6
Pectoral fin length	10	8.5	14.3	9.2	9	11.6
Caudal fin length	22	17.9	28.8	18.7	25	25.8
Maximal body length	48	38.4	60.3	39.1	86	39.8
Minimal body length	9	7.2	12.4	8.1	-	-
Eye diameter	5	4.2	6.8	4.4	11	5.3
Interorbital length	8	6.7	11.6	7.5	12	5.8
Preorbital length	16	13.0	21.3	13.8	36	16.6
Postorbital length	5	4.1	6.8	4.4	6	2.9
Meristic counts						
First dorsal fin rays	I		I		I	
Second dorsal fin rays	33		33		31	
Anal fin rays	31		31		31	
Pectoral fin rays	13		13		13	
Caudal fin rays	I+10+I		I+10+I		I+10+I	
Total weight (gram)	71		61		196	

Fig. 2: Specimen of** Stephanolepis diaspros **collected in the Bay of Monastir, Gulf of Hammamet (ref. INSTM--Ste-dia-01), scale bar = 30 mm.
Sl. 2: Primerek vrste** Stephanolepis diaspros**, ujet v Monastirju v zalivu Hammamet (ref. INSTM-Ste--dia-01), merilo = 30 mm.

The capture of the specimen more probably occurred during its migration from the southern area, where the species lives freely in the wild, than from the northern area, where an established population can also be found, inhabiting the Lagoon of Bizerte (Shaiek *et al.*, 2019), a restricted area communicating with the open sea by a narrow navigation canal (Harzallah, 2003; Ounifi-Ben Amor *et al.*, 2016). Apparently, the specimen was captured together with large *S. salpa*, probably adults, which are considered almost exclusively herbivorous (Bauchot & Hureau, 1986). *S. diaspros* feeds on a large variety of benthic invertebrates, and sometimes on algae and plants (Zouari-Ktari *et al.*, 2008). Therefore, competition pressure between herbivorous fish species and *S. diaspros* remains generally limited, since the latter also find available food in the seagrass meadows they inhabit (El-Ganainy & Sabra, 2008).

At present, *S. diaspros* is known throughout the Tunisian coast, although the capture of a single specimen in the Gulf of Hammamet does not constitute sufficient evidence to draw any conclusions about the real status of the species in this area. Further records are needed to confirm the hypothesis of a successful establishment of a *S. diaspros* population in this eastern Tunisian region. However, the present record fills a gap in the distribution of the species along the Tunisian coast. Conversely, it appears that *S. diaspros* is successfully established in two areas; the Gulf of Gabès and the Lagoon of Bizerte. Morphometric measurements and meristic counts recorded in specimens from these areas are practically identical (see Tab. 1), suggesting that the same population may be inhabiting the two separate areas. However, the plausibility of such a hypothesis would have to be verified by means of molecular tools and genetic analysis. *S. diaspros* remains abundant in Tunisian waters, to the point that this region could at present be considered the core area of the species in the central Mediterranean Sea, and probably in the wider Mediterranean as well.

POJAVLJANJE AFRIŠKEGA KOSTOROGA, *STEPHANOLEPIS DIASPROS* (MONACANTHIDAE), V OSREDNJEM SREDOZEMSKEM MORJU IN PRVI PODATEK ZA TUNIZIJSKO OBALO

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POVZETEK

Avtorji poročajo in razpravljajo o najdbi primerka afriškega kostoroga, Stephanolepis diaspros *Fraser-Brünner, 1940. Ta je bil prvič najden v zalivu Hammamet v vzhodni Tuniziji. Ta primer je zapolnil vrzel v razširjenosti te vrste vzdolž tunizijske obale in predstavlja pomembno območje te vrste v osrednjem Sredozemskem morju in morda v celotnem bazenu.*

Ključne besede: *Stephanolepis diaspros*, širjenje areala, zaliv Hammamet, vzhodna Tunizija

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NEW RECORD OF *EPINEPHELUS AREOLATUS* IN THE MEDITERRANEAN SEA: FIRST RECORD FROM SYRIA

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ABSTRACT

One specimen of the Areolate Grouper Epinephelus areolatus *(Forsskål, 1775) was caught on 29th May 2019 off the coast of Latakia. This represents the first record of the species for the Syrian waters and the fourth for the Mediterranean Sea. We finally discuss its introduction pathway in the Mediterranean.*

Key words: Serranidae, eastern Mediterranean, non-indigenous fish, citizen science

NUOVA SEGNALAZIONE DI *EPINEPHELUS AREOLATUS* NEL MAR MEDITERRANEO: PRIMA SEGNALAZIONE DALLA SIRIA

SINTESI

Un esemplare di Epinephelus areolatus *(Forsskål, 1775) è stato catturato il 29 maggio 2019 al largo della costa di Latakia. Questa cattura rappresenta la prima segnalazione della specie da acque siriane e la quarta segnalazione per il mare Mediterraneo. Si discute la via di introduzione di questa specie in Mediterraneo.*

Parole chiave: Serranidae, Mediterraneo orientale, pesci non indigeni, scienza del cittadino

INTRODUCTION

The Mediterranean Sea hosts six non-indigenous *Epinephelus* Bloch, 1793 species, namely *Epinephelus areolatus* (Forsskål, 1775), *Epinephelus coioides* (Hamilton, 1822), *Epinephelus fasciatus* (Forsskål, 1775), *Epinephelus geoffroyi* (Klunzinger, 1870), *Epinephelus malabaricus* (Bloch & Schneider, 1801) and *Epinephelus merra* Bloch, 1793 (Golani *et al.*, 2002, 2015).

Among them, *E. areolatus*, commonly known as the Areolate Grouper, is a species of Indo-Pacific origin, whose distribution extends from the Red Sea and eastern coast of Africa to southern Japan and New Caledonia (Froese & Pauly, 2021). In its native range, *E. areolatus* is common in coastal waters, on seagrass beds and on soft bottoms close to hard substrates, such as rocky reefs or dead corals, where it feeds on fish and benthic invertebrates (Heemstra & Randall 1993; Randall *et al.*, 1998). This species was first recorded from the Mediterranean Sea based on a specimen caught along the Israeli coast in 2015 (Rothman *et al.*, 2016). More recently, two further specimens were collected in Lebanon in 2019 (Bariche & Edde, 2020).

We hereby report for the first time the presence of *E. areolatus* in Syrian waters, discussing the introduction pathway of this recently introduced non-indigenous fish in the Mediterranean Sea.

MATERIAL AND METHODS

On 11th May 2020, a Syrian professional fisherman posted a photo of a fish unknown to him on the Facebook®group “مدمن صيد” (fishing addict), asking for an identification. The particular color pattern of the grouper, represented by a reticulated pattern of yellow-brownish spots scattered over body (Heemstra & Randall, 1993; Craig *et al.*, 2012), easily allowed the authors of the present note to identify it as *E. areolatus*. Soon after, we contacted the fisherman asking for further data about the catch. In particular, the fish was caught on 29th May 2019

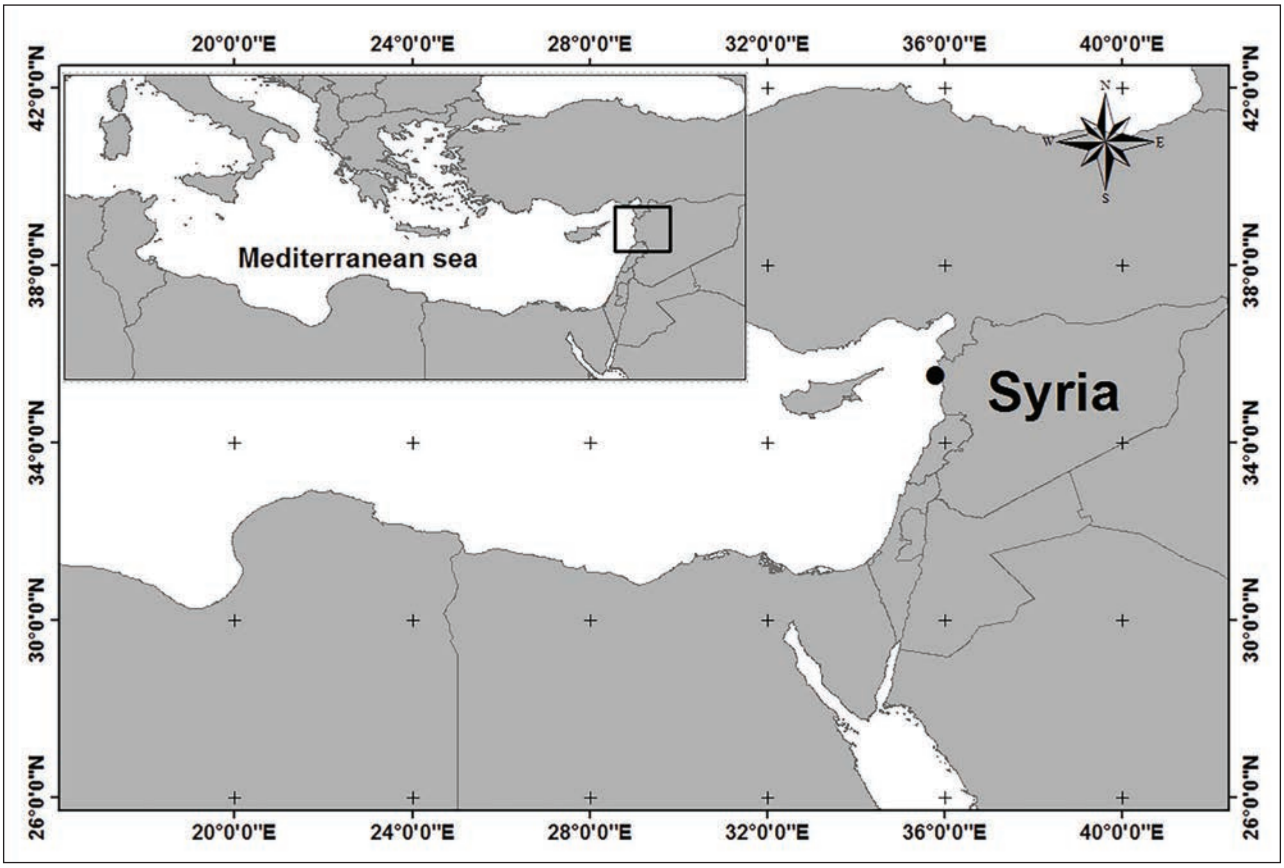

Fig. 1: Location in which the specimen of *Epinephelus areolatus* ***was caught on 29 May 2019, at Lattakia, Syria, eastern Mediterranean Sea.***

Sl. 1: Zemljevid obravnavanega območja z označeno lokaliteto, kjer je bil 29. maja 2019 pri Latakiji (Sirija, vzhodno Sredozemsko morje) ujet primerek rdečepikaste kirnje.

Fig. 2:** Epinephelus areolatus, **specimen caught on 29 May 2019 with a trolling line operating at a depth of 61 m at Lattakia, Syria (photo by Nizar Aziz).
Sl. 2: Primerek rdečepikaste kirnje (**Epinephelus areolatus**), ujet na parangal 29. maja 2019 na globini 61 m pri Latakiji (Sirija, vzhodno Sredozemsko morje) (foto: Nizar Aziz).

with a trolling line operating at a depth of 61 m, off the coast of Latakia, northern Syria (35°32’27.6”N 35°45’04.2”E) (Fig. 1). Unfortunately, the specimen (Fig. 2) was consumed by the fisherman and therefore it was not possible to carry out further analysis. However, measurements of the fish’s size were carried out analyzing the photo provided by the fisherman using the ImageJ software (Schneider *et al.*, 2012): the length of the fish was estimated using as standard the size of the thumbnail of the fisherman (Scannella *et al.*, 2020). Moreover, using the coefficients of the total length-weight relationship, it was possible to estimate the weight of the fish (Froese & Pauly, 2021).

RESULTS AND DISCUSSION

The fish had an estimated total length (TL) of 37 cm, a standard length (SL) of 30.5 cm, and a weight of 702 g. It represents the fourth specimen of *E. areolatus* reported from the Mediterranean Sea and the first known from Syria. *Epinephelus areolatus* was commonly reported as a Lessepsian immigrant (Rothman *et al.*, 2016; Bariche & Edde, 2020). Indeed, considering that past records occurred near the Suez Canal, and the fact that the species naturally occurs in the Red Sea, the introduction through this pathway is the most probable explanation for its presence in the basin. Concerning our record from Syrian waters, we also suggest the Suez Canal as introduction pathway for the Mediterranean Sea, or a secondary introduction from an established Mediterranean population (Coll *et al.*, 2010).

This Lessepsian immigrant appears to spread quite rapidly through the Mediterranean Sea, and although to date only four specimens were recorded, we can’t rule out the presence of an established population in the eastern part of the basin. Further studies are therefore necessary to better understand the expansion dynamics of this species, whose abundance is still probably low. In this regard, social media and citizen science play an important role in the monitoring and early detection of non-indigenous species (Azzurro *et al.*, 2013; Bariche & Azzurro, 2016; Giovos *et al.*, 2019; Tiralongo *et al.*, 2019, 2020; Azzurro & Tiralongo, 2020; Al Mabruk *et al.*, 2021).

In conclusion, the increasing number of alien fish, and in general of alien species, in the Mediterranean Sea, and in particular in its eastern part, highlights a dramatic ecosystem change due to alteration of its biodiversity. The Mediterranean Sea is the most globally impacted ecoregion by bioinvasions (Katsanevakis *et al.*, 2014). To date, more than 100 alien fish species have been recorded in the Mediterranean Sea (Galil & Goren, 2014), and their introduction rate seems to increase continuously, primarily due to the opening of the Suez Canal (Katsanevakis *et al.*, 2014). Monitoring programs, with the help of citizen scientists, appear to be an excellent low-cost support in order to study the biological invasions dynamics in the basin and to upgrade the checklist in neglected country such as Syria (Ali, 2018; Al Mabruk *et al.*, 2021).

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NOVI ZAPIS O POJAVLJANJU RDEČEPIKASTE KIRNJE (*EPINEPHELUS AREOLATUS)* V SREDOZEMSKEM MORJU: PRVI PODATKI ZA SIRIJO

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POVZETEK

*Primerek rdečepikaste kirnje (*Epinephelus areolatus *(Forsskål, 1775)) je bil ujet 29. maja 2019 ob obali Latakije. Gre za prvi zapis o pojavljanju te vrste za sirske vode in četrti za Sredozemsko morje. Avtorji razpravljajo o načinu prihoda vrste v Sredozemsko morje.*

Ključne besede: Serranidae, vzhodno Sredozemsko morje, tujerodne ribe, ljubiteljska znanost

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SREDOZEMSKI MORSKI PSI

SQUALI MEDITERRANEI

MEDITERRANEAN SHARKS

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NOTES ON A RARE CASE OF BLUNTNOSE SIXGILL SHARK *HEXANCHUS GRISEUS* STRANDED ON THE COAST OF TUSCANY IN THE CENTRAL TYRRHENIAN SEA

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ABSTRACT

*A rare stranding event involving a 297 cm long mature male bluntnose sixgill shark (*Hexanchus griseus*) occurred on the Tuscan coast in the central Tyrrhenian Sea. The stranded specimen had 6 rows of teeth indicating that it belonged to the* H. griseus *and not to the* Hexanchus nakamurai *species, which only has 5. Biometric data on two teeth of the left front region of the lower jaw were collected. The body of the specimen did not show evidence of capture, only a deep cut at the height of the orbital arch suggesting a crash or the ramming of a boat.*

Key words: bluntnose sixgill shark, *Hexanchus griseus*, shark stranding, teeth, Mediterranean Sea

NOTE SU UN RARO CASO DI SPIAGGIAMENTO DI CAPOPIATTO *HEXANCHUS GRISEUS* LUNGO LA COSTA TOSCANA NEL MAR TIRRENO CENTRALE

SINTESI

*Un raro evento di spiaggiamento che ha coinvolto un capopiatto maschio maturo lungo 297 cm (*Hexanchus griseus*) si è verificato lungo la costa toscana nel mar Tirreno centrale. L'esemplare spiaggiato presentava 6 file di denti che indicavano l'appartenenza alla specie* H. griseus e *non alla specie* Hexanchus nakamurai*, che ne ha solo 5. Sono stati raccolti dati biometrici su due denti della regione anteriore sinistra della mascella inferiore. Il corpo dell'esemplare non mostrava segni di cattura, solo un profondo taglio all'altezza dell'arco orbitale che suggeriva una collisione o lo speronamento di una barca.*

Parole chiave: capopiatto, *Hexanchus griseus*, spiaggiamento di squalo, denti, Mediterraneo

INTRODUCTION

The bluntnose sixgill shark *Hexanchus griseus* (Bonnaterre, 1788) is a deepwater, benthic, littoral and semi-pelagic shark (Compagno *et al.*, 2005), listed as near threatened (NT) by the Red List of the International Union for Conservation of Nature (I.U.C.N.) (*Finucci et al.*, 2020). Juveniles may approach the coast in cold water, while adults live in shallow waters close to submarine canyons (Compagno *et al.*, 2005). *H. griseus* is found in the Pacific and Indian Oceans, off the eastern and western Atlantic coasts, and in the Mediterranean Sea (Bass *et al.*, 1975), up to 1875 meters deep (Compagno *et al.*, 2005). The bluntnose sixgill shark makes day and night excursions, moving from a depth of 250 m up to 20 m, near the surface (Andrews *et al.*, 2009). The biology of *H. griseus* in the Mediterranean is poorly known and the little information published focuses mostly on its ichthyological characteristics (Capapé *et al.*, 2003). Cases of hermaphroditism, although rare in elasmobranchs, seem to be present in bluntnose sixgill shark (Daniel, 1928). The maturity is reached at 309–330 cm of total length (TL) in males and 350–420 cm TL in females, while the maximum size reached is probably 550 cm TL (Compagno *et al.*, 2005). In the present article, authors report an incident of a stranded bluntnose sixgill shark found on the Tuscan coast (central Tyrrhenian Sea) and provide information on the examined specimen. Furthermore, the authors review the occurrence status of *H. griseus* in the Mediterranean Sea in light of available data.

MATERIAL AND METHODS

On 16 March 2016, a bluntnose sixgill shark was found on the beach of Marina di Grosseto in Tuscany (coordinates: 42°43′24.5″N 10°58′19.4″E), Italy (Fig. 1a). This area, located in the northwestern Mediterranean, more precisely, in the central Tyrrhenian Sea, is characterised by a sandy bottom that slowly degrades

Fig. 1: (A)** Hexanchus griseus**; (B) tooth measurement; (C) teeth; (D) MEDLEM report; (E) claspers; (F) damaged eye.
Sl. 1: (A)** Hexanchus griseus**; (B) merjenje zob; (C) zobovje; (D) MEDLEM poročilo; (E) klasperja; (F) poškodovano oko.

before reaching significant depths. The specimen, found in late afternoon, was quickly collected and taken to landfill by the local authorities, thus only allowing for a collection of limited biometric data based on a few samples of teeth, and checking the external condition of the specimen. The shark was measured on the beach and its total length (TL) was recorded as a straight line extending from the tip of the snout to the tip of the upper lobe of the caudal fin, with the latter in the depressed position. This type of measurement represents the maximum length according to Compagno (1984). The available data were entered in the MEDLEM reporting form (Fig. 1d).

RESULTS

The male specimen displayed a pair of calcified claspers and was probably mature (Fig. 1e). Its size was 294 cm TL, it had no external abrasions or signs of capture by fishing gear; the mouth was free and without hooks. At the level of the left eye socket there was a deep horizontal cut and the eye was damaged (Fig. 1f). Six dental rows were observed and the dental formula 20/13 corresponded to that of H. griseus according to Last & Stevens (2009). Biometric analyses of two teeth A1 and A2 (Fig. 1c) of the front left region of the lower jaw were performed using a caliper (Fig. 1b). The biometric measurements, taken in mm, are shown in Table 1. The sixgill shark species *H. griseus* (Bonnaterre, 1788) and *Hexanchus nakamurai* (Teng, 1962) stand out for the presence of six rows of distinctly comb-shaped teeth in the lower jaw in the former and five rows in the latter species; moreover, *H. griseus* has a short, blunt, broadly rounded snout and a dorsal-caudal distance approximately equal to its dorsal fin base length, while *H. nakamurai* has a relatively longer snout that is more pointed and narrow, and a dorsal-caudal distance that is much longer than the dorsal-fin base length (Ebert *et al.*, 2013). In addition, Adnet (2006) stated that *H. griseus* and *H. nakamurai* are hard to distinguish, especially because of the similarity between the lower teeth of juvenile or sub-adult specimens in both species.

DISCUSSION

A historical survey of Mediterranean reports since 1892 shows that *H. griseus* has been captured in restricted areas of the western basin more commonly than in the eastern one (Capapé *et al.*, 2003). *H. griseus* is included in the I.U.C.N. Red List, and even though its populations are considered stable, they still require careful monitoring; in fact, species with similar life histories, often called ‘K-selected’ (Camhi *et al.*, 1998), can be affected by deepwater fishery (Walls *et al.*, 2015). Between 1666 and 2014, the MEDLEM (Serena *et al.*, 2014) database for the Mediterranean Sea recorded occurrences of bluntnose sixgill shark (*H. griseus*) in Maltese waters (20 specimens; GSA 15); in the northern Tyrrhenian Sea (45 specimens; GSA 9); in the southern Adriatic Sea; in the northern Ionian Sea; in the southern waters of Sicily (21 specimens; GSA 18, 19, and 16 respectively); along the coasts of Tunisia (GSA 13 and 14) (Capapé *et al.*, 2003; 2004); and in Turkish waters (24 specimens). The Mediterranean Sea has been divided into 30 geographical sub-areas, called GSAs, by the General Fishery Commission for the Mediterranean - GFCM. Kabasakal (2013) states that 150 specimens of *H. griseus* were caught by commercial fishing vessels in the seas of Turkey between 1967 and 2013, 90 of which were recorded in the Marmara Sea. Based on an analysis of internet-based media reports on rare and large sharks of Turkey, Kabasakal & Bilecenoğlu (2020) indicated that nearly 52 percent (139 out of 268 specimens) of sharks captured between 2006 and 2020 were *H. griseus*. The bluntnose sixgill shark is also regularly captured along the coast of Lebanon (Lteif, 2015) and along the coasts of Calabria (21 specimens; GSA 10 and 19), (Leonetti *et al.*, 2020). Stranding of bluntnose sixgill sharks in the Mediterranean Sea is rare, particularly in consideration of their presence at great depths. Kabasakal (2006) reported a female specimen (450 cm TL) stranded in the Dardanelles Strait on 5 June 1999. Although in the present case it was not possible to collect all the samples needed to provide a more useful contribution to the knowledge of the biology of this species, it was nevertheless possible to establish that the number of rows of teeth equalled 6, which excluded the possibility that the shark could be a *H. nakamurai*, whose maximum TL does not

Tab. 1: Five measurements were collected for each tooth: CH, crown height; RH, root height; TH, total height; BWT, basal width of the tooth; HC, height of the cusp.
Tab. 1: Za vsak zob je bilo opravljenih pet meritev: CH, višina krone; RH, višina korenine; TH, celotna višina; BWT, bazalna širina zoba; HC, višina grbice.

Biometric measurements of the teeth (mm)		
	A1	A2
CH	10.3	9.84
RH	12.3	11.42
TH	19.97	19.49
BWT	28.99	28.06
HC	6.69	6.36

exceed 180 cm. It is important to remember that it is difficult to distinguish between specimens of the two species without precise information on their body size or maturity and only by comparing the teeth. In fact, Adnet (2006) showed that the two recent species of the genus *Hexanchus* have a similar dental development but with a different growth rate: at same tooth width, *H. griseus* retains a "young" morphology compared to that of *H. nakamurai* and the distinction between the two species in relation to dentition is currently limited to the presence, in some individuals, of a vertical median cusp on the symphyseal tooth in *H. nakamurai*, and different dental formulae. The size of the stranded animal and the presence of hard and well-calcified claspers indicated its probable maturity, although its body size was slightly smaller than the minimum size at maturity indicated by Compagno et al. (2005), which is 309 cm for males. Observations suggest that H. griseus matures at a smaller size in the Mediterranean than elsewhere (Capapé *et al.*, 2004). The examination of the collected teeth confirmed the equation for establishing the size of the animal based on the measurement of the tooth base. As a matter of fact, in large shark species such as *H. griseus*, the length of the body (Total Length according to Compagno, 1984) and the width of the teeth in each row are well correlated (R = from 0.95 to 0.98, $p < 0.001$). A simple linear regression equation expresses the relationship between the width of the lower teeth and the length of the shark's body, which can be calculated as follows: shark's length (in cm) = 111 × tooth's width (in cm) + 3.9 (R = 0.97, $p < 0.001$; N = 243) (Adnet, 2006). If we were to apply the equation in this instance, it would have been possible to estimate a length of about 325 cm, slightly greater than the measured one, thus confirming the correctness of the proposed equation. With regard to the reasons of the stranding, the absence of apparent damages from fishing tools and the presence of a deep cut at the eye level may suggest the possibility that this male specimen rose to the surface due to various reasons that could have also caused its death by ramming such as, for example, an accident with a boat. Injured sixgill sharks may be at risk for post-release or post-accident disability, or mortality due to long-term pathologic consequences of anthropogenically induced scars (Kabasakal, 2010). Andrews *et al.* (2009) found that in Puget Sound (USA), sixgill sharks showed consistent diel behavioural patterns throughout the year and inhabited greater depths during the day than during the night, being more active (with greater variation in depth and greater rates of vertical movement) at night. It is interesting to note that, in our case, the stranding occurred in March, right at the beginning of the spring season when, just like in Puget Sound, the movement to the surface of these sharks is more frequent. Seasonally, sixgill sharks occupy deeper habitats in autumn and winter than they do in spring, and are more active in autumn (Andrews *et al.*, 2009). Moreover, in the Mediterranean, little is known about the behaviour of these sharks: Capapé *et al.* (2004) states that *H. griseus* is probably able to live and reproduce in the Mediterranean Sea; however, further observations are needed to confirm that a sustainable bluntnose sixgill shark population has been established here, especially off the Maghrebi coast. Incidental capture of a new-born specimen (60 cm TL) with an unhealed umbilical scar (birthmark) between the pectoral fins suggested the possibility of a nursery ground of *H. griseus* in northern Aegean Sea bathyal grounds (Kabasakal, 2013). Moreover, another possible nursery ground was suggested in the Marmara Sea, where several juveniles (120 to 250 cm TL) were incidentally captured (Kabasakal, 2013). Finally, lack of information on the movements of the specimens along Turkish coasts reveals the necessity of tagging surveys of *H. griseus* in the mentioned region to understand the spatial and bathymetric movement patterns of this species (Kabasakal, 2013). Meager & Sumpton (2016) suggest that an integrated approach of using stranding and bycatch data may provide an indicator of long-term trends for data-limited cetaceans, and that stranding programs can give a faithful representation of the species composition of cetacean assemblages, while standardised bycatch rates can provide a measure of relative abundance. Therefore, in the long term, the stranding of elasmobranchs, however rare and even in the case of animals living in the deep but periodically venturing to surface waters, could provide useful insights for an evaluation of their health status. This information provides a useful contribution to the biometric data available for this species, with particular reference to teeth, and testifies to a rare case of stranding.

ZAPIS O REDKEM PRIMERU MORSKEGA PSA ŠESTEROŠKRGARJA *HEXANCHUS GRISEUS*, KI JE NASEDEL NA TOSKANSKI OBALI V OSREDNJEM TIRENSKEM MORJU

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POVZETEK

*Avtorji poročajo o redkem primeru, ko je na toskanski obali v osrednjem Tirenskem morju nasedel 297 cm dolg odrasel samec morskega psa šesteroškrgarja (*Hexanchus griseus*). Nasedli primerek je imel 6 nizov zob, po katerih ga je bilo možno razlikovati od sorodne vrste* Hexanchus nakamurai*, ki ima 5 nizov. Avtorji so opravili biometrijo na dveh zobeh levega sprednjega dela. Na telesu morskega psa ni bilo videti znakov ulova, le globoka rana v višini očesnega loka priča o morebitnem trku s plovilom.*

Ključne besede: morski pes šesteroškrgar, *Hexanchus griseus*, nasedli morski pes, zobovje, Sredozemsko morje

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THE OCCURRENCE OF THE COMMON ANGEL SHARK *SQUATINA SQUATINA* IN THE ADRIATIC SEA

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ABSTRACT

The common angel shark Squatina squatina *is considered a critically endangered species in the Mediterranean, so much so that in Croatian Adriatic waters it deserves the highest level of protection. While in the 19th and the first half of the 20th century it was a common species here, it has been very rarely encountered over the last few decades. This paper aims to present the data on two additional records of* S. squatina *from the Adriatic and discuss its recent status with a proposal for effective management measures.*

Key words: angel sharks, *Squatina squatina*, critically endangered, Adriatic Sea, Mediterranean Sea

PRESENZA DEL PESCE ANGELO *SQUATINA SQUATINA* IN ADRIATICO

SINTESI

Il pesce angelo Squatina squatina*, specie in grave pericolo di estinzione nel Mediterraneo, merita il più alto livello di protezione nelle acque adriatiche croate. La specie, precedentemente comune nel 19° e nella prima metà del 20° secolo, è stata trovata molto raramente durante gli ultimi decenni. L'articolo mira a presentare i dati su due ritrovamenti aggiuntivi di* S. squatina *nell'Adriatico e a discutere il suo stato recente, con una proposta di misure di gestione efficaci.*

Parole chiave: pesce angelo, *Squatina squatina*, pericolo estinzione, Adriatico, Mediterraneo

INTRODUCTION

Angel sharks are a group of at least 22 species, all in the genus *Squatina* (Ellis *et al*., 2020). Three species of angel shark are present in the Mediterranean with overlapping ranges. Of these, the sawback angelshark *Squatina aculeata* Cuvier 1829 is mainly documented in the central basin along the southern Mediterranean coast as far as the eastern basin, including the Aegean Sea (Başusta, 2002; Soldo & Bariche, 2016; Gordon *et al.*, 2019), but not in the Adriatic Sea, while the other two species, the smoothback angel shark *Squatina oculata* Bonaparte, 1840 and the common angel shark *Squatina squatina* (Linnaeus, 1758), are reported as Adriatic species (Lipej *et al.*, 2004).

Angel sharks have dorso-ventrally flattened bodies and broad pectoral fins, which gives them a ray-like appearance. However, the anterior margins of the pectoral fins are not fused to the side of the head, and the five pairs of gill slits are lateral, not ventral, thus distinguishing angel sharks from rays (Compagno, 1984; Gordon *et al.*, 2020). Unfortunately, the body shape and preference for coastal waters of many angel sharks makes them susceptible to capture by a variety of demersal fisheries, both commercial and recreational, from the very birth. As a result, angel sharks have been identified as one of the most threatened families of chondrichthyans (sharks, skates, rays, and chimaeras) in the world, with many requiring urgent conservation action (Dulvy *et al.*, 2014). All three Mediterranean species are assessed as critically endangered in the Mediterranean due to past population declines, running an extremely high risk of extinction in the wild (Gordon *et al.*, 2019).

In relation to the Adriatic Sea, Brusina (1888) wrote that in the Gulf of Trieste and Dalmatia *S. oculata* was rarer than *S. squatina*; Jardas (1996) defined *S. oculata* as rare throughout the Adriatic Sea; and now, after several decades without any new records of *S. oculata* in the Adriatic, we can presume this species to be locally extinct.

The body in *S. squatina* is strongly flattened dorso-ventrally, with a very wide head and very wide pectoral and pelvic fins and no anal fin. The origin of the first dorsal fin is above the pelvic fin free rear tip, the caudal fin lower lobe larger than upper lobe. Nasal barbels are not fringed and spiracles are large. There are 5 pairs of gill slits, not visible when the shark rests on the sea bottom. Dorsal surface of light brown-gray color or dark with 1–3 straight dark bands on pectoral fins and small white and dark spots and dark patches; ventral surface white. Upper teeth with one cusp, small and pointed; lower teeth similar. *S. squatina* can reach a maximum size of 244 cm. The size at birth is 24–30 cm, at maturity the size of males is 80–132 cm, and of females 128–169 cm (Compagno, 1984; Lipej *et al.*, 2004).

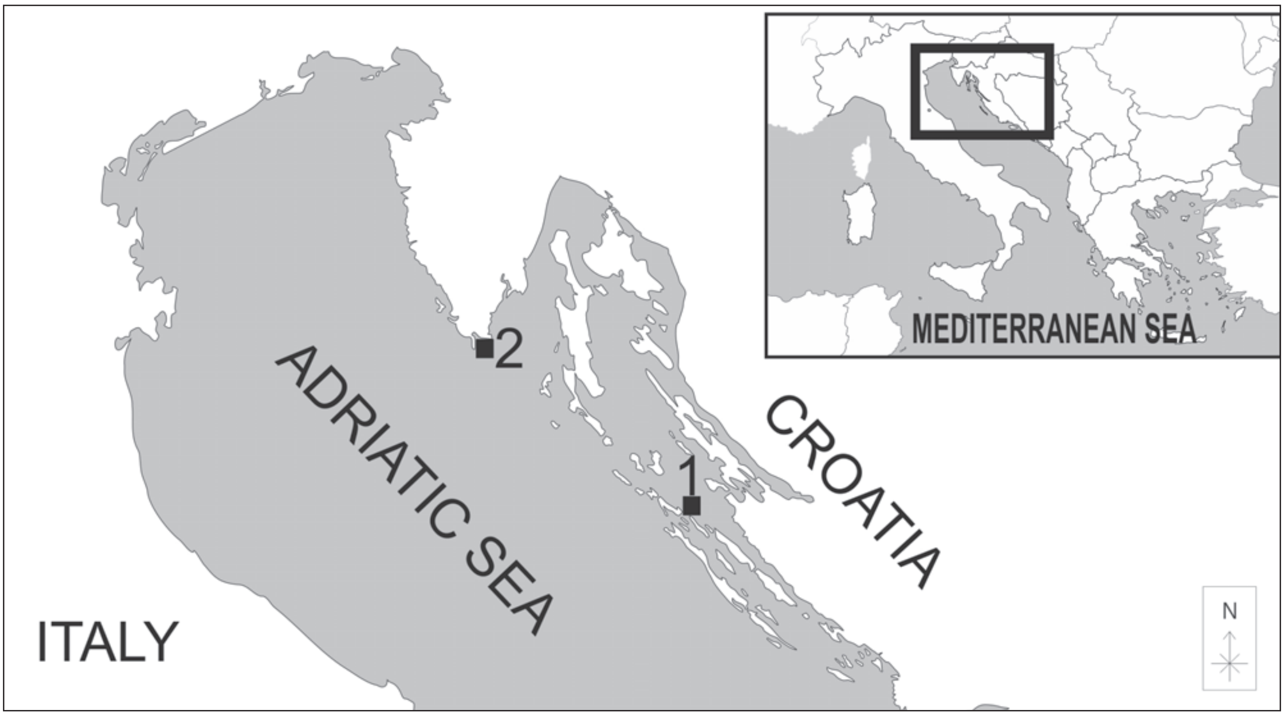

Fig. 1: Capture and release site of two male specimens of** S. squatina**.
Sl. 1: Mesto ulova in izpustitve dveh samcev sklata** (S. squatina)**.

Brusina (1888) reported that (at his time) the common angel shark was abundantly caught in the Adriatic Sea. Jardas (1996) considered *S. squatina* to be rare throughout the Adriatic while only in the area of the Neretva River and Zadar did it seem to be more common. Bello (1999) wrote that the angel shark was infrequently caught in the southeastern part and rarely netted in the southwestern part of the Adriatic Sea. Matjašič *et al.* (1976) inserted *S. squatina* on the list of the fauna and flora of northern Adriatic. In the Kvarner region, this species was not registered between 1973 and 1996 (Jardas *et al.*, 1998).

Previous data indicate that *S. squatina* was often a by-catch of bottom trawls. Angel shark was reported as a caught species in 1948 during the Hvar expedition, but the Medits expedition which took place 50 years later, in 1998, failed to confirm the presence of this species (Jukić-Peladić *et al*., 2001). Soldo (2006) considered both Adriatic angel shark species as very rare and critically endangered within the local area. Based on that opinion Croatia, within its waters, accorded both angel shark species the highest level of protection (strictly protected status) in the Adriatic.

In Croatia, angel sharks were historically targeted, in fact, one of the large mesh size gillnets was called *sklatara* after the Croatian term for the angel shark – *sklat*. Something similar was indicated by Fortibuoni *et al.* (2016), who reported that according to naturalists' accounts and historical documents, the species was so abundant in the Northern Adriatic in the 19th and early 20th centuries as to sustain targeted fisheries, and large quantities of *S. squatina* were sold in the main fish markets, but during the 1960s, the species collapsed and became economically extinct. However, Fortibuoni *et al.* (2016) also concluded that even if *S. squatina* was never detected in the area during scientific surveys conducted between 1948 and 2014, it emerged from interviews with fishermen that the species is not extirpated from the Adriatic Sea. Such conclusion was also supported by occasional records from the Adriatic; Holcer & Lazar (2017), for example, reported 4 records from the 2008–2016 period (two from the Murter area and two from Kvarner).

Thus, this paper aims to present new and older data on the occurrence of common angel shark in the Adriatic and to discuss the recent status of this critically endangered species.

MATERIAL AND METHODS

The first specimen was caught on 8 March 2007 by a gillnet with 180 mm mesh size, at a depth of 50 m, near Point Križ – the Island of Sestrunj (Fig. 1). The second specimen was caught on 23 April 2021 with a trammel net at the depth of 23 m in front of Debeljak Bay, near Point Kamenjak (the southernmost tip of the Istrian Peninsula) (Fig. 1).

Tab. 1: Morphometric measurements of the specimen caught on 8 March 2007.
Tab. 1: Morfometrične meritve primerka, ujetega 8. marca 2007.

Morphometric parameter	**mm/g**
Total length - TOT	1080
Precaudal length - PRC	940
Pre-second dorsal length – PD2	825
Pre-first dorsal length – PD1	690
Preorbital length – POB	52
Prepectoral length – PP1	135
Preanal length – PAL	495
Dorsal caudal margin – CDM	160
Pectoral anterior margin – P1A	310
Pectoral base - P1B	160
Width with fins	635
Body width	245
Clasper inner length – CLI	165
Mouth width – MOW	135
Internarial space – INW	80
First dorsal height – D1H	95
First dorsal inner margin - D1L	80
First dorsal base – D1B	50
Total weight	11204
Liver weight	338
Stomach weight full	381
Stomach content weight	184

The first specimen was caught and landed dead during a scientific survey, and therefore fully measured to the nearest mm and weighed to the nearest 0.01 g. After the dissection of the specimen, its stomach was isolated and examined.

The second specimen was landed on a boat alive. The fisherman contacted the Pula Aquarium and their staff collected the specimen, taking it to the water tank in the aquarium, where it was kept alive.

RESULTS

Based on the diagnostic characteristics described by Compagno (1984) and Lipej *et al.* (2004), both specimens were identified as males of *S. squatina*. Morphometric measures of the first adult specimen (Fig. 2) taken according to the guidelines of Compagno (1984) are presented in Table 1.

Fig. 2: The adult male specimen of* S. squatina *caught on 8 March 2007 by gillnet.
Sl. 2: Odrasel samec sklata (*S. squatina*), ujet 8. marca 2007 v zabodno mrežo.

The analysis of the stomach content revealed an omnivorous diet for *S. squatina* as the content included a whole black scorpionfish *Scorpaena porcus* Linnaeus 1758, remains of gilthead seabream *Sparus aurata* Linnaeus 1758, as well as several beaks of squid and cuttlefish. Leaves of seagrass *Posidonia oceanica* were also found in it, but it could not be concluded whether they had been ingested intentionally or accidentally during the pursuit of prey. Interestingly, this specimen was caught in the very Zadar archipelago area that had been historically identified as the habitat of the common angel shark.

The second specimen was landed alive (Fig. 3) on a fishing boat on 23 April 2021 and transported and kept alive in the water tank of the Pula Aquarium. Their staff only performed basic measurements in order to keep the handling at a minimum and thus increase the specimen's chances of recovery. This immature male measured 68 cm in length, 37 cm in width, and weighed 3.2 kg. After nearly two weeks in the Aquarium, the specimen successfully recovered and it was decided it should be released alive on 4 May 2021 in the adjacent waters of the Marine Protected Area of the National Park Brijuni (exact location known but not publicly available).

DISCUSSION

Historically, *S. squatina* was common across large areas of coastal, continental and insular shelves of the Northeast Atlantic (southern Norway to Western Sahara), and the Mediterranean and Black Seas. Nowadays, records of this species are reported throughout the Mediterranean including the southern coasts of the western and central basins, the Ligurian, Northern Tyrrhenian, and Adriatic Seas on the northern coast, and the Levant and Aegean Seas in the eastern basin (Gordon *et al.*, 2019). It has also been documented in the Sea of Marmara and is the only angel shark species known to have been present in the Black Sea, with contemporary captures around the Bosporus Strait (Serena, 2005).

However, although angel sharks are reported, their records are rare. Usually, these rely on fisheries data and reports of by-catch, as well as novel approaches such as citizen science, social media, and interviews with fishers aimed at increasing knowledge on distribution (Fortibuoni *et al.*, 2016; Gordon *et al.*, 2019). On the other hand, the usefulness of scientific surveys, which are normally

Fig. 3: The immature male specimen of** S. squatina **caught and landed alive on 23 April 2021.
Sl. 3: Mladostni primerek sklata** (S. squatina)**, ki je bil ujet in izpuščen 23. aprila 2021.

considered a good source of various data, has been questioned in relation to detection of rare species, due to a complete lack of data on angel sharks in scientific trawl surveys conducted in the Adriatic Sea since 1948 (Jukić-Peladić *et al.*, 2001; Fortibuoni *et al.*, 2016; Holcer & Lazar, 2017).

An additional problem, quite common in the Mediterranean, is that frequently records from fisheries only classify angel sharks at genus level, which affects the possibility to determine the population status at species level. Precise data on angel sharks are thus hidden due to misreporting in fisheries or marketing under alternative common names. In many Mediterranean areas, angel sharks have been confused with other species, *e.g. Lophius* spp. or rays, particularly guitarfishes (species of the genus Rhinobatus). A recent analysis from the Adriatic Sea (Bakiu & Soldo, 2021) pointed to the reported landing of angel sharks and sand devils nei group (Squatinidae) in Albania. This Adriatic country was regularly reporting angel shark catches, with the largest catch stated in 2010 (78 tons). The last report dates to 2016, when a catch of 3 tons was declared. However, after conducting a scientific survey on shark catches, including interviews with fishermen, Bakiu & Soldo (2021) concluded that the reported catches were likely misidentified, like presumably in some other Mediterranean countries (Gordon *et al.*, 2019).

Given the critically endangered status of angel sharks in the Mediterranean, there are several existing protective measures that can be implemented for these species. In a binding Recommendation adopted by the 24 parties to the GFCM (GFCM/36/2012/3, amended to GFCM 42/2018/2) it has been agreed that retention and sale of 24 elasmobranchs listed in Annex II of the Barcelona Convention, including all three species of the Mediterranean angel shark, should be prohibited. The European Union (EU) transposed the GFCM Recommendation into EU Regulation (EU 2015/2102), prohibiting the retention of all three species of angel shark in the Mediterranean and augmenting the prior listing of *S. squatina* as a prohibited species under the Common Fisheries Policy annual fisheries quotas (Gordon *et al.*, 2019). However, the implementation of full protection measures at national levels by EU Member States has been poor. A positive example is Croatia, which is recognized as a champion in the protection of sharks and rays. The group of 28 species of sharks and rays that have been declared as strictly protected species, includes both Adriatic angels sharks. Nevertheless, being granted the maximum level of protection alone will not prevent the species from being caught, especially the angel sharks inhabiting the inshore area, where the fishing effort and the use of a broad range of bottom fishing gear in small- and large-scale fisheries are the most extensive. Therefore, the efforts of conservation action should not stop at the implementation of relevant international and regional obligations into national legislation, as fishery within angels sharks' habitats will continue. Although the results of this paper show that some angel sharks can indeed be landed alive and subsequently released back into the sea, proper management cannot rely on the possibility that the shark will be landed on a boat in good condition and that the fishermen involved will have the incentive and be motivated to release the protected species properly. Thus, the vital conservation issue is, after the implementation of conservation measures into national legislation, to identify and map the critical habitats occupied by angel sharks. As it can be presumed that those habitats will be defined within the inshore area, where proclaiming a marine protected area is a very sensitive and lengthy (if even possible) process, with different responsibilities, authorities, and interests overlapping, usually between fishery and environmental protection administration, the goal should be to determine limited, but large enough habitats where the use of bottom fishing gear will be restricted exclusively to the selective gear that cannot be used to target angel sharks. Having a protected area where the use of large mesh size gillnets and trammel nets, as well as towing fishing gear (which is completely unselective to relatively larger marine species) will be forbidden could result in giving a chance to angel shark populations to recover from depletion and hopefully reach the levels where they would not be endangered anymore.

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POJAVLJANJE NAVADNEGA SKLATA (*SQUATINA SQUATINA*) V JADRANSKEM MORJU

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POVZETEK

*Navadni sklat (*Squatina squatina*), danes opredeljen kot kritično ogrožena vrsta v Sredozemskem morju, ima v hrvaškem delu Jadrana najvišji nivo varovanja. To, še v 19. in 20. stoletju pogosto vrsto, so v zadnjih desetletjih le redko ujeli. Avtor v pričujočem prispevku poroča o dveh primerih ulova navadnega sklata v Jadranskem morju in razpravlja o njegovem trenutnem statusu ter predlaga učinkovite mere upravljanja z vrsto.*

Ključne besede: sklati, *Squatina squatina*, kritično ogrožena vrsta, Jadransko morje, Sredozemsko morje

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INTENTIONAL STRANDING OF A BLUE SHARK, *PRIONACE GLAUCA* (CARCHARHINIFORMES: CARCHARHINIDAE), IN PURSUIT OF PREY

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ABSTRACT

A short video recorded by a resident on 22 October 2020, on the Tisan-Yeşilovacık coast (northeastern Mediterranean), revealed the intentional stranding of a large specimen of Prionace glauca *in order to pursue prey. Intentional stranding is a hunting strategy that differs from the blue shark's usual feeding behaviour; however, the reported event was nothing more than a lucky coincidence that shed a different light on the hunting behaviour of* P. glauca*. Moreover, the present incident is crucial as it shows that large shark species living in open waters can enter coastal waters for feeding purposes, increasing the likelihood of dangerous encounters with humans.*

Key words: *Prionace glauca*, blue shark, stranding, hunting, coastal waters, eastern Levant

INCAGLIO INTENZIONALE DI UNA VERDESCA, *PRIONACE GLAUCA* (CARCHARHINIFORMES: CARCHARHINIDAE), ALL'INSEGUIMENTO DELLA PREDA

SINTESI

Un breve video registrato da un residente il 22 ottobre 2020, lungo la costa di Tisan-Yeşilovacık (Mediterraneo nord-orientale), ha rivelato l'incaglio intenzionale di un grosso esemplare di Prionace glauca*, per inseguire una preda. L'arenamento intenzionale è una strategia di caccia che differisce dall'usuale comportamento alimentare della verdesca. Tuttavia, l'evento riportato non è stato altro che una fortunata coincidenza che ha gettato una luce diversa sul comportamento di caccia di* P. glauca*. Il presente incidente è inoltre cruciale in quanto dimostra che le grandi specie di squali che vivono in acque aperte possono entrare nelle acque costiere per nutrirsi, aumentando la probabilità di incontri pericolosi con l'uomo.*

Parole chiave: *Prionace glauca*, verdesca, incaglio, caccia, acque costiere, Levante orientale

INTRODUCTION

The blue shark, *Prionace glauca* (Linnaeus, 1758), is an oceanic and circumglobal shark inhabiting temperate and tropical waters (Ebert & Stehmann, 2013). It is probably the widest-ranging chondrichthyan and nomad of the oceans, occurring from surface to at least 350 m in depth (Ebert & Stehmann, 2013). *P. glauca* is one of the well-documented pelagic sharks of the Mediterranean Sea (Serena *et al.*, 2020). Historically, the Mediterranean distribution of the blue shark extended into the Sea of Marmara, at least during the first quarter of the 20th century (Ninni, 1923), where it is now considered to be extinct (Kabasakal, 2020).

Small fishes and cephalopods, especially squids, associated with pelagic and inshore habitats, compose the primary prey of *P. glauca* (Tricas, 1979; Ebert & Stehmann, 2013). Although *P. glauca* is mainly an oceanic shark (Ebert & Stehmann, 2013), its coastal occurrences in very shallow waters have also been documented (Kabasakal, 2010); however, intentional stranding of the blue shark has not been observed previously. In the present article, the authors report on an incident of intentional stranding of a large *P. glauca* specimen in pursuit of prey. Intentional stranding is a conspicuous hunting strategy, which is mostly observed in killer whales, *Orcinus orca*, when hunting for elephant seal pups, in pursuit of prey, the hunter swims directly to the surf zone and intentionally strands itself (Guinet & Bouvier, 1995).

MATERIAL AND METHODS

On 22 October 2020, a short (22 second) video of the present incident of intentional stranding of blue shark was recorded on the Tisan-Yeşilovacık coast (northeastern Mediterranean; Fig. 1) by a resident, Mr. Mustafa Çınar. The footage was emailed to the second author, who forwarded it to the first author to confirm species identification and analyses of the feeding behaviour. Species identification is based on the field marks provided by Ebert and Stehmann (2013). Feeding responses of the present blue shark were based on the feeding behaviour of *P. glauca* described by Tricas (1979). The footage has been archived by the authors and is available for further inspection on request.

Fig. 1: Map depicting the approximate location (*) of the blue shark's intentional stranding on the Tisan-Yeşilovacık coast, northeastern Mediterranean Sea.
Sl. 1: Zemljevid obravnavanega območja s približno lokaliteto (*), kjer je namerno nasedel sinji morski pes ob obali Tisan-Yeşilovacık v severovzhodnem Sredozemskem morju.

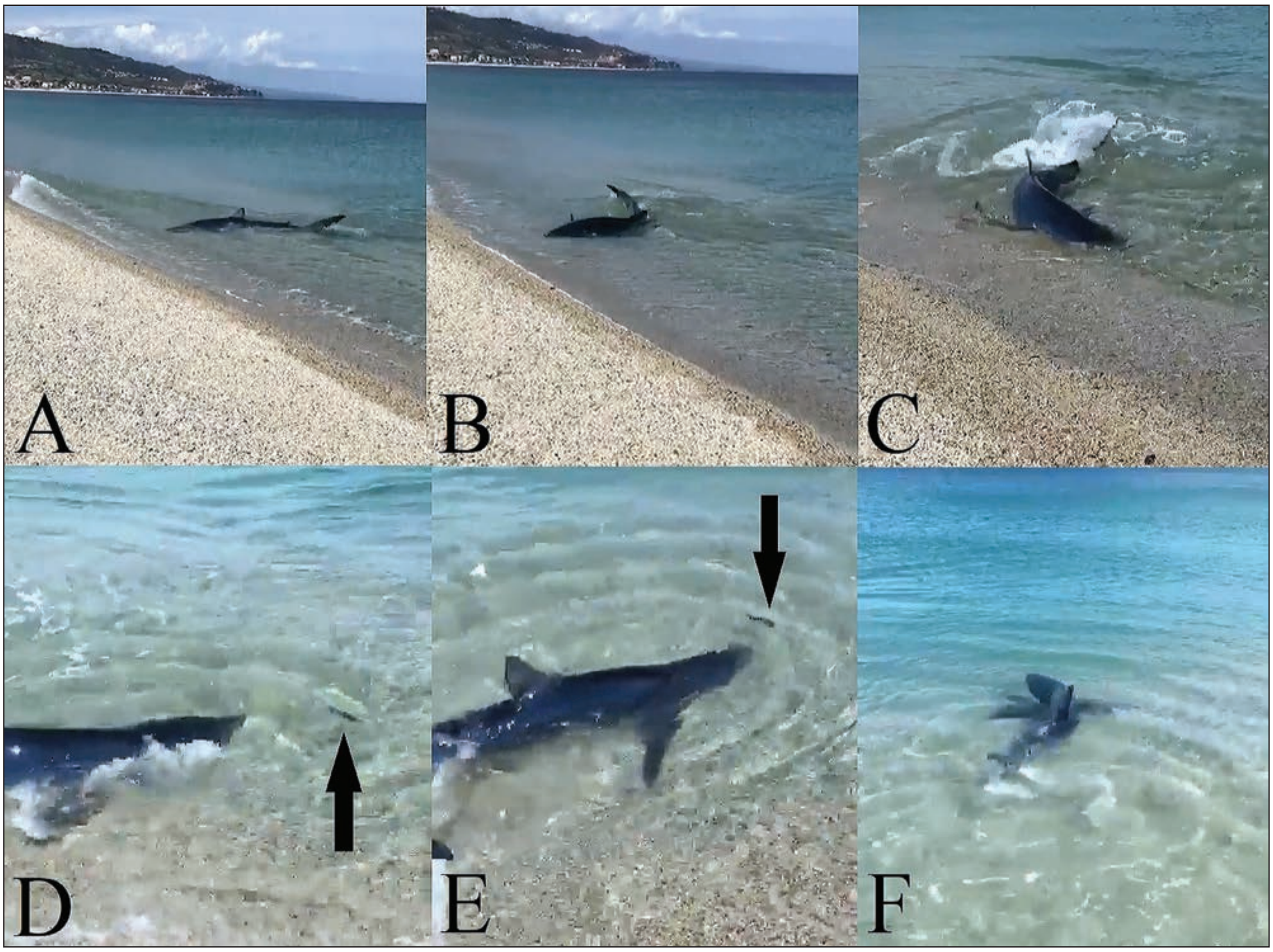

Fig. 2: Sequentially captured images of intentional stranding of a *P. glauca* ***during hunting: (a) charging of the blue shark; (b) bending tail and body just before turning; (c) turning; (d, e) head swaying; and (f) turning and moving away from the swash zone (Video footage courtesy of Mr. Mustafa Çınar).***
Sl. 2: Zaporedni posnetki namernega nasedanja sinjega morskega psa *P. glauca* ***med lovom: (a) priprava; (b) zvijanje repa in telesa tik pred obratom; (c) obrat; (d, e) zibanje glave; in (f) obrat in umik iz obrežnega pasu (avtor posnetka: Mr. Mustafa Çınar).***

RESULTS AND DISCUSSION

Dorsal coloration of the present specimen is dark blue, turning brighter on sides (Fig. 2); body slender (Fig. 2a, e, f) with long, pointed pectoral fins (Fig. 2e, f); the first dorsal fin is almost on the mid-body, but slightly closer to the pectoral-fin bases than the pelvic fins (Fig. 2a, e); the second dorsal fin is remarkably smaller than the first one (Fig. 2a); the caudal fin is narrow-lobed (Fig. 2a). The observed characters coincided with the field marks of *P. glauca*, presented by Ebert and Stehmann (2013). The total length of the shark was estimated to be 200 cm.

During the first seconds of the video, the blue shark was observed accelerating in a straight line (charging) into the swash zone (Fig. 2a, b), then turning in an alert state, and subsequently starting a series of slow to fast lateral head swaying movements (Fig. 2c). The head swaying lasted nearly 11 seconds and was performed in an intentionally stranded status in the swash zone (Fig. 2b, c, d, e). During that time a fish, probably the prey, was seen moving around the blue shark's head (Fig. 2d, e). The shark made several unsuccessful attempts at grabbing it, then turned to the seaboard and moved away (Fig. 2f). The total duration of the observed intentional stranding of the blue shark was 17 seconds.

Killer whales, *Orcinus orca* (Linnaeus, 1758), are known for employing intentional stranding techniques when hunting sea lions and seals (Guinet & Bouvier, 1995; Vila *et al*., 2008). Intentional stranding observed in *O. orca* is a very specialised hunting strategy. Juvenile killer whales practice it for a remarkably long time, learning through apprenticeship (Guinet

& Bouvier, 1995). Previous studies have shown that beaching play is an essential step in a successful intentional stranding of the killer whale, allowing the capture of prey (Guinet & Bouvier, 1995). Since no beaching play was observed in the present incident, the intentional stranding of the blue shark likely resulted from the predator's charging in the direction of the shoreline in too shallow coastal waters.

In an extensive survey on the feeding behaviour of *P. glauca*, near Santa Catalina Island, California (Tricas, 1979), underwater observation of blue shark during hunting revealed four feeding responses, namely, slow head swaying, turning, charging, and tail standing. In the present incident we observed three of the four feeding movements, all except the tail standing, which in the mentioned survey manifested with the shark first circling the lower portion of a school of prey, then moving up to the prey and assuming a near-vertical attitude, using broad tail sweeps to maintain position (Tricas, 1979). Since the blue shark in our case intentionally stranded, the tail standing was not possible; however, a quick sequence of charging, turning, head swaying, and turning again before the blue shark left the swash zone, was observed (Fig. 2).

Although *P. glauca* is an oceanic shark, frequently in pursuit of pelagic prey (Tricas, 1979; Ebert & Stehmann, 2013), the present incident suggests that it may occasionally use the intentional stranding technique to feed on coastal prey. Feeding was also reported as a possible reason for the unusual presence of *P. glauca* recruits in Galician coastal waters (Bañón *et al.,* 2016). The presence of coastal organisms has been observed in stomach contents of the blue shark. Tricas (1979) reported the presence of fishes associated with coastal habitats, such as the jack mackerel (*Trachurus symmetricus*), the pipefish (*Syngnathus californiensis*), and the blacksmith (*Chromis punctipinnis*), in the stomach contents of a *P. glauca* sampled in Californian waters. Kabasakal (2010) observed the remains of goatfish (*Mullus* sp.) and cuttlefish (*Sepia* sp.) in the stomach content of a juvenile blue shark (98 cm TL) incidentally caught in the shallow waters of Edremit Bay (northeastern Aegean Sea).

The present incident of intentional stranding was a display of hunting strategy differing from the blue shark's usual feeding behaviour ((Tricas, 1979). It was, generally speaking, nothing more than a lucky coincidence, which nevertheless provided a different perspective to the hunting behaviour of *P. glauca*. Although the blue shark is not very aggressive, it is not very timid either and has been known to harass spearfishing divers (Ebert & Stehmann, 2013). It is recognised that, besides *P. glauca*, several other large shark species, such as the shortfin mako shark (*Isurus oxyrinchus*) and the sandbar shark (*Carcharhinus plumbeus*), can also be seen in the coastal waters of the study area. Due to intensive fishing and aquaculture activities in the region the possibility of human encounter with large predatory sharks may be increasing. In a recent encounter of this kind with sandbar sharks, aquaculture divers have been involved in a provoked attack (Ergüden *et al.*, 2020). The present incident is important as it shows that large shark species living in open waters can enter coastal waters for feeding purposes, and this increases the likelihood of dangerous encounters with humans.

Although *P. glauca* is the most common shark in the eastern Mediterranean (Bariche, 2012; Damalas & Megalofonou, 2012), it is considered critically endangered in the Mediterranean Sea due to bycatching in pelagic fisheries (Otero *et al.*, 2019). Therefore, monitoring the existence and seasonality of large shark species, such as *P. glauca*, occurring in the region, especially near aquaculture cages, is of great importance in terms of both the survival of shark species and the safety of people.

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The authors thank to Mr. Mustafa Çınar for providing the footage of an intentionally stranded blue shark.

NAMERNO NASEDANJE SINJEGA MORSKEGA PSA, *PRIONACE GLAUCA* (CARCHARHINIFORMES: CARCHARHINIDAE), MED ZASLEDOVANJEM PLENA

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POVZETEK

Domačin z obale Tisan-Yeşilovacık (severovzhodno Sredozemsko morje) je 22. oktobra 2020 posnel krajši videoposnetek o namernem nasedanju velikega primerka sinjega morskega psa, Prionace glauca*, ki je zasledoval plen. Namerno nasedanje je plenilska strategija, drugačna od običajnega plenjenja. Slučajna in srečna okoliščina, v kateri je nastal posnetek, je obelodanila nenavadno vedenje. Poleg tega je ta primer pomemben, ker je pokazal da lahko odprtovodni morski psi lahko zaidejo v obalne vode zaradi prehranjevanja, s tem pa do večje možnosti nevarnih srečanj s človekom.*

Ključne besede: *Prionace glauca*, sinji morski pes, nasedanje, lov, obalne vode, vzhodni Levant

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USING CITIZEN SCIENCE TO DETECT RARE AND ENDANGERED SPECIES: NEW RECORDS OF THE GREAT WHITE SHARK *CARCHARODON CARCHARIAS* OFF THE LIBYAN COAST

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ABSTRACT

*The presence of the great white shark (*Carcharodon carcharias*) in the Mediterranean Sea is well documented, but encounters with this species are rare and all assumptions about its spatial and temporal distribution are heavily relying on anecdotal observations. To date, only one record off the Libyan coast has been reported, raising the question if this species is underreported in these waters or simply represents a rare occasional transient. We utilised citizen science-sourced data to document the presence of the great white shark off the Libyan coast, and found six additional records for this species from the period between 2017 and 2020. Our study points out the need for scientific monitoring of this species along the Libyan coast to facilitate the establishment of effective conservation plans to protect this critically endangered species.*

Key words: Elasmobranchii, cartilaginous fish, conservation biology, fisheries, social media, threatened species

USO DELLA SCIENZA DEL CITTADINO PER INDIVIDUARE SPECIE RARE E IN PERICOLO: NUOVI RITROVAMENTI DEL GRANDE SQUALO BIANCO *CARCHARODON CARCHARIAS* AL LARGO DELLA COSTA LIBICA

SINTESI

*La presenza del grande squalo bianco (*Carcharodon carcharias*) nel Mediterraneo è ben documentata, ma gli incontri con questa specie sono rari e tutte le ipotesi sulla sua distribuzione spaziale e temporale sono fortemente basate su osservazioni aneddotiche. Fino ad oggi, è stato riportato un solo avvistamento al largo della costa libica, portando alla domanda se questa specie sia sotto-segnalata in queste acque o semplicemente rappresenti un raro transitorio occasionale. Gli autori hanno utilizzato i dati forniti dai cittadini per documentare la presenza del grande squalo bianco al largo della costa libica. Hanno trovato dati inerenti sei avvistamenti aggiuntivi di questa specie tra il 2017 e il 2020. Lo studio sottolinea la necessità di un monitoraggio scientifico di questa specie lungo la costa libica per facilitare l'istituzione di piani di conservazione efficaci per proteggere questa specie minacciata.*

Parole chiave: Elasmobranchii, pesci cartilaginei, biologia della conservazione, pesca, social media, specie minacciate

INTRODUCTION

The great white shark *Carcharodon carcharias* (L., 1758) is, with a total length of at least six meters (Randall, 1973; Castro, 2012), one of the largest marine predators worldwide. This cosmopolitan species inhabits mainly temperate and subtropical waters, with adult individuals rarely entering tropical waters (Compagno, 2001). In the Mediterranean Sea, white sharks have been frequently reported from the Strait of Sicily (Storai *et al*., 2000; Ben-Amor *et al*., 2020; Tiralongo *et al*., 2020), the Tyrrhenian Sea (Storai *et al*., 2000), the Gulf of Lions (De Maddalena & Zuffa, 2009), the Balearic Islands (Morey *et al*., 2003), the Adriatic Sea (De Maddalena, 2000; Soldo & Jardas, 2002), the Ionian Sea (Papaconstantinou, 2014), the Marmara Sea, including the Bosphorus Strait (Kabasakal, 2003, 2014, 2016), and the Aegean Sea (Kabasakal, 2014, 2016, 2019; Papaconstantinou, 2014). Based on the occurrence of neonates, small juveniles and pregnant females, the existence of two possible nursery areas has been proposed in the Mediterranean Sea, one in the Strait of Sicily, Central Mediterranean Sea (Fergusson, 1996; Saïdi *et al*., 2005; Bradaï & Saïdi, 2013) and another in Edremit Bay, northern Aegean Sea (Kabasakal, 2016, 2020a,b).

Molecular studies examining the genetic profile of white sharks via the mt-DNA control region have revealed the presence of an isolated Mediterranean population, which exhibits little genetic variability and only has limited genetic exchange with the Atlantic population (Gubili *et al*., 2011; 2015; Leone *et al*., 2020). This lack of genetic diversity coupled with little or no contemporary immigration from the Atlantic renders the Mediterranean population extraordinarily prone to extinction (Gubili *et al*., 2011; 2015). According to the IUCN Red List of Threatened Species, white sharks are declared globally vulnerable (VU; Rigby *et al*., 2019), while the Mediterranean population is listed as critically endangered (CR; Soldo *et al*., 2016). In an attempt to assess population trends and dynamics for white sharks in the Mediterranean, Moro *et al*. (2020) compiled a comprehensive database of 773 white shark records between 1860 and 2016 and found a 52–96% overall population decline in different Mediterranean sectors and a contraction in spatial distribution. It should be noted that encounters with white sharks in the Mediterranean Sea are usually rare and very sporadic in nature. Therefore, all hypotheses about distribution, migration patterns, parturition, and the conservation status of white sharks in the Mediterranean Sea rely on anecdotal observations, like historical captures and sighting data (Fergusson, 1996; De Maddalena & Heim, 2012; Boldrochhi *et al*., 2017; Moro *et al*., 2020). Due to insufficient fishery data for many shark species, especially rare ones (Damalas & Megalofonou, 2012; Cashion *et al*., 2019), and the absence of coordinated scientific surveys, citizen science has frequently been used to monitor the presence of rare shark species in the Mediterranean Sea (e.g., Giovos *et al*., 2019; Kabasakal & Bilecenoğlu, 2020; Jambura *et al*., 2021).

Landing almost 4.3 tonnes of chondrichthyan fishes in 2015, Libya is the leading country for chondrichthyan catches in the Mediterranean Sea (Jeffries, 2019). However, little is known about the presence of white sharks in Libyan waters and only a single record of a large female white shark off the Libyan coast does exist (Galaz & De Maddalena, 2004). Assessing the presence of white sharks in Libyan waters is, consequently, of utmost importance for future conservation planning of this iconic shark species. In our study, a systematic online search on popular social media platforms (i.e., Facebook, YouTube, Instagram, and Twitter) was conducted to document the presence of the great white shark *C. carcharias* along the Libyan coast and to augment our understanding of the distribution and ecology of this rare species in the Mediterranean Sea.

MATERIAL AND METHODS

Records of white shark *C. carcharias* off the Libyan coast were accumulated within the context of the citizen-science initiative "Monitoring Elasmobranchii in Libyan Waters", which was conducted by "Marine Biology in Libya". This programme puts a focus on the occurrence of chondrichthyan fishes in the Mediterranean Sea and applies a verified citizen science model, in which citizen-submitted observations are checked by experts (Gardiner *et al*., 2012). The records either came directly from fishermen reporting their catch, or through systematic online searches on social media platforms, namely Facebook, YouTube, Instagram, and Twitter using the Arabic keyword for great white shark (القرش الأبيض, "alqarsh al'abyad") and shark (قرش, "qarash"; or كلب بحر, "kaleb baher"). Following the ethical code proposed by Monkman et al. (2018), all web scraping was performed responsibly to avoid compromising any personal data or images. All records had to be accompanied by photographic evidence confirming the identification of the reported species. Authenticity and originality of the images were checked with the Google automatic image recognition tool. Species identification was based on the following features: (1) heavily, long-snouted spindle-shaped body; (2) strong keels on caudal peduncle; (3) large first dorsal fin, very small second dorsal and anal fins; (4) lunate caudal fin; (5) large, flat, triangular, serrated teeth; (6) long

Tab. 1: Observations of great white sharks (Carcharodon carcharias) reported from the Mediterranean Sea between 2017 and 2020. Abbreviation: YOY, young-of-year. *size and ontogenetic stage estimated by the observer.
Tab. 1: Opazovanja belih morskih volkov (Carcharodon carcharias), ki so bila v Sredozemskem morju dokumentirana v letih 2017-2020. Okrajšava: YOY, enoletni primerek. *velikost in ontogenetski stadij, ki ga je ocenil opazovalec.

Country	Region	Date	Fishing type	Condition	Sex	Ontogeny	TL [cm]	Weight [kg]	Coordinates	Source
Italy	Lampedusa	23.05.2020	observation	alive	female	adult	500	-	-	Tiralongo *et al.* (2020)
Libya	Bouri field	29.07.2017	observation	alive	-	adult*	600*	-	34.054444°N, 12.789972°E	this study
	Buerat	16.05.2018	gillnet	dead	female	juvenile	230	135	31.399611°N, 15.736333°E	this study
	Brega	12.01.2020	observation	dead	male	adult	520	-	30.3475°N, 19.441528°E	this study
	Daryanah	23.04.2020	observation	alive	-	adult*	600*	-	32.398306°N, 20.339444°E	this study
	Tripoli	21.09.2020	gillnet	dead	female	YOY	140	-	-	this study
	Tripoli	04.11.2020	observation	alive	-	adult*	600*	-	32.959333°N, 13.167389°E	this study
Turkey	Gökçeada	01.2017	gillnet	dead	-	juvenile	180	-	-	Kabasakal (2020a)
	Altınoluk	04.2017	gillnet	alive	-	YOY	160	-	-	Kabasakal (2020a)
	Didim	04.06.2017	purse seine	dead	male	juvenile	200	60	-	Kabasakal *et al.* (2019)
	Izmir	14.04.2018	gillnet	dead	female	juvenile	180	-	-	Kabasakal *et al.* (2019)
	Sousse	28.04.2020	drift longline	dead	female	juvenile	232	90	35.016944°N, 12.186389°E	Ben-Amor *et al.* (2020)
	Kumkale	08.06.2020	gillnet	dead	-	YOY	155	-	-	Kabasakal (2020b)
	Enez	14.06.2020	observation	alive	-	juvenile	200	-	-	Kabasakal (2020b)

gill slits; (7) black eyes; (8) sharp colour change from greyish dorsally to white ventrally; (9) pectoral fins with black tips on the ventral side (Ebert *et al.*, 2013). Subsequent interviews were conducted with citizen scientists to confirm the reported data and obtain further information. If direct contact with the observer was not successful, the record was considered ambiguous and subsequently discarded. In addition to date and location, the following data were added to each record when possible: (1) time, (2) fishing method, (3) condition, (4) sex, (5) estimated total length (TL_{est}), (6) weight (Tab. 1). Estimated total lengths were validated by comparing the shark with objects of known size in the photos. When applicable, ontogenetic stages were identified based on the total length following Boldrocchi *et al.* (2017): young of the year (YOY) (TL ≤ 1.75 m), juvenile (TL 1.75–3.0 m), subadult (♂TL 3.0–3.6 m; ♀TL 3.0–4.5 m), adult (♂TL > 3.6 m; ♀TL > 4.5 m).

RESULTS

Between 2017 and 2020, six white sharks (*C. carcharias*) were reported off the Libyan coast, constituting 42.9% of all published records of this species in the entire Mediterranean Sea during the same period (Tab. 1). One record was from 2017, one from 2018, and four were from 2020. Half of the recorded white sharks were reported dead (n=3); two of them were caught in set gillnets and one was washed ashore (see cases 2, 3, and 5). Ontogenetic stage and sex could be determined for four and three individuals, respectively; two sharks were adults (one male, one of unknown sex) and two were juveniles (both female). A short description for each record is provided below.

Case 1: On 29 July 2017, a white shark was filmed from an oil platform while swimming near the surface in the Bouri Offshore Field, 120 km north of the Libyan coast, (34.054444°N, 12.789972°E; Figs. 1, 2A; Tab. 1). It was not possible to determine the sex or size of this specimen. The observer, however, estimated it to be 6 m long, and, therefore, likely an adult specimen.

Case 2: On 16 May 2018, a small white shark was caught in a gillnet near the village of Buerat, 84 km west of Sirte (31.399611°N, 15.736333°E; Figs. 1, 2B; Tab. 1). The shark was alive when captured, but was landed and sold at the local fish market. The fishermen identified it as a shortfin mako shark (*Isurus oxyrinchus*), however, the black tips on the ventral side of the pectoral fins and the flat triangular teeth clearly indicate it was a white shark. The specimen was a female measuring 2.3 m (total length, TL) and, therefore, a juvenile.

Case 3: On 12 January 2020, a large white shark was washed ashore near the town of Brega, 300 km east of Sirte (30.3475°N, 19.441528°E; Figs. 1, 2C; Tab. 1). No external injuries that would explain the cause of death could be detected. The specimen was a male with well developed claspers and measuring 5.2 m (TL). We, therefore, conclude that this specimen represented an adult individual.

Case 4: On 23 April 2020, a white shark was observed swimming near the surface following a small fishing vessel, which carried out blast fishing near the town of Daryanah, 32 km east of Benghazi

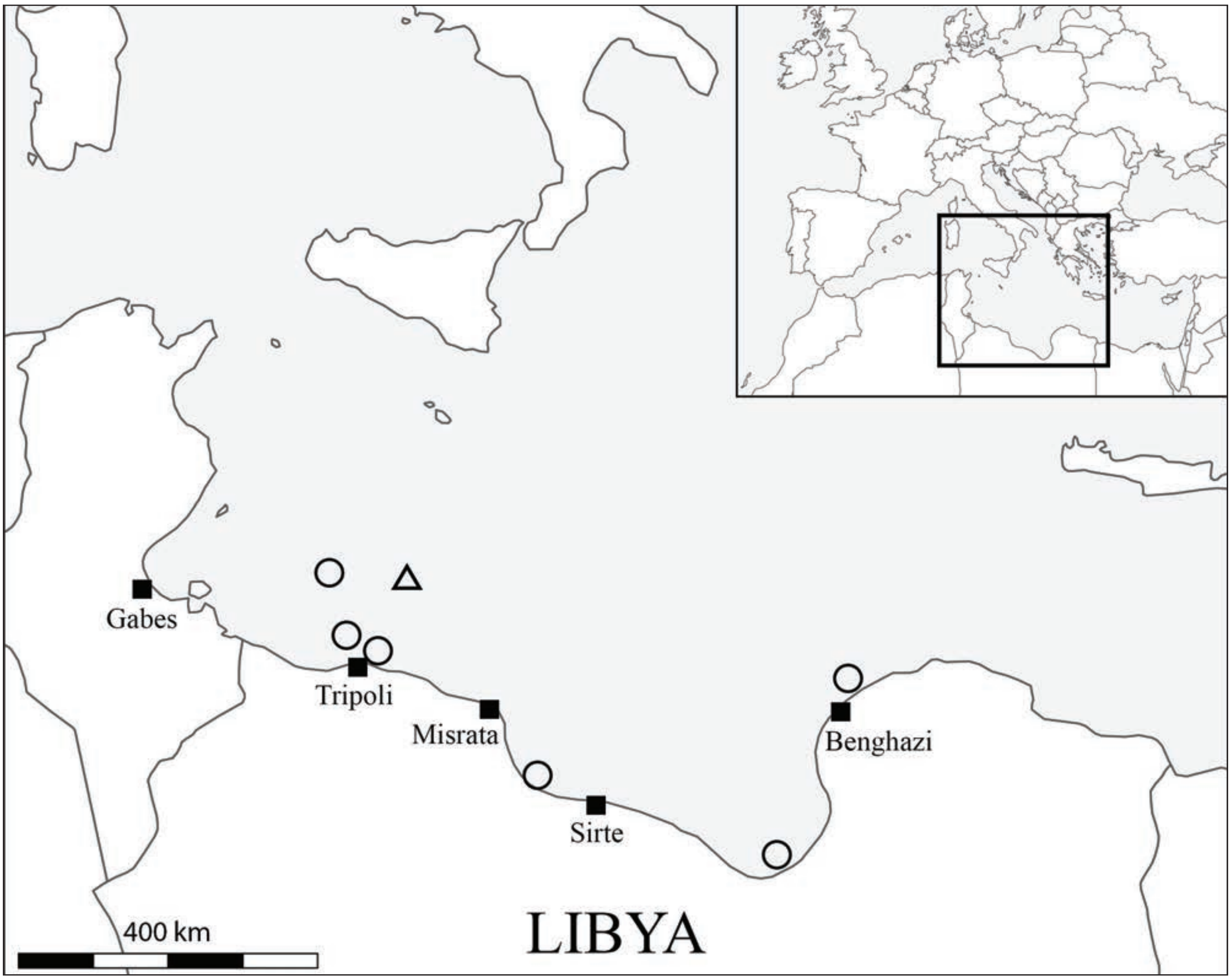

Fig. 1: Occurrence of the great white shark (*Carcharodon carcharias*) off the Libyan coast. Recent records (circle) were reported between 2017 and 2020, while the only previously published record (triangle) was reported in 2002. Detailed information about each observation is provided in Table 1.
Sl. 1: Pojavljanje belega morskega volka (*Carcharodon carcharias*) vzdolž libijske obale. Recentni podatki (krogci) izvirajo med leti 2017 in 2020, medtem ko je bil edini dokumentirani zapis o pojavljanju te vrste (trikotnik) objavljen leta 2002. Natančni podatki o vsakem od opazovanih primerov so navedeni v Tabeli 1.

(32.398306°N, 20.339444°E; Fig. 1; Tab. 1). The fishermen estimated the shark to be 6 m long. The video material, however, did not allow confirmation of this estimate. Although the shark was reported to be alive, at the end of the video sequence one of the fishermen threw dynamite towards the shark in order to chase it off and probably killed it.

Case 5: On 21 September 2020, a small white shark was caught in a set gillnet and landed in the Bab Albaher fish market in Tripoli (Figs 1, 2D; Tab. 1). The exact locality where this individual was caught could not be reconstructed. However, due to the ongoing civil war in Libya, fishing boats from Tripoli are not allowed to enter the Gulf of Sidra and are restricted to the area between the Libyan-Tunisian boundary to the west and the city of Misrata to the east. Therefore, it is certain that this individual was caught in the area around Tripoli. The shark was a female measuring 1.4 m. The presence or absence of an umbilical scar could not be verified because the whole ventral side of the shark was cut open. Nevertheless, the total length is well within the size category of young of year (YOY < 1.75 m) and, therefore, it is considered as such here. This record represents the southernmost occurrence of a YOY white shark in the Mediterranean Sea.

Case 6: On 4 November 2020, a white shark was observed in the proximity of two small fishing vessels near Tripoli (32.959333°N, 13.167389°E; Figs. 1, 2E; Tab. 1). The shark was swimming close to the surface and was accompanied by seven pilot fish (*Naucrates ductor*). The total length was estimated to be 6 m by the fishermen, but the video sequence did not allow confirmation of this estimate or identification of the sex of the specimen.

DISCUSSION

The presence of white sharks in the Mediterranean Sea has been known since the Middle Ages (476–1453) but is documented solely based on anecdotal reports of rather rare encounters (De Maddalena & Heim, 2012; Boldrocchi *et al*., 2017). In the present paper, citizen science-sourced data from social media platforms was used to gain a more detailed insight into the occurrence, distribution, and ecology of this elusive species along the Libyan coast. The species was previously only reported from this region in a single record of an adult female shark caught in a tuna cage 55 miles off Tripoli (Galaz & De Maddalena, 2004). Our search resulted in six additional records reported over a relatively short period (between 2017 and 2020), indicating that this species might be more common in this area than previously thought. In a recent study, five specimens of *C. carcharias* were reported from the North East Aegean Sea, based on social media and internet sources (Kabasakal & Bilecenoğlu, 2020), further indicating the importance and potential of such data sources (and citizen science in general) for white shark research in the Mediterranean Sea.

Our results suggest that both immature and mature white sharks exploit the waters off the Libyan coast. The Central Mediterranean Sea is characterised by high biodiversity, especially in the area around the Strait of Sicily (Spanò & De Domenico, 2017), which is also an area displaying a high occurrence of white sharks (Fergusson, 1996; Boldrocchi *et al*., 2017). Fergusson (1996) proposed that this region was critical for the species' reproduction and that the neritic waters of Sicily and Tunisia served as nursery areas, a hypothesis that has been supported by subsequent studies (e.g., Saïdi *et al*., 2005; Bradaï & Saïdi, 2013; Boldrocchi *et al*., 2017).

Our observations of a young of the year and a juvenile white shark along the Libyan coast represent the southernmost occurrence of immature individuals of this species in the Mediterranean Sea and suggest that the Central Mediterranean nursery area might not be restricted to Sicily and Tunisia but may extend as far south as Libya. This seems reasonable, as white sharks can inhabit vast nursery grounds with YOYs travelling up to 700 km within a month (Weng *et al*., 2007). The Gulf of Gabes, a frequently suggested nursery ground for white sharks (Saïdi *et al*., 2005; Bradaï & Saïdi, 2013), is situated ca. 350 km west of where the YOY reported here was landed. It should be noted that incidental captures of YOY and juvenile white sharks in Tunisia usually occur in winter and spring, with a peak in February, while no YOY or juvenile has been reported in September so far, when the specimen documented here was caught. Therefore, an eastwards movement of YOY and juvenile white sharks from their primary nursery area in the Gulf of Gabes cannot be excluded either. The juvenile specimen reported here was caught further east, ca. 700 km west of the Gulf of Gabes. Previously, juveniles were reported to travel greater distances than YOYs (Kabasakal, 2020a), further indicating that the Libyan coast might serve as an extension of the nursery ground of the Gulf of Gabes. More data, however, is needed to confirm this.

The great white shark *C. carcharias* is listed as an Appendix II species of the Convention on International Trade in Endangered Species (CITES) and is also included in the Barcelona Convention Annex II SPA/BD protocol. According to the Fisheries Commission for the Mediterranean Sea (GFCM), white sharks caught during fishing operations have to be released promptly and unharmed to the greatest extent possible. They cannot be retained on board, transferred, landed or sold (Recommendation GFCM/42/2018/2). Our study revealed that critically endangered white

Fig. 2: Reports of great white sharks** (Carcharodon carcharias) **observed off the Libyan coast between 2017 and 2020. Detailed information about each observation is provided in Table 1. Photo credits: (A) Jamal Al hamali, (B) Archive Marine Biology in Libya Society, (C) Mohamed Ahmed Salah, (D) Kamal Zager, (E) Aimen Al jerbie.

Sl. 2: Pojavljanje morskega volka** (Carcharodon carcharias) **vzdolž libijske obale v obdobju med 2017 in 2020. Natančni podatki o vsakem od opazovanih primerov so navedeni v Tabeli 1. Avtorji fotografij: (A) Jamal Al hamali, (B) Archive Marine Biology in Libya Society, (C) Mohamed Ahmed Salah, (D) Kamal Zager, (E) Aimen Al jerbie.

sharks are caught and sold in Libya, despite Libya being a member of the GFCM and, therefore, obliged to follow this recommendation. One of the main problems we identified when talking to fishermen about their records was that they were completely unaware of the presence of white sharks in their fishing area and usually mistook the reported specimens for shortfin makos (*Isurus oxyrinchus*). We therefore urge for the organisation of educational and awareness campaigns aimed at aiding fishermen in correctly identifying white sharks and informing them about the white shark's conservation status and regulations that are in place to help this species recover in the Mediterranean Sea.

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UPORABA LJUBITELJSKE ZNANOSTI ZA PRIDOBIVANJE PODATKOV O REDKI IN OGROŽENI VRSTI: NOVI PODATKI O POJAVLJANJU BELEGA MORSKEGA VOLKA *CARCHARODON CARCHARIAS* OB LIBIJSKI OBALI

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POVZETEK

*Čeprav je navzočnost belega morskega volka (*Carcharodon carcharias*) v Sredozemskem morju dobro raziskana, so srečanja s to vrsto redka, domneve o njeni prostorski in časovni razširjenosti pa temeljijo predvsem na anekdotičnih opazovanjih. Do zdaj je bil objavljen le en zapis o pojavljanju ob libijski obali, zaradi katerega ni jasno ali je pojavljanje te vrste podcenjeno ali pa gre za redko in slučajno vrsto. V tem prispevku so avtorji želeli z uporabo podatkov na osnovi ljubiteljske znanosti dokumentirati navzočnost belega morskega volka ob libijski obali. Zbrali so 6 dodatnih primerov pojavljanja te vrste med leti 2017 in 2020, ki se nanašajo na komaj skotene mladiče ter mladostne in odrasle primerke. V prispevku poudarjamo potrebo po raziskovalnem monitoringu te vrste vzdolž libijske obale, ki bi olajšala pripravo učinkovitih varstvenih načrtov za varovanje te kritično ogrožene vrste.*

Ključne besede: Elasmobranchii, hrustančnice, ohranitvena biologija, ribištvo, družbena omrežja, ogrožena vrsta

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A NEW RECORD OF *CLINITRACHUS ARGENTATUS* (OSTEICHTHYES: CLINIDAE) FROM THE TUNISIAN COAST (CENTRAL MEDITERRANEAN SEA)

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ABSTRACT

The present note reports a new record of Clinitrachus argentatus *(Risso, 1810) from Tunisian waters based on a specimen found in the stomach contents of a black scorpion fish* Scorpaena porcus *Linnaeus, 1758. The cline was only slightly digested, proving that the prey and the predator occurred in the same area. This finding extends the range of the species off the Tunisian coast, which was previously only reported from southern areas.*

Key words: *Clinitrachus argentatus*, prey, predator, stomach content, *Scorpaena porcus*

NUOVO RITROVAMENTO DI *CLINITRACHUS ARGENTATUS* (OSTEICHTHYES: CLINIDAE) AL LARGO DELLA COSTA TUNISINA (MEDITERRANEO CENTRALE)

SINTESI

La presente nota riporta un nuovo ritrovamento di Clinitrachus argentatus *(Risso, 1810) nelle acque tunisine, basato su un esemplare trovato nel contenuto stomacale di uno scorfano nero* Scorpaena porcus *Linnaeus, 1758. La bavosella d'alga era solo leggermente digerita, dimostrando che la preda e il predatore si trovavano nella stessa zona. Questa scoperta estende l'areale della specie al largo della costa tunisina, mentre in precedenza era stata segnalata solo da aree meridionali.*

Parole chiave: *Clinitrachus argentatus,* preda, predatore, contenuto dello stomaco, *Scorpaena porcus*

INTRODUCTION

Clinitrachus argentatus (Risso, 1810) commonly occurs in shallow coastal waters of the north-eastern Atlantic from Portugal (Carneiro *et al.*, 2014) to Morocco (Lloris & Rucabado, 1998). The species is known throughout the western Mediterranean Basin, the Adriatic Sea, the Sea of Marmara, and the Bosphorus Strait (Wirtz & Zander, 1986), its eastward distribution reaching the Levant Basin (Golani, 2005; Ali, 2108; Bariche & Fricke, 2019). While southwards, *C. argentatus* is not reported from the coast of Egypt (El Sayed *et al.*, 2017), it does occur along the Libyan shore (El Baraasi *et al.*, 2019).

In Tunisia, *C. argentatus* was first recorded off Salakta, a city located on the eastern part of the coast, where Gharred (1999) observed 21 specimens, measuring between 29 and 76 mm in total length. Since then no additional of *C. argentatus* had been recorded in the wild although several studies focussing on the local ichthyofauna were performed (Bradaï *et al.*, 2004; El Kamel-Moutalibi *et al.*, 2009; Ounifi-Ben Amor *et al.*, 2016; Rafrafi-Nouira, 2016). The present is a report of a new *C. argentatus* found in the stomach contents of a black scorpion fish *Scorpaena porcus* Linnaeus, 1758 during a study on the diet of this species (Rafrafi-Nouira *et al.*, 2016).

MATERIAL AND METHODS

The specimen of *C. argentatus* was found in the stomach contents of a black scorpionfish, *Scorpaena porcus* Linnaeus, 1758 caught on 21 October 2013 in a commercial gill net with a mesh size of 26 mm, off Ras Jebel, northern Tunisia, on rocky bottom partially covered by sea grass and algae, at 37°14'331.84"N and 10°09'52.35"E (Fig. 1). The scorpionfish was an adult male measuring 188 mm in total length (TL) and its total body weight (TBW) reached 142 g. The specimen of *C. argentatus* measured 48 mm TL and weighed at least 3.1 g (Fig. 2). The digestion slightly affected the distal end of its caudal fin and areas of its anal fin. Some measurements and meristic counts were recorded and summarised in Table 1. The specimen was fixed in 10% buffered formaline and preserved in 75% ethanol. It was deposited in the Ichthyological Collection of Institut Supérieur de Pêche et d'Aquaculture of Bizerte, located in Menzel Jemil (Tunisia), under catalogue number ISPAB Cli-arg 01.

RESULTS AND DISCUSSION

Although it was slightly affected by the beginning of digestion in the stomach of *S. porcus*, the present specimen was identified as *C. argentatus* through the combination of the following morphological characters: body flattened laterally, covered with cycloid scales deeply embedded in skin; caudal peduncle thin; head conical and more pointed than in specimens from the Blenniidae family according to Wirst & Zander (1986); dorsal fin with deep incision, anterior part consisting of three spines, posterior part high, especially in its distal area, the meristic formula of dorsal fin similar to that recorded by Orlando-Bonaca & Trkov (2016). The colour of the specimen was orange-reddish with yellow areas, which was rather unusual compared to Orlando-Bonaca & Trkov (2016), who noted that the species is dark green or brownish with a marbled pattern, displaying some white or silver areas. Additionally, Orlando-Bonaca & Trkov (2016) added that the colour pattern of the species varies according to the macroalgal species used by *C. argentatus* as a hiding place, and can

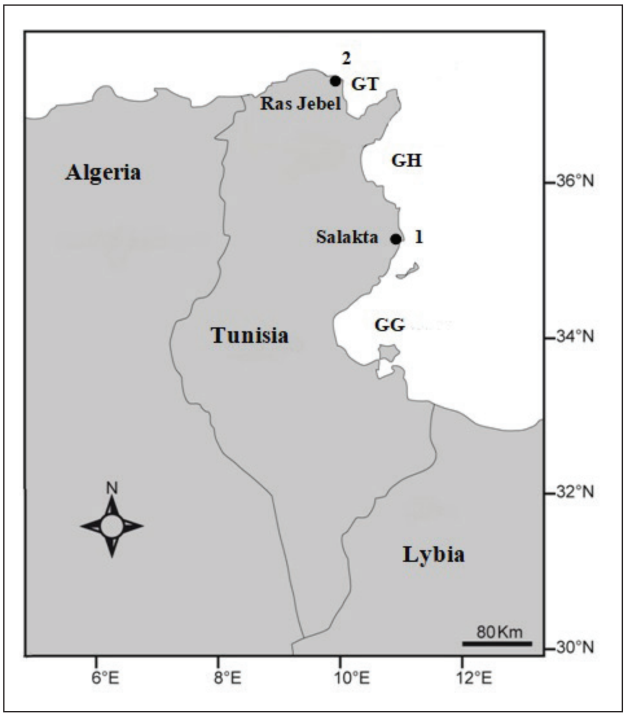

Fig. 1: Map of Tunisia indicating the capture sites of *Clinitrachus argentatus* ***in the Tunisian coast. 1. Off Salakta, eastern Tunisia (Gharred, 1999; Bradaï, 2000). 2. Off Ras Jebel, northern Tunisia (this study). GT, Gulf of Tunis. GH, Gulf of Hammamet. GG, Gulf of Gabès.***

Sl. 1: Zemljevid Tunizije z označenimi lokalitetami, kjer je bila potrjena srebrnica *(Clinitrachus argentatus)* ***na tunizijski obali. 1. Salakta, vzhodna Tunizija (Gharred, 1999; Bradaï, 2000). 2. Ras Jebel, Severna Tunizija (ta študija). GT, Tuniški zaliv. GH, Hamameški zaliv. GG, Gabeški zaliv.***

Fig. 2: *Clinitrachus argentatus* **from the northern Tunisian coast (ref. ISPAB-Cli-arg 01), specimen found in the stomach contents of a black scorpion fish** *Scorpaena porcus*, **scale bar = 20 mm.**
Sl. 2: **Primerek srebrnice (***Clinitrachus argentatus***) (ref. ISPAB-Cli-arg 01), najden v želodcu rjavega škarpoča (***Scorpaena porcus***), ujetega na severni tunizijski obali. Merilo = 20 mm.**

be brown, reddish, or purplish. The unusual colour of the present specimen could be explained by the chemical secretions of the predator affecting the prey's skin during the early phase of digestion.

The description, morphometric measurements, and meristic counts recorded in the present specimen were in total accordance with Wirtz & Zander (1986) and Orlando-Bonaca & Trkov (2016). Therefore, these patterns confirm the occurrence of *C. argentatus* in Tunisian waters and extend the distribution range of the species in the area. However, a migration of the species from southern to northern areas remains doubtful and improbable, as the species is not prone to long-distance migrations. Additionally, the presence of an only slightly digested *C. argentatus* in the gut of a *S. porcus* clearly demonstrated that the prey and the predator inhabit the same area. The non-occurrence of *C. argentatus* between Ras Jebel (northern Tunisia) and Salakata (eastern Tunisia) does not indicate that the species' distribution is fragmented throughout the Tunisian coast. *C. argentatus* is a rather overlooked species due to poor sampling efforts; similar instances were reported for other fish species in Tunisian waters (Rafrafi-Nouira, 2016).

Similarly, the relative scarcity of *C. argentatus* throughout the wider Mediterranean Sea is probably due to the fact that it is a cryptic species inhabiting macroalgal assemblages and sea grass meadows at very low depths, where it is difficult to observe (Orlando-Bonaca & Trkov, 2016; Tiralongo *et al.*, 2016). Additionally, such biotopes are poorly exploited by commercial fishing gears and colonised by small fish species generally belonging to the gobiidae and blenniidae families (Tiralongo

***Tab. 1:* Morphometric measurements with percentages of standard length (% SL), meristic counts, and total weight recorded in** *Clinitrachus argentatus* **from the northern Tunisian coast (ref. ISPAB-Cli-arg 01), specimen found in the stomach contents of a black scorpion fish** *Scorpaena porcus.*
Tab. 1:* Morfometrične meritve z deleži standardne dolžine (% SL), meristična štetja in celokupna masa srebrnice (Clinitrachus argentatus***) iz severne tunizijske obale (ref. ISPAB-Cli-arg 01), najdene v vsebini želodca rjavega škarpoča (***Scorpaena porcus***).**

Ref. ISPAB-Cli-arg 01	**Value**	
Morphometric measurements	**mm**	**% SL**
Total length	48	129.7%
Standard length (SL)	37	100%
Head length	7	18.9%
Eye diameter	3	8.1%
Pre-orbital length	4	10.8%
Meristic counts		
Dorsal fin rays	III + XXVIII/3	
Anal fin rays	?	
Pectoral fin rays	9	
Pelvic fin rays	2	
Total weight in gram	3.2 (?)	

et al., 2016). Therefore, misidentification between close related species cannot be totally ruled out. All these species are of low commercial interest and discarded at sea or not delivered in fish markets, but kept by fishermen for their own consumption. They are also affected by predation pressure for food, a good instance is herein provided by *C. argentatus*; Tiralongo *et al*. (2016) noted the occurrence of scorpaenid species such as *S. scrofa* Linnaeus, 1758 and *S. maderensis* Valenciennes, 1833, living together with small fishes, which are also their preferential prey (Hureau & Litvinenko, 1986). Additionally, shallow coastal waters are facing anthropogenic pollution, which progressively reduces benthic vegetation and negatively affects fish biodiversity (Lipej *et al.*, 2003) and likely certain small species that inhabit these ecosystems, such as *C. argentatus* (Orlando-Bonaca & Trkov, 2016), as well.

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NOVI ZAPIS O POJAVLJANJU SREBRNICE *CLINITRACHUS ARGENTATUS* (OSTEICHTHYES: CLINIDAE) IZ TUNIZIJSKE OBALE (OSREDNJE SREDOZEMSKO MORJE)

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POVZETEK

V pričujočem zapisu avtorji poročajo o novi najdbi srebrnice Clinitrachus argentatus *(Risso, 1810) iz tunizijskih voda na podlagi primerka, najdenega v želodcu rjavega škarpoča* Scorpaena porcus *Linnaeus, 1758. Srebrnica je bila le delno prebavljena, na podlagi česar avtorji sklepajo, da plenilec in plen izvirata iz istega življenjskega okolja. Ta najdba dopolnjuje spoznanja o razširjenosti te vrste vzdolž tunizijske obale, saj je bila doslej potrjena le v južnih predelih.*

Ključne besede: *Clinitrachus argentatus,* plen, plenilec, vsebina želodca, *Scorpaena porcus*

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VARIAZIONI PLURIENNALI DEL FENOMENO DELLO SPIAGGIAMENTO DI SPECIE ITTICHE NELLO STRETTO DI MESSINA, CON PARTICOLARE ATTENZIONE ALLE SPECIE MESOPELAGICHE

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SINTESI

I risultati di un anno solare di monitoraggio del fenomeno dello spiaggiamento di specie ittiche lungo la costa siciliana dello Stretto di Messina, hanno permesso di mettere a confronto i dati raccolti, sia quantitativi che qualitativi, con i risultati delle ricerche realizzate da autori del passato. Le osservazioni sono state condotte con cadenza giornaliera prescindendo dalle condizioni meteomarine, e astronomiche fondamentali nella regolazione di questo peculiare fenomeno. I dati, devono essere interpretati in maniera non assoluta poiché lo spiaggiamento è un fenomeno che assume caratteristiche di occasionalità ed è regolato da leggi probabilistiche. Dall'indagine è emersa una evidente variazione rispetto al passato, con una rilevante diminuzione di specie. Sono stati effettuati approfondimenti sulle 17 specie di pesci mesopelagici in comune con le ricerche degli autori del passato, in modo da avere un quadro sull'andamento di tali variazioni.

Parole chiave: spiaggiamento, Stretto di Messina, specie mesopelagiche

MULTI-YEAR CHANGES IN FISH STRANDING PHENOMENA IN THE STRAIT OF MESSINA, WITH PARTICULAR ATTENTION TO MESOPELAGIC SPECIES

ABSTRACT

This study provides data on one-year monitoring of the stranding phenomenon in the Strait of Messina, reporting information on the abundance and frequency of beached fish species. A comparison with previous studies performed in the area has allowed to describe the changes in this phenomenon over the course of a century.

Key words: stranding phenomenon, Strait of Messina, mesopelagic species

INTRODUZIONE

Lo Stretto di Messina deve la sua notorietà alle forti correnti di marea i cui effetti sono conosciuti sin dall'antichità. Alle prime osservazioni scientifiche operate da Galileo nel "Dialogo sopra i due massimi sistemi" seguirono successivamente quelle di numerosi altri Autori come Ribaud (1824), Longo (1882), Platania (1905), Mazzarelli (1909), Marini (1910), sebbene il primo trattato di dinamica fisica fu scritto da Vercelli (1925) e approfondito successivamente insieme a Picotti (Vercelli & Picotti, 1926). Studi relativamente recenti hanno esaminato le tematiche inerenti l'andamento di tali correnti di marea (Defant, 1940; De Domenico, 1987; Mosetti, 1988; Cortese *et al.,* 1990; Ammendolia *et al*., 2018). Uno degli aspetti più interessanti, legati ai fenomeni idrodinamici nello Stretto di Messina è lo spiaggiamento di numerose specie di organismi marini, che è un fenomeno naturale che si verifica in quest'area e consiste nel rinvenimento di esemplari appartenenti a diversi phyla animali e vegetali sulla battigia (Mazzarelli, 1909; Genovese *et al*., 1971; Battaglia *et al.,* 2017). La causa primaria è dovuta al regime idrodinamico molto intenso che si sviluppa in quest'area (Mazzarelli, 1909), determinato da correnti di marea pulsanti, che ogni sei ore circa, tra i bacini del Mar Ionio e del Mar Tirreno, provocano il verificarsi di una inversione del flusso della corrente (Vercelli, 1925; Vercelli & Picotti, 1926). Uno degli effetti di questi fenomeni idrodinamici è la risalita di acque profonde provenienti dal bacino ionico fino alle acque superficiali. Tale risalita, anche grazie alla fisiografia dello Stretto, gioca un ruolo fondamentale nello spiaggiamento, poiché trasporta in pochissimo tempo la fauna profonda verso la superficie. Questo trasporto provoca negli organismi choc pressori, che spesso causano agonia e morte. In seguito il moto ondoso, la corrente e il vento ne determinano lo spiaggiamento sul litorale (Mazzarelli, 1909; Genovese *et al*., 1971; Battaglia *et al.,* 2017).

Sono diversi i fattori, oltre al regime idrodinamico e le correnti di marea, che possono favorire o influenzare il fenomeno dello spiaggiamento: direzione del vento, ciclo lunare, pressione atmosferica, stagionalità, parametri ecologici e biologici (Battaglia *et al.,* 2017). In particolare, per quanto concerne gli organismi mesopelagici, l'abitudine a compiere migrazioni nictimerali può amplificare il fenomeno (Battaglia *et al*., 2017). Infatti, la migrazione verticale giornaliera del zooplancton nelle ore notturne verso la superficie (Marshall, 1960), innesca lo spostamento di moltissime specie mesopelagiche che per motivi trofici seguono le loro prede negli strati d'acqua superficiali. La risalita verso strati batimetrici meno profondi espone queste specie (molto spesso di piccole dimensioni) al rischio di essere "intercettate" dalla corrente di risalita (Battaglia *et al*., 2017). Le pionieristiche osservazioni del naturalista messinese Anastasio Cocco hanno permesso, per la prima volta in Mediterraneo, la descrizione tassonomica delle specie ittiche profonde rinvenute spiaggiate sulla costa siciliana dello Stretto di Messina (Ammendolia *et al.,* 2014). Da allora, il fenomeno dello spiaggiamento ha richiamato l'attenzione di numerosi studiosi provenienti da tutta Europa, tra i quali spicca la figura di Auguste Krohn, che definì lo Stretto di Messina come "il paradiso degli zoologi". Mazzarelli (1909) mise per la prima volta in relazione le peculiarità idrodinamiche dello Stretto con il fenomeno dello spiaggiamento di specie definite a quel tempo "abissali" e ciò, per la prima volta in Mediterraneo, consentì studi sugli stadi larvali, giovanili e sullo sviluppo di diverse specie

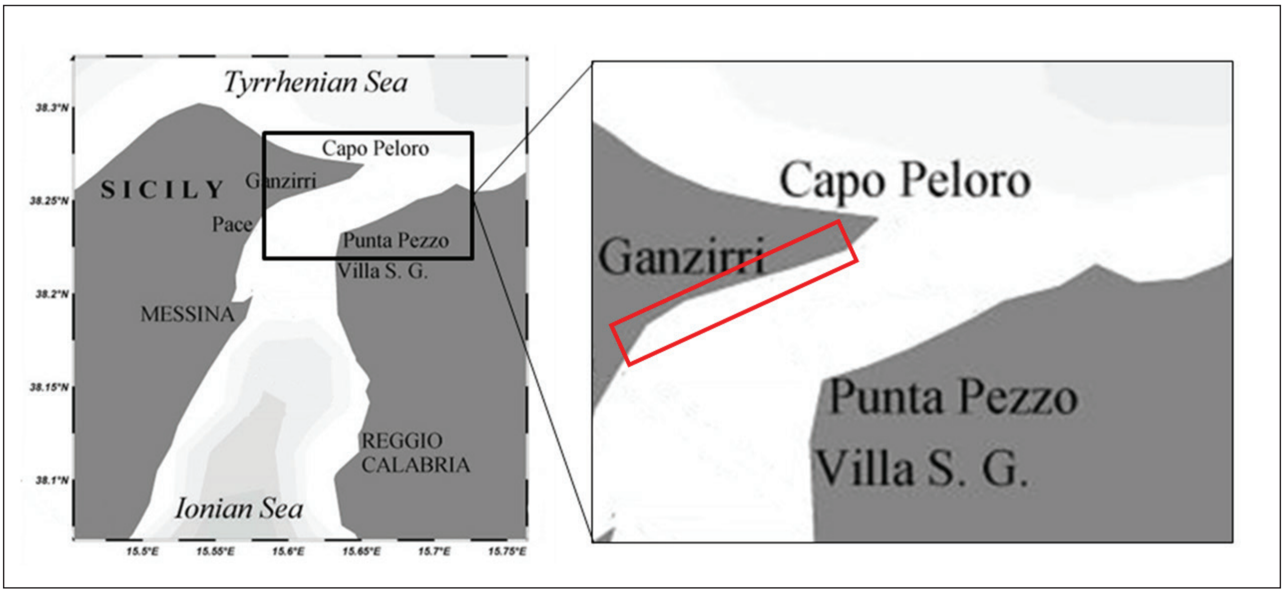

Fig. 1: Area di campionamento di 2,3 km lungo la costa siciliana dello Stretto di Messina.
Sl. 1: 2,3 km dolgo območje vzorčenja ob sicilijanski obali Mesinske ožine.

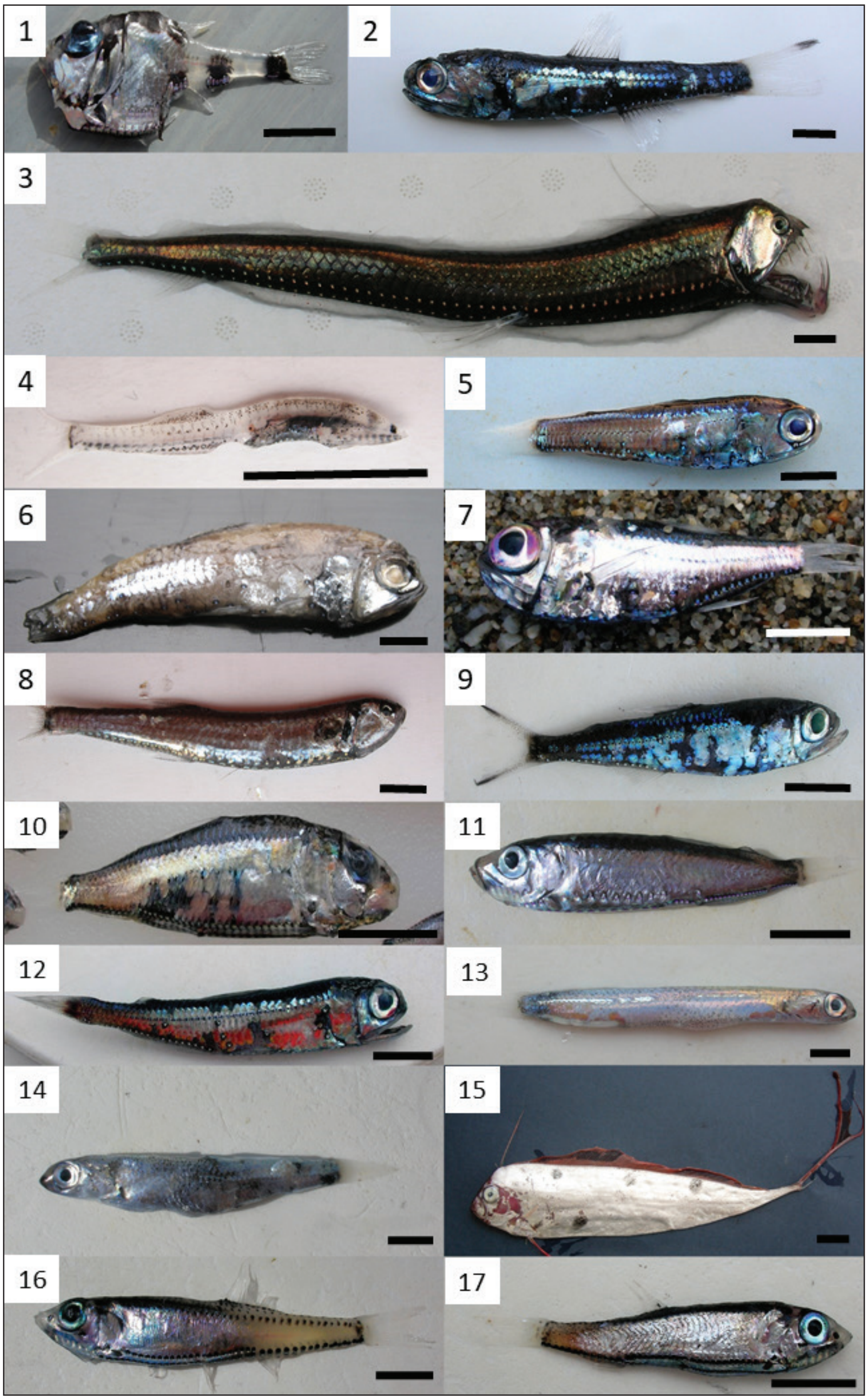

Fig. 2: Specie mesopelagiche utilizzate per la comparazione tra i diversi censimenti considerati (scale bar: 1 cm) – 1) *Argyropelecus hemigymnus***; 2)** *Ceratoscopelus maderensis;* **3)** *Chauliodus sloani;* **4)** *Cyclothone braueri;* **5)** *Diaphus holti;* **6)** *Diaphus rafinesquei;* **7)** *Electrona rissoi;* **8)** *Gonostoma denudatum;* **9)** *Hygophum benoiti;* **10)** *Ichthyococcus ovatus;* **11)** *Maurolicus muelleri;* **12)** *Mictophum punctatum;* **13)** *Microstoma microstoma;* **14)** *Nansenia oblita;* **15)** *Trachypterus trachypterus;* **16)** *Vinciguerria attenuata;* **17)** *Vinciguerria poweriae.*

Sl. 2: Mezopelaške vrste, uporabljene za primerjavo med različnimi obravnavanimi popisi (merilo: 1 cm) – 1) *Argyropelecus hemigymnus;* **2)** *Ceratoscopelus maderensis;* **3)** *Chauliodus sloani;* **4)** *Cyclothone braueri;* **5)** *Diaphus holti;* **6)** *Diaphus rafinesquei;* **7)** *Electrona rissoi;* **8)** *Gonostoma denudatum;* **9)** *Hygophum benoiti;* **10)** *Ichthyococcus ovatus;* **11)** *Maurolicus muelleri;* **12)** *Mictophum punctatum;* **13)** *Microstoma microstoma;* **14)** *Nansenia oblita;* **15)** *Trachypterus trachypterus;* **16)** *Vinciguerria attenuata;* **17)** *Vinciguerria poweriae.*

ittiche, soprattutto mesopelagiche (Sanzo, 1912; 1913a; 1913b; 1914; 1915; 1918a; 1918b). Successivamente molti altri autori hanno investigato gli aspetti legati al fenomeno (Genovese *et al.,* 1971; Berdar *et al.,* 1977; 1983; 1988; Guglielmo *et al.*, 1995, Battaglia *et al.*, 2017). In tempi recenti, numerosi studiosi si sono inoltre interessati della biologia riproduttiva (Bonina & Contini, 1974; Donato *et al.,* 1976), dell'ecologia trofica (Berdar *et al.,* 1979a; Battaglia *et al.,* 2014; Esposito *et al.*, 2014; Battaglia *et al.,* 2018), delle parassitosi (Berdar *et al.,* 1979b; Spalletta *et al.*, 1995; Gaglio *et al.,* 2018;), delle analisi biometriche (Donato *et al.,* 1976; 1977; Potoschi *et al.*, 2000; 2003; Battaglia *et al.*, 2010; 2015), della presenza di microplastiche nei contenuti stomacali (Romeo *et al.,* 2016), della struttura e l'ultrastruttura degli organi luminosi (Cavallaro *et al.,* 2004; 2015; 2019; 2020) e della bioluminescenza (Baguet & Marechal, 1976; Christophe *et al.*, 1979;; Baguet *et al.*, 1980, 1995) presente in specie ittiche mesopelagiche spiaggiate.

Scopo del presente lavoro è stato quello di operare una comparazione in termini di abbondanza numerica e frequenza di specie tra i censimenti del passato e quello qui descritto, focalizzando l'attenzione su alcune specie ittiche al fine di poter descrivere alcuni aspetti dell'evoluzione nel tempo del fenomeno dello spiaggiamento lungo il litorale siciliano dello Stretto di Messina.

MATERIALI E METODI

La raccolta delle specie ittiche spiaggiate sull'arenile siciliano dello Stretto di Messina (Fig. 1) è stata effettuata con frequenza giornaliera durante le prime ore del mattino, lungo la fascia che si estende per alcuni metri dalla linea di battigia (Battaglia *et al.,* 2017). Il campionamento è stato effettuato durante l'anno solare compreso tra il 1 giugno 2015 e il 31 maggio 2016 da tutti gli autori.

Il materiale biologico raccolto è stato immediatamente trasportato in laboratorio ed esaminato per l'identificazione tassonomica, seguendo le chiavi di identificazione di Whitehead *et al.* (1984-1986), e per le successive analisi quantitative. È stata effettuata una analisi qualitativa delle specie ittiche rinvenute, registrando anche il numero di esemplari ritrovati in ogni giornata di campionamento. Sono state calcolate le abbondanze complessive per ciascuna specie e famiglia nel periodo di ricerca e per ogni mese.

Focalizzando l'attenzione sulle specie mesopelagiche, al fine di poter meglio esaminare l'andamento del fenomeno dello spiaggiamento nel tempo, sono stati considerati i cen-

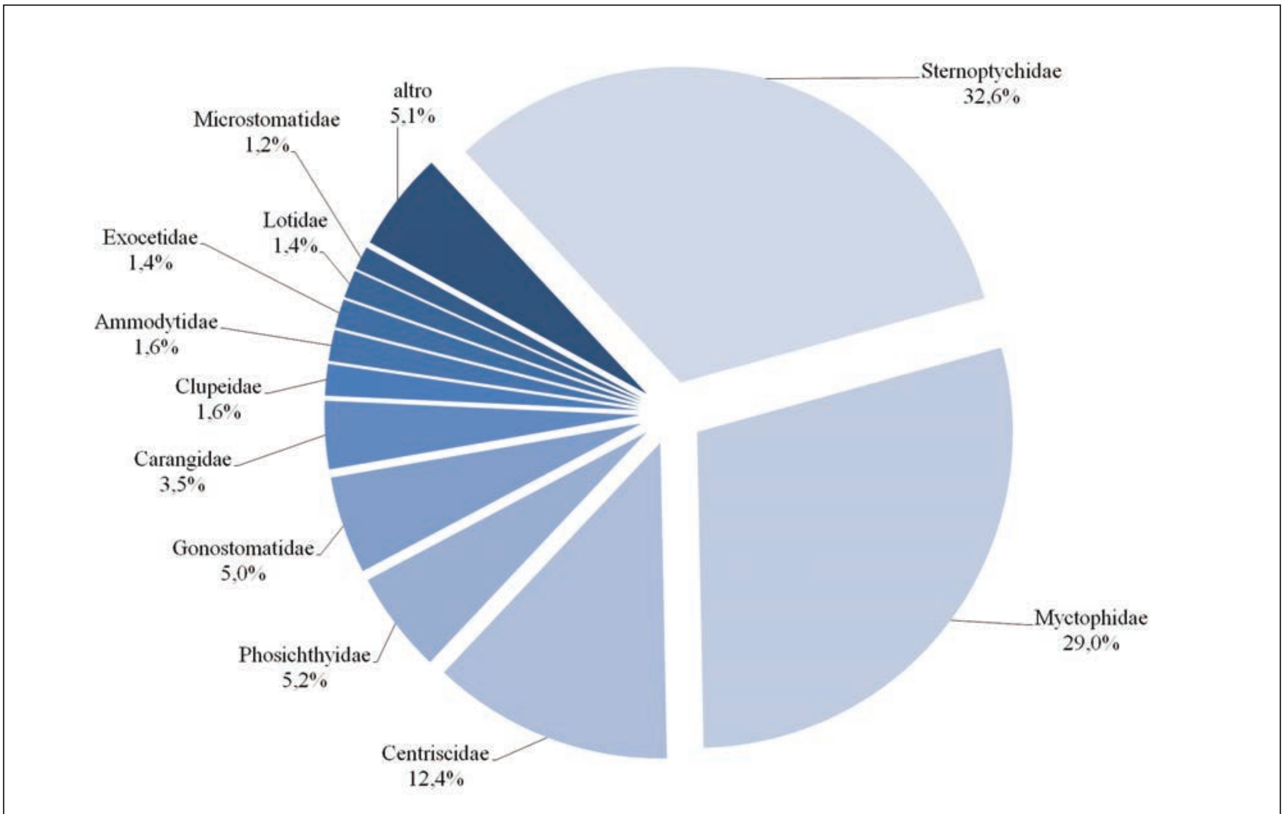

Fig. 3: Abbondanza percentuale dei teleostei spiaggiati sulla costa dello Stretto di Messina nel periodo 1.6.2015 – 31.5.2016, raggruppati per famiglie.
Sl. 3: Številčnost (v odstotkih) kostnic, ki so v obdobju od 1.6.2015 do 31.5.2016 nasedle na obali Mesinske ožine, razvrščene po družinah.

simenti del passato in cui venivano riportati per ogni specie dati esaurienti di abbondanze di tali organismi con cadenza mensile (Genovese *et al.,* 1971, Berdar *et al.,* 1977; 1988-1989) e comparati col presente studio. Inoltre, per integrare i dati di presenza/assenza delle specie è stata anche considerata la ricerca di Mazzarelli (1909), cioè la prima a fornire un quadro sul fenomeno dello spiaggiamento, sebbene non siano in essa riportati dati di abbondanze numeriche.

Sulla base di quanto detto, sono state selezionate le 17 specie mesopelagiche (Fig. 2) che sono risultate presenti in tutti i censimenti oggetto del confronto. Sono stati comparati quindi valori di abbondanza delle specie, considerando anche i periodi (mesi) di spiaggiamento.

Inoltre, per ciascuna specie, è stata calcolata la frequenza di spiaggiamento in termini percentuali di giorni/anno e in termini di presenza/assenza nei 12 mesi del periodo di campionamento.

RISULTATI E DISCUSSIONE

I risultati delle osservazioni e delle raccolte effettuate nell'arco dell'annualità presa in esame, sono riportati nel Supplemento 1. Sono state censite un totale di 78 specie di pesci, distribuite in 46 famiglie, per un numero complessivo di 3043 individui. Sono stati esclusi da questo conteggio gli 83 esemplari di larve leptocefaliche in quanto la loro corretta classificazione è ancora oggetto di studi tassonomici parallelamente condotti alla nostra indagine ed in corso di realizzazione. La specie più abbondante è risultata l'*Argyropelecus hemigymnus* (n = 977), seguita da *Hygophum hygomii* (n=311) e *Hygophum benoiti* (n=315).

In Figura 3 è riportato il grafico relativo all'abbondanza percentuale dei pesci spiaggiati, raggruppati per famiglia, nel periodo preso in esame. Si nota una netta prevalenza di esemplari appartenenti alle famiglie Sternoptychidae (32,6% del totale degli individui, rappresentati principalmente dalla specie *A. hemigymnus*) e Myctophidae (29%). Quest'ultima famiglia è quella più rappresentata in termini di specie rinvenute, ben undici (11) a fronte di 32 famiglie censite con una singola specie.

L'andamento dell'abbondanza dei ritrovamenti nei diversi periodi dell'anno è riportata in Figura 4. Il grafico mette in evidenza che gli intervalli temporali più favorevoli sono certamente quelli invernali - primaverili, dalla seconda metà del mese di febbraio fino al mese di maggio. In questi periodi si è infatti registrato un primo picco dei ritrovamenti. Un secondo picco, meno elevato rispetto al periodo primavera-inverno, è stato registrato nel mese di novembre.

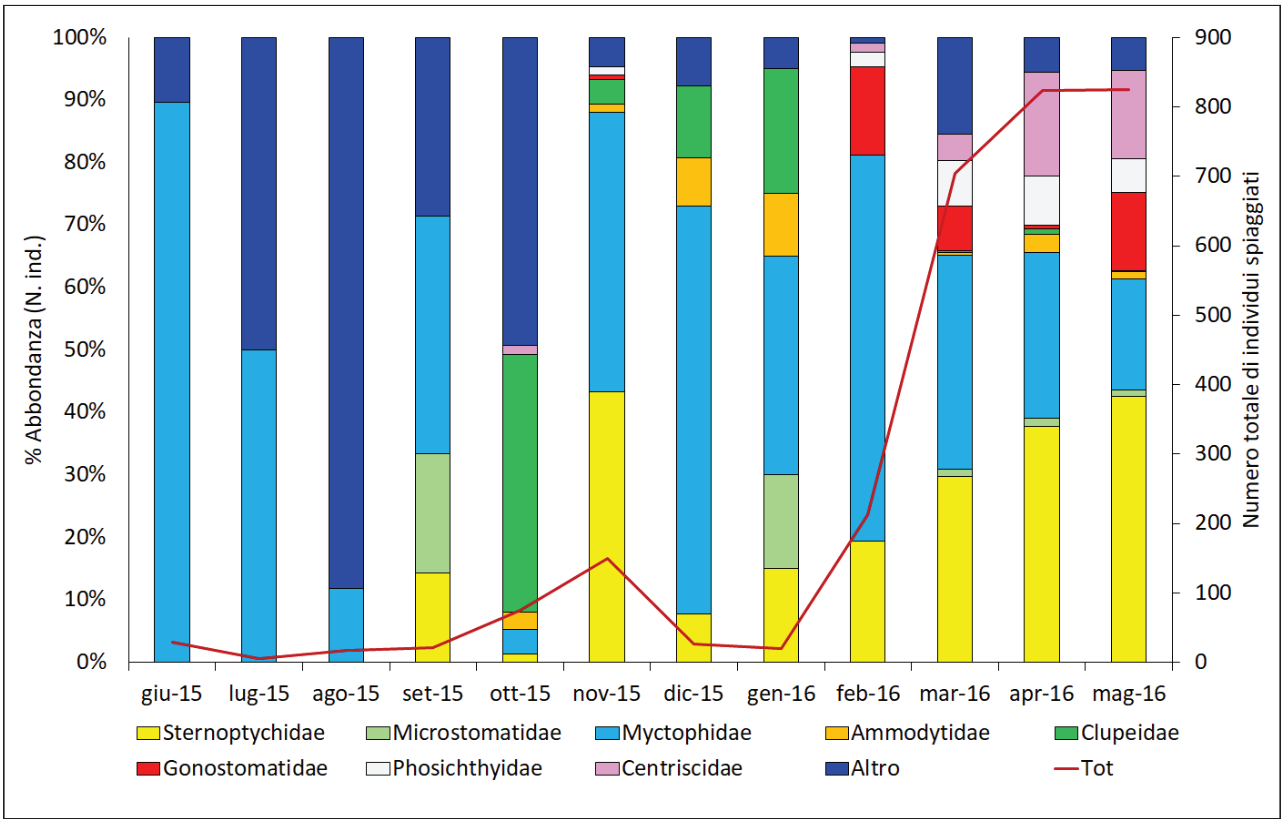

Fig. 4: Andamento dei ritrovamenti per mese e per famiglia di teleostei spiaggiati nel periodo di campionamento considerato (1.6.2015 – 31.5.2016).
Sl. 4: Gibanje števila najdb po mesecih in družinah nasedlih kostnic v obravnavanem obdobju vzorčenja (1.6.2015-31.5.2016).

I valori percentuali delle frequenze di spiaggiamento per le 17 specie mesopelagiche considerate, calcolate in termini di n° mesi/anno e n° giorni/anno sono descritte nei grafici riportati in Figura 5. Le specie più frequenti sono risultate *M. punctatum, A. hemigymnus* e *H. benoiti*. In termini di frequenza mensile a queste si aggiungono anche *E. risso* e *V. poweriae*.

I risultati della comparazione con i censimenti del passato (Genovese *et al.,* 1971; Berdar *et al.,* 1977; 1988-1989) vengono riassunti nel Supplemento 2, in cui sono riportate rispettivamente le abbondanze di spiaggiamento negli anni 1971, 1977, 1987-88 e 2015-2016.

Da questa valutazione è stata esclusa l'indagine di Mazzarelli (1909) poiché l'autore non operò valutazioni quantitative sulle specie spiaggiate ma ne osservò esclusivamente la presenza nel corso del periodo del suo campionamento. Il lavoro di Mazzarelli è invece compreso nella valutazione dei periodi di spiaggiamento delle 17 specie considerate, in modo da valutare la presenza delle stesse nei mesi dell'anno (Suppl. 3). I periodi considerati abbracciano un arco temporale di 107 anni e dalla loro analisi si evince che Mazzarelli (1909) rinviene la quasi totalità delle specie durante tutto l'arco dell'anno 1909 tranne cinque di esse che ritrova solo in determinati periodi.

Si riporta a seguire la valutazione della comparazione effettuata per singola specie considerata.

Argyropelecus hemigymnus Cocco, 1829

Tra le specie che spiaggiano lungo le coste dello Stretto di Messina, è tra quelle numericamente più significative, sia in termini di abbondanza che di frequenza. I nostri dati sul reperimento di questo teleosteo sono simili a quelli di Mazzarelli (1909), Genovese *et al.* (1971) e Berdar *et al.* (1977), mentre Berdar *et al.* (1988-1989) nel 1988-1989 non lo rinvengono nel mese di luglio. Anche Goode & Bean (1895), riportano che Giglioli reperì diverse centinaia di esemplari in soli tre giorni a causa delle forti correnti. Si può affermare che la specie spiaggia stabilmente tutto l'anno, nonostante flessioni in termini quantitativi nei periodi estivi.

Ceratoscopelus maderensis Lowe, 1839

C. maderensis è piuttosto comune sia in Mediterraneo che in Atlantico in quanto tra le specie più numerose in termini di quantità di individui, a comporre lo strato riflettente profondo (Backus *et al.,* 1968; Olivar *et al.,* 2012). Mazzarelli (1909) lo ritrova spiaggiato nei mesi da gennaio a marzo mentre secondo Genovese *et al.* (1971) è presente su tutti i litorali indagati e per tutto l'anno. I nostri dati riportano esigui ritrovamenti limitati ai mesi di aprile e maggio. Anche i due censimenti operati da Berdar *et al.* (1977; 1988-1989) fanno registrare dati contrastanti, infatti, a fronte di grande abbondanza e frequenza durante il corso della prima indagine si riscontra forte diminuzione nella seconda.

Chauliodus sloani, Bloch & Schneider, 1801

È una specie che si rinviene comunemente spiaggiata lungo tutti i litorali dello Stretto di Messina. Mazzarelli (1909) la segnala in tutti i mesi dell'anno mentre Genovese *et al.* (1971) la ritrovano da dicembre fino a primavera inoltrata, con numerosità di individui piuttosto elevate. Anche Berdar *et al.* (1977) registrano abbondanti ritrovamenti in tutti i mesi dell'anno, esclusi luglio e agosto, mentre nel 1988-1989 osservano la presenza di questa specie solo da gennaio a giugno. A testimonianza del fatto che il fenomeno dello spiaggiamento sia di non facile interpretazione e di come gli eventi atmosferici ed idrodinamici lo condizionino senza regole ben precise e stabilite. Durante il nostro censimento sono stati ritrovati solo due esemplari di *C. sloani*: uno a novembre ed uno a maggio.

Cyclothone braueri Jespersen & Tâning, 1926

La specie è considerata come quella che annovera, tra tutti i vertebrati, la maggiore consistenza numerica delle sue popolazioni e quindi il reperimento della stessa si verifica con grandi quantità di biomassa che spesso sono costituite appunto da più specie congeneri (Palma, 1982). Mazzarelli (1909) non lo cita tra i teleostei spiaggiati come *C. braueri,* bensì come *C. microdon,* ed annovera questa specie come rinvenibile per tutto l'anno. Genovese *et al.* (1971) riportano ritrovamenti nei mesi di marzo e maggio con un picco a marzo. Berdar *et al.* (1977) rinvengono la specie quasi tutto l'anno, con l'eccezione dei mesi di agosto e settembre, mentre Berdar *et al.* (1988-1989) la rinvengono dal mese di gennaio fino a marzo. I nostri dati riportano una costanza di reperimento di *C. braueri* da febbraio a maggio con moderate frequenze numeriche, per un totale di 150 esemplari. Incrociando i dati, la frequenza della specie è pertanto da ritenersi stabile.

Diaphus holti Tåning, 1918

Mazzarelli (1909) non la citò fra le specie soggette al fenomeno poiché è stata istituita da Tåning nel 1918, confondendola probabilmente con la specie affine *D. rafinesquii*. Genovese *et al.* (1971) ne registrano il reperimento da novembre a maggio ed in tutte le località da essi esplorate. Il censimento effettuato da Berdar *et al.* (1977) riporta dati interessanti poiché si registrano campioni reperiti quasi tutto l'anno, esclusi i mesi estivi. Tale dato non è però confermato dalla successiva indagine di Berdar *et al.* (1988-1989) che segnalano individui spiaggiati solo nei mesi di gennaio e febbraio. I nostri risultati sono simili a quelli di Genovese *et al.* (1971) con un leggero slittamento dell'inizio del periodo dei ritrovamenti (cinque esemplari tra dicembre e maggio). Alla luce di questi dati la reperibilità della specie è da considerarsi in lieve diminuzione.

Diaphus rafinesquii Cocco, 1838

La specie non è molto comune. Discordanti sono i dati tra i censimenti di Mazzarelli (1909), quelli di Genovese *et al.* (1971) ed il nostro, infatti Mazzarelli (1909) la ritrova durante tutto l'anno, mentre Genovese *et al.* (1971) la rinvengono da gennaio a maggio. Berdar *et al.* (1977) riportano nel censimento del 1977 una notevole frequenza di ritrovamenti, mentre nella ricerca del 1988-1989 registra-

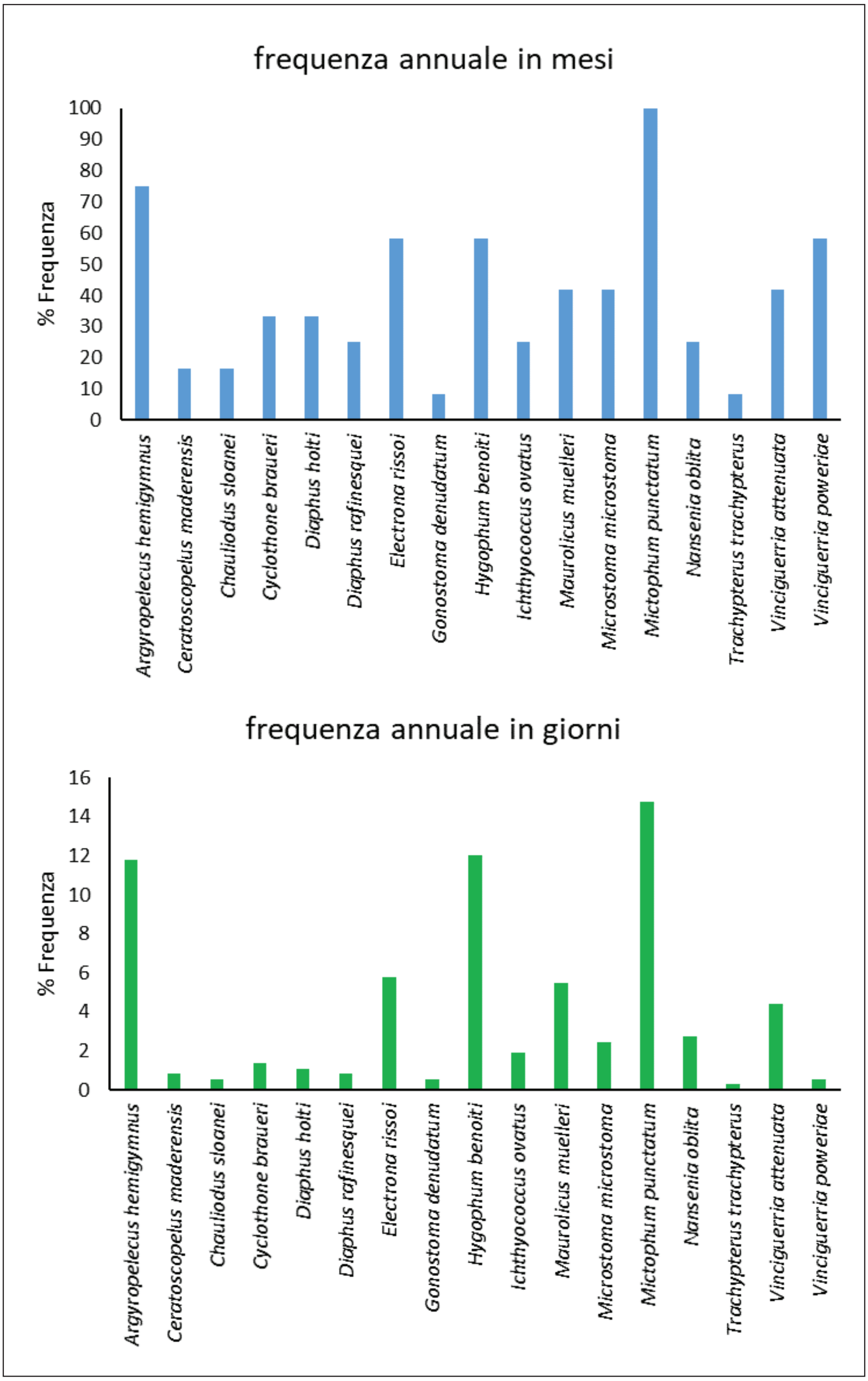

Fig. 5: Valori di frequenza percentuale calcolata in numero di mesi/anno e numero di giorni/anno per le 17 specie mesopelagiche considerate.
Sl. 5: Frekvenca v odstotkih, izračunana na podlagi števila mesecev/leto in števila dni/leto za 17 obravnavanih mezopelaških vrst.

rono ritrovamenti di pochi esemplari unicamente nei mesi di gennaio e febbraio (Berdar *et al*. 1988-1989). Il presente lavoro ha permesso di registrare il ritrovamento di un totale di 8 esemplari nell'arco di tempo compreso tra novembre ed aprile. *D. rafinesquii* sembra quindi aver subito una flessione di abbondanza e frequenza di reperimento.

Electrona risso Cocco, 1829

Specie piuttosto comune, viene segnalata da Mazzarelli (1909), in località Faro (ME) durante tutti i mesi dell'anno, con un'abbondanza maggiore nei mesi invernali. I risultati di Genovese *et al*. (1971) riportano la comparsa della specie sui litorali dello Stretto di Messina da novembre a maggio, mentre Berdar *et al*. (1977), censisce la specie per tutto l'arco dell'anno ed in maniera abbondante in termini numerici e di frequenze. Gli stessi autori nel 1988-1989 osservano uno spiaggiamento poco abbondante, con un picco isolato nel mese di agosto (Berdar *et al*., 1988-1989). I nostri dati riportano una significativa frequenza di *E. rissoi* nel periodo che va da novembre a maggio, con un totale di 311 esemplari, permettendo così di affermare che la specie ha una reperibilità stabile.

Gonostoma denudatum Rafinesque, 1810

Sia Mazzarelli (1909) che Genovese *et al*. (1971) rinvengono individui di *G. denudatum* spiaggiati nei mesi da febbraio a maggio. Gli autori sottolineano come in questo periodo gli esemplari ritrovati fossero maturi sessualmente. Berdar *et al.* (1977), rinvengono la specie tutto l'anno tranne nel mese di ottobre, mentre nel 1988-1989 la osservano nei mesi di gennaio, febbraio ed aprile (Berdar *et al.,* 1988-1989). Durante il nostro censimento la specie non è stata ritrovata in quantità significative, infatti solo due esemplari sono stati trovati spiaggiati nel mese di maggio. Tali risultati ascrivono la specie alla categoria di quelle in forte diminuzione.

Hygophum benoiti Cocco, 1838

Secondo Mazzarelli (1909) e Genovese *et al*. (1971), *H. benoiti* è tra i mictofidi più comuni, sia in termini di frequenza che di abbondanza. Tali dati sono confermati anche da Berdar *et al.* (1977) che ritrovano esemplari anche nel mese di agosto. Berdar *et al*. (1988-1989) registrano una diminuzione nella frequenza degli spiaggiamenti di questa specie (esemplari vengono rinvenuti spiaggiati solo nei mesi da gennaio a marzo), sebbene le abbondanze restino elevate. Dai dati raccolti nel presente lavoro, la specie ha fatto registrare invece importanti raccolte nei mesi da novembre a maggio (in totale 315 esemplari), con un incremento in termini sia di frequenza che di abbondanza.

Ichthyococcus ovatus Cocco, 1838

Mazzarelli (1909) osserva spiaggiamenti di *I. ovatus* durante tutto l'anno, con notevoli concentrazioni nei mesi di novembre e dicembre. Genovese *et al*. (1971) lo ritrovano in un numero esiguo di esemplari, con massima concentrazione nei mesi da dicembre a maggio. Berdar *et al*. (1977) la rinvengono invece tutto l'anno tranne nei mesi di luglio, agosto ed ottobre, mentre nel 1988-1989 non rinvengono alcun esemplare (Berdar *et al.,* 1988-1989). Nel nostro censimento tale specie è stata reperita in basse quantità (12 esemplari in totale) solo nel periodo compreso tra febbraio e maggio. Pertanto, lo spiaggiamento di questa specie può essere considerato caratterizzato da un andamento altalenante, con una recente diminuzione.

Maurolicus muelleri Gmelin, 1789

Gli spiaggiamenti di questa specie sono piuttosto comuni nello Stretto di Messina. Mazzarelli nel 1909, scrive che gli esemplari si rinvengono spiaggiati in tutti i mesi dell'anno, come confermato più tardi anche da Genovese *et al*. (1971) e Berdar *et al.* (1977) (questi ultimi autori la rinvengono tutto l'anno tranne nel mese di luglio). Oltre 10 anni dopo, Berdar *et al*. (1988-1989) la ritrovano soltanto dal mese di gennaio a quello di marzo. I nostri ritrovamenti sono limitati ai mesi compresi tra novembre e maggio, sebbene con una scarsa abbondanza (in totale n° 16 esemplari). Riteniamo dunque lo spiaggiamento della specie in regressione.

Microstoma microstoma Risso, 1810

Secondo Mazzarelli (1909) è possibile ritrovare questa specie spiaggiata in tutti i mesi dell'anno, specialmente da novembre a marzo. Genovese *et al*. (1971) la rinvengono sui litorali siciliani dello Stretto nel periodo da gennaio a maggio. Berdar *et al.* (1977) la ritrovano per tutto l'anno tranne nei mesi di luglio ed ottobre, mentre nel 1988-1989 la rinvengono nei mesi di gennaio e di marzo (Berdar *et al.,* 1988-1989). I nostri risultati sono simili a quelli di Genovese *et al*. (1971), ma gli esemplari hanno fatto registrare frequenze e abbondanze più basse (venti in totale). Genericamente possiamo considerarla come specie che spiaggia stabilmente e con lievi incrementi.

Myctophum punctatum Rafinesque, 1810

Assieme ad *A. hemigymnus* è la specie ittica più frequente e fa registrare anche abbondanze considerevoli. Mazzarelli (1909) la segnala nei mesi da aprile a giugno. Genovese *et al*. (1971), riportano ritrovamenti durante tutto l'anno, come confermato anche dalle nostre osservazioni sia in termini di frequenza che di abbondanza. Berdar *et al.* (1977, 1988-1989), confermano tale andamento anche se con dati di abbondanza superiori rispetto a tutti gli altri censimenti qui presi in esame. Possiamo affermare che la reperibilità della specie sia stabile nel tempo.

Nansenia oblita Facciolà, 1887

Mazzarelli (1909) osserva lo spiaggiamento della specie nei mesi da aprile a maggio. Genovese *et al*. (1971), la segnalano da marzo a maggio, con un'alta frequenza in quest'ultimo mese, mentre qualche esemplare è stato rinvenuto anche nel mese di dicembre. Berdar *et al.* (1977) la rinvengono nei mesi di gennaio, da marzo a maggio ed a ottobre, mentre successivamente Berdar *et al.* (1988-1989) la osservano dal mese di gennaio fino a marzo. Le nostre osservazioni registrano ritrovamenti di esemplari da marzo a maggio con una frequenza piuttosto bassa.

Trachipterus trachypterus Gmelin, 1789

Mazzarelli (1909) riporta la notizia che *T. trachypterus* veniva comunemente catturato nel porto di Messina nei mesi primaverili. Nei mesi di marzo ed aprile ricadono i ritrovamenti di Genovese *et al*. (1971), che riportano il reperimento di sei esemplari. Berdar *et al.* (1977, 1988-1989), lo segnalano con simili frequenze nei mesi di marzo e aprile. L'unico esemplare da noi ritrovato è stato rinvenuto nel mese di aprile. Tali osservazioni portano a ritenere che la specie sia poco comune e che la sua frequenza di spiaggiamento sia stabile nel tempo.

Vinciguerria attenuata Cocco, 1838

Mazzarelli (1909) e Genovese *et al*. (1971) registravano spiaggiamenti di questa specie in tutti i mesi dell'anno. Berdar *et al.* (1977) la rinvengono tutto l'anno tranne nel mese di luglio, mentre successivamente (Berdar *et al*., 1988-1989), la reperiscono nei mesi di gennaio e febbraio. I nostri dati riportano una discreta abbondanza di esemplari spiaggiati, con buona continuità nel periodo da febbraio a maggio, con ritrovamenti anche a novembre, per un totale di 144 esemplari. Possiamo considerare lo spiaggiamento di questa specie in lieve flessione.

Vinciguerria poweriae Cocco, 1838

Questa specie, morfologicamente molto simile alla congenere *V. attenuata*, è stata reperita, nel censimento oggetto del presente lavoro, una volta nel mese di febbraio e due volte nel mese di maggio. Mazzarelli (1909) non la rinviene mentre, Genovese *et al*. (1971) hanno raccolto ben 123 esemplari in tutto l'arco dell'anno. Il trend positivo è confermato nel censimento Berdar *et al.* (1977), con un notevole incremento. Tuttavia, Berdar *et al.* (1988-1989) segnalano pochi ritrovamenti limitati al mese di febbraio. La specie spiaggia dunque con frequenze incostanti e abbondanze variabili.

CONCLUSIONI

Nel presente studio, l'analisi dei dati relativi al monitoraggio del fenomeno dello spiaggiamento ha evidenziato un decremento numerico in termini di specie di teleostei rinvenuti sull'arenile (78 specie), rispetto ai censimenti passati (135 specie rinvenute da Genovese et al. (1971) e 159 rinvenute da Berdar *et al.* (1977)). Nonostante il forte decremento nel numero di specie e nelle abbondanze di alcuni teleostei, i pesci mesopelagici *C. braueri, D. holti, E. rissoi, H. benoiti, I ovatus, M. microstoma, V. attenuata e V. poweriae* hanno fanno registrare lievi incrementi di frequenza e abbondanza. Inoltre, a differenza dei risultati presenti in letteratura (Mazzarelli, 1909; Genovese *et al.*, 1971; Berdar *et al.,* 1988-1989) solo due specie sono state da noi reperite per tutto il corso dell'anno, ovvero *A. hemigymnus* e *M. punctatum*.

La valutazione comparativa eseguita limitatamente alle stime di abbondanza e reperibilità delle 17 specie prese in considerazione, ha fornito dati interessanti circa l'andamento del fenomeno dello spiaggiamento nel tempo. Il dato principale è una oggettiva diminuzione delle biomasse reperibili spiaggiate. Quali siano le cause della dimostrata diminuzione quali-quantitativa degli organismi spiaggiati, non è facile da stabilire. Certamente tale fenomeno è da attribuire ad un complesso di combinazioni che vanno dalle variazioni morfologiche delle linee di costa, dovuta alla costante erosione delle spiagge del litorale (Berdar *et al*., 1993; Boschi & Dragoni, 2000) alla variabilità delle condizioni meteomarine fortemente influenzate da fenomeni di inquinamento globale come l'effetto serra (CDP Italy Report 2017), dall'inquinamento della fascia costiera alle pressioni sempre più imponenti della pesca industriale sugli stock ittici con conseguente incidenza sul funzionamento delle catene trofiche (Guglielmo *et al*., 1995; Potoschi *et al*., 1996; Battaglia *et al*., 2013).

Differenze e variabilità tra le specie spiaggiate sono inoltre attribuibili ai diversi adattamenti ecologici ed alla morfologia delle specie mesopelagiche. Infatti, pesci di piccole dimensioni, come *A. hemigymnus, C. braueri* e *V. attenuata* sono maggiormente soggetti a trasporto passivo dovuto alle forti correnti, rispetto a quelli che hanno una maggiore capacità di nuoto e spostamento (Battaglia et al., 2017). Gli individui appartenenti a queste specie risultano più vulnerabili e in particolari condizioni di forti correnti, non sono in grado di contrastare le rapide risalite verticali dalle acque profonde verso gli strati superficiali. Per questo motivo rappresentano le specie più abbondanti tra la fauna spiaggiata.

Lo spiaggiamento deve comunque essere considerato un fenomeno non costante e modulato da regole legate ad un numero piuttosto consistente di variabili biologiche, idrodinamiche, meteorologiche, ecc. Pochi sono invece i fattori costanti, quali ad esempio il periodo dell'anno in cui il fenomeno si verifica con più alta frequenza. Tale periodo presenta il picco di massima incidenza durante i mesi invernali e primaverili (da Ottobre fino a Maggio) con punte minime nei mesi estivi. Presumibilmente una delle cause è da imputare allo stato di omotermia invernale che favorendo la massima circolazione nella colonna d'acqua, facilita i movimenti attivi verso la superficie. Inoltre, vista la massima frequenza ed abbondanza nei mesi primaverili, un'altra causa è sicuramente l'innescarsi della catena trofica al termine dei mesi invernali che beneficia della mobilizzazione dei nutrienti e dell'aumento della produzione primaria, che favorisce le migrazioni verticali di specie profonde verso le risorse trofiche superficiali e favorisce i cicli riproduttivi delle specie.

VEČLETNE SPREMEMBE V NASEDANJU RIBJIH VRST V MESINSKI OŽINI S POSEBNIM OZIROM NA MEZOPELAŠKE VRSTE

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POVZETEK

Na podlagi rezultatov enoletnega monitoringa nasedanja ribjih vrst vzdolž sicilijanske obale v Mesinski ožini so avtorji primerjali dobljene kvalitativne in kvantitativne podatke s podatki, objavljenimi v predhodnih raziskavah. Opazovanja so bila opravljena vsak dan, ne glede na meteorološke in astronomske razmere, ki so temeljne pri tem pojavu. Podatke je treba tolmačiti s previdnostjo, saj je nasedanje občasen pojav in je odvisen od različnih spremenljivk. Podatki raziskave so pokazali občutno zmanjšanje vrst v primerjavi s predhodnimi raziskavami. Avtorji so poglobili poznavanje o 17 mezopelaških vrstah, ki so bile potrjene tudi v predhodnih raziskavah, da bi poskusili razumeti razvoj tovrstnih sprememb.

Ključne besede: nasedanje, Mesinska ožina, mezopelaške vrste

Supplemento 1: Abbondanza numerica delle specie ittiche spiaggiate sulla costa dello Stretto di Messina nel periodo 1.6.2015 – 31.5.2016.
Priloga 1: Število primerkov posameznih ribjih vrst, nasedlih na obalah vzdolž Mesinske ožine v obdobju od 1.6.2015 do 31.5.2016.

FAMIGLIA	SPECIE	2015							2016					TOT
		G	L	A	S	O	N	D	G	F	M	A	M	
Ammodytidae	*Gymnammodytes cicerelus* (Rafinesque, 1810)				1	2	2	2	2		3	24	12	48
Anguillidae	*Anguilla anguilla* Linneo, 1758												2	2
Apogonidae	*Apogon imberbis* (Linneo, 1758)			1				1			2			4
Argentinidae	*Argentina sphyraena* Linneo, 1758						2							2
Atherinidae	*Atherina boyeri* Risso, 1810					7			1					8
Atherinidae	*Atherina hepsetus* Linneo, 1758											2	1	3
Carangidae	*Trachinotus ovatus* (Linneo, 1758)		1	1										2
Carangidae	*Trachurus trachurus* Linneo, 1758										30			30
Carangidae	*Trachurus picturatus* (Bowdich, 1825)											2		2
Carangidae	*Trachurus mediterraneus* (Steindachner, 1758)											52	20	72
Carapidae	*Carapus acus Brünnich*, 1768										1			1
Centriscidae	*Macroramphosus scolopax* (Linneo, 1758)					1								1
Centriscidae	*Macroramphosus gracilis* Lowe, 1839									3	30	137	205	375
Centrolophidae	*Centrolophus niger* (Gemlin, 1789)										3	3		6
Centrolophidae	*Schedophilus medusophagus* Cocco, 1839											3		3
Cepolidae	*Cepola macrophthalma* (Linneo, 1758)										1			1
Chlorophthalmidae	*Chlorophthalmus agassizi* Bonaparte, 1840						2							2
Clinidae	*Clinitrachus argentatus* (Risso, 1810)											1		1
Clupeidae	*Sardinella aurita* Valenciennes, 1847					26	6	3	4		2	7	1	49
Congridae	*Conger conger* Linneo, 1758											2		2
Congridae	*Gnathophis mystax* Delaroche, 1809											3	1	4
Dasyatidae	*Pteroplatytrygon violacea* (Bonaparte, 1832)											1		1
Engraulidae	*Engraulis encrasicolus* Linneo, 1758					5								5
Exocetidae	*Hirundichthys rondeletii* Valenciennes, 1847				16	28								44
Gobiidae	*Pomatoschistus minutus* (Pallas, 1770)						1							1
Gobiidae	*Lesueurigobius suerii* (Risso, 1810)												1	1
Gonostomatidae	*Cyclothone braueri* Jespersen & Tâning,1926									x	50	x	100	150
Gonostomatidae	*Gonostoma denudatum* Rafinesque, 1810												2	2
Labridae	*Symphodus roissali* (Risso, 1810)			1										1
Labridae	Labridae ind.									1				1
Lotidae	Lotidae ind.										40			40
Lotidae	*Gaidropsarus mediterraneus* Linneo, 1758											3		3
Macrouridae	*Coelorinchus caelorhincus* Risso, 1810												1	1
Macrouridae	*Nezumia aequalis* (Günther, 1878)											1		1
Merluccidae	*Merluccius merluccius* Linneo, 1758										1			1
Microstomatidae	*Microstoma microstoma* Risso, 1810				4				3		2	3	8	20
Microstomatidae	*Nansenia oblita* Facciolà, 1887										4	11	1	16
Moronidae	*Dicentrarchus labrax* (Linneo, 1758)						1							1
Mugilidae	Mugilidae ind.											3		3
Mullidae	*Mullus barbatus* Linneo, 1758		1										1	2
Myctophidae	*Myctophum punctatum* Rafinesque, 1810	26	3	2	14	2	30	1	1	12	23	52	20	186
Myctophidae	*Electrona risso* Cocco, 1829					1	30	10		102	34	24	110	311
Myctophidae	*Hygophum benoiti* Cocco, 1838						2	6	5	12	136	134	20	315
Myctophidae	*Hygophum hygomii* Lütken, 1892						1				40	3		44
Myctophidae	*Diaphus rafinesquii* Cocco, 1838						3			4		1		8
Myctophidae	*Diaphus dumerilii* (Bleeker, 1856)						1							1
Myctophidae	*Diaphus holti* Tåning, 1918							1		1		1	2	5
Myctophidae	*Ceratoscopelus maderensis* Lowe, 1839											3	2	5
Myctophidae	*Notoscopelus elongatus* Costa, 1844										4	1		5
Myctophidae	*Lampanyctus crocodilus* Risso, 1810										1			1
Myctophidae	*Lobianchia gemellarii* Cocco, 1838											1		1
Nomeidae	*Cubiceps gracilis* (Lowe, 1843)					1						3	3	7
Paralepididae	*Lestidiops sphyrenoides* (Risso, 1820)							1						1
Paralepididae	*Paralepis coregonoides* Risso, 1826												2	2
Phosichthyidae	*Vinciguerria attenuata* (Cocco, 1838)						2			2	50	45	45	144
Phosichthyidae	*Ichthyococcus ovatus* Cocco, 1838									3		8	1	12
Phosichthyidae	*Vinciguerria poweriae* (Cocco, 1838)										1		2	3
Phycidae	*Phycis phycis* Linneo, 1776										24	4		28
Pomacentridae	*Chromis chromis* Linneo, 1758												13	13
Scomberesocidae	*Scomberesox saurus* Walbaum, 1792											1	1	2
Scombridae	*Auxis rochei* (Risso, 1810)	2	2											4
Scorpaenidae	*Scorpaenodes arenai* Torchio 1962											1		1
Scorpenidae	*Scorpaena porcus* Linneo, 1758			2								1	2	5
Serranidae	*Anthias anthias* (Linneo, 1758)				1							9	2	12
Sparidae	*Pagellus acarne* (Risso 1827)	1										1	1	3
Sparidae	*Sarpa salpa* (Linneo, 1758)			3								1		4
Sparidae	*Diplodus annularis* (Linneo, 1758)			1										1
Sparidae	*Boops boops* (Linneo, 1758)											2		2
Sphyraenidae	*Sphyraena sphyraena* (Linneo, 1758)					1								1
Sternoptychidae	*Argyropelecus hemigymnus* (Cocco, 1829)				2	1	61	1	3	41	204	308	356	977
Sternoptychidae	*Maurolicus muelleri* (Gmelin, 1789)						4	1			5	3	3	16
Stomiidae	*Chauliodus sloani* Bloch & Schneider, 1801						1						1	2
Trachipteridae	*Zu cristatus* Bonelli, 1820						1							1
Trachipteridae	*Trachipterus trachypterus* (Gmelin, 1789)											1		1
Trichiuridae	*Lepidopus caudatus* (Euphrasen, 1788)									1	2			3
Tripterygiidae	*Tripterygion melanurum* Guichenot, 1850			1										1
Tripterygiidae	*Tripterygion tripteronotum* (Risso, 1810)											1	1	2
Xiphidae	*Xiphias gladius* Linneo, 1758			1										1
	Larve leptocefaliche								2	10	5	27	39	83

Supplemento 2: Valutazione comparativa dei dati del presente studio con quelli di Genovese** et al. **(1971) e di Berdar** et al. **(1977, 1988-1989). (+ 1-10; ++ 10-50; +++ 50-200; ++++ oltre i 200).

Priloga 2: Primerjalna opredelitev podatkov pričujoče raziskave s podatki iz raziskav Genovese** et al. **(1971) in Berdar** et al. **(1977, 1988-1989). (+ 1-10; ++ 10-50; +++ 50-200; ++++ več kot 200).

SPECIE	RIFERIMENTO BIBLIOGRAFICO	Gen	Feb	Mar	Apr	Mag	Giu	Lug	Ago	Set	Ott	Nov	Dic
Argyropelecus hemigymnus	Genovese *et al.* (1971) Berdar *et al.* (1977) Berdar *et al.* (1988-1989) Presente lavoro	++++ ++++ ++++ +	++++ ++++ ++++ ++	++++ ++++ +++ ++++	++++ ++++ +++ ++++	++++ ++++ +++ ++++	+ ++++ +++	+	+	++++ ++++ ++++ +	++++ ++++ +++ +	++++ ++++ ++ ++	++++ ++++ +++ +
Ceratoscopelus maderensis	Genovese *et al.* (1971) Berdar *et al.* (1977) Berdar *et al.* (1988-1989) Presente lavoro	++ ++ ++	+ ++ +	++ ++ +	++ + +	+ + +	+	+	+ +	+	+	+	+ +
Chauliodus sloani	Genovese *et al.* (1971) Berdar *et al.* (1977) Berdar *et al.* (1988-1989) Presente lavoro	+ ++ ++	++ ++ ++	++ +++ +	+++ + +	++++ ++++ ++ +	+ +++ +		+	++	+	+ +	++ ++
Cyclothone braueri	Genovese *et al.* (1971) Berdar *et al.* (1977) Berdar *et al.* (1988-1989) Presente lavoro	++++ ++++	++++ + ++	++++ ++++ +++ ++	++++ ++	++ ++++ +++	+	+			+	+	+ ++
Diaphus holti	Genovese *et al.* (1971) Berdar *et al.* (1977) Berdar *et al.* (1988-1989) Presente lavoro	+ +	++ +	++ ++	++ + +	++ + +	+			+		+	++ + +
Diaphus rafinesquii	Genovese *et al.* (1971) Berdar *et al.* (1977) Berdar *et al.* (1988-1989) Presente lavoro	++ + ++	+ + + +	++ ++	++ + +	++ +	+			+		++	+
Electrona rissoi	Genovese *et al.* (1971) Berdar *et al.* (1977) Berdar *et al.* (1988-1989) Presente lavoro	+ ++ +	+++ + +++	++ +++ + ++	++ ++ ++	++ +++ +++	++ ++		+++ + +++	+++	++++ +++ +	++ ++++ ++	+++ ++ ++
Gonostoma denudatum	Genovese *et al.* (1971) Berdar *et al.* (1977) Berdar *et al.* (1988-1989) Presente lavoro	+ + ++	++ ++ +	++ +	+++ ++	++++ ++ + +	+ ++	+	+	+		++	++ +
Hygophum benoiti	Genovese *et al.* (1971) Berdar *et al.* (1977) Berdar *et al.* (1988-1989) Presente lavoro	+++ +++ ++++ +	++++ ++++ ++++ ++	++++ +++ ++ +++	++++ ++ +++	+++ ++ ++	+++ +++	+	++++ +++	++ ++++	+++ +	++++ +++ +	++++ +++ +
Ichthyococcus ovatus	Genovese *et al.* (1971) Berdar *et al.* (1977) Berdar *et al.* (1988-1989) Presente lavoro	+ ++	++ +	+++ ++	+++ + +	++ ++ +	++			+		+	+ +
Maurolicus muelleri	Genovese *et al.* (1971) Berdar *et al.* (1977) Berdar *et al.* (1988-1989) Presente lavoro	++ ++ +	+ ++ +++	++++ ++++ ++ +	++++ ++ +	+++ +++ +	+ ++		+	+	+ +	+ ++ +	+++ ++ +
Microstoma microstoma	Genovese *et al.* (1971) Berdar *et al.* (1977) Berdar *et al.* (1988-1989) Presente lavoro	+ ++ +	+	++ ++ + +	++ + +	+ + +	++		+	++ +		+	+ +
Mictophum punctatum	Genovese *et al.* (1971) Berdar *et al.* (1977) Berdar *et al.* (1988-1989) Presente lavoro	+ ++ +++ +	++ ++ ++	++ +++ ++++ ++	++ + + ++	++ +++ +++ ++	++ +++ +++ ++	+ +	+++ +++ ++++ +	++ +++ ++	++++ ++++ +	++ +++ ++	+++ +++ +
Nansenia oblita	Genovese *et al.* (1971) Berdar *et al.* (1977) Berdar *et al.* (1988-1989) Presente lavoro	+ ++	++	++ +++ + +	++ ++ ++	++ ++ +						+	+
Trachypterus trachypterus	Genovese *et al.* (1971) Berdar *et al.* (1977) Berdar *et al.* (1988-1989) Presente lavoro			+ + ++	++ + ++ +	++							
Vinciguerria attenuata	Genovese *et al.* (1971) Berdar *et al.* (1977) Berdar *et al.* (1988-1989) Presente lavoro	++ +++ +	+++ +++ + +	++++ +++ ++	++++ +++ ++	++++ +++ ++	+ ++		+ +	++	+ ++	++ ++ +	++++ +++
Vinciguerria poweriae	Genovese *et al.* (1971) Berdar *et al.* (1977) Berdar *et al.* (1988-1989) Presente lavoro	+	+ ++ +	++ +++ +	++ ++	+ ++ +	+ +		+	+	+ ++	+	+++ ++

Supplemento 3: Descrizione comparativa dei periodi di ritrovamento delle 17 specie campione nell'ambito dei censimenti operati da: Mazzarelli (1909), Genovese* et al. *(1971), Berdar* et al. *(1977; 1988-1989) ed il presente studio.
Priloga 3: Primerjava obdobij, v katerih je bilo najdenih 17 tarčnih vrst v okviru opravljenih vzorčevalnih popisov v študijah Mazzarelli (1909), Genovese* et al. *(1971), Berdar* et al. *(1977; 1988-1989) in v pričujoči raziskavi.

Specie	**Mazzarelli (1909)**	**Genovese** *et al.* **(1971)**	**Berdar** *et al.* **(1977)**	**Berdar** *et al.* **(1988-1989)**	**Presente lavoro**
Argyropelecus hemigymnus	tutto l'anno	tutto l'anno	tutto l'anno	da Gennaio a Giugno e da Settembre a Dicembre	tutto l'anno
Ceratoscopelus maderensis	da Gennaio a Marzo	Maggio e Agosto	da Gennaio a Marzo	Gennaio	da Aprile a Maggio
Chauliodus sloani	tutto l'anno	da Gennaio a Giugno e Dicembre	da Gennaio a Febbraio e da Aprile a Maggio	da Gennaio a Marzo e da Maggio a Giugno	Maggio
Cyclothone braueri	tutto l'anno	Marzo e Maggio	Gennaio e Marzo	Da Gennaio a Marzo	da Febbraio a Maggio
Diaphus holti	-	da Novembre a Maggio	Gennaio	-	da Dicembre a Maggio
Diaphus rafinesquii	tutto l'anno	da Gennaio a Maggio	da Gennaio a Febbraio	Gennaio	da Novembre a Aprile
Electrona rissoi	tutto l'anno	da Novembre a Maggio	da Gennaio a Marzo e Agosto	Agosto	da Novembre a Maggio
Gonostoma denudatum	da Febbraio a Maggio	da Febbraio a Maggio	da Gennaio a Febbraio e Maggio	Gennaio	Marzo
Hygophum benoiti	tutto l'anno	tutto l'anno	da Gennaio a Marzo	da Gennaio a Marzo	da Novembre a Maggio
Ichthyococcus ovatus	tutto l'anno	da Dicembre a Maggio	-	-	da Febbraio a Maggio
Maurolicus muelleri	tutto l'anno	da Gennaio a Giugno e da Ottobre a Dicembre	da Gennaio a Marzo	da Febbraio a Marzo	da Novembre a Maggio
Microstoma microstoma	tutto l'anno	da Gennaio a Maggio	Gennaio e Marzo	Gennaio	da Gennaio a Maggio
Mictophum punctatum	da Aprile a Giugno	tutto l'anno	Gennaio, da Marzo a Giugno e da Agosto a Settembre	da Gennaio a Marzo, da Maggio a Giugno, da Agosto a Settembre	tutto l'anno
Nansenia oblita	da Aprile a Maggio	da Marzo a Maggio	da Gennaio a Marzo	da Gennaio a Febbraio	da Marzo a Maggio
Vinciguerria attenuata	tutto l'anno	da Gennaio a Giugno, Agosto e da Ottobre a Dicembre	da Gennaio a Febbraio	-	da Febbraio a Maggio
Vinciguerria poweriae	-	da Gennaio a Giugno, Agosto e da Novembre a Dicembre	Febbraio	-	da Marzo a Maggio
Trachipterus trachypterus	da Marzo a Maggio	da Marzo a Maggio	da Marzo ad Aprile	da Marzo ad Aprile	Aprile

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SKELETAL AND PUGHEAD DEFORMITIES IN THE SADDLE BREAM *OBLADA MELANURA* (OSTEICHTHYES: SPARIDAE) FROM THE TUNISIAN COAST (CENTRAL MEDITERRANEAN SEA)

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ABSTRACT

The article describes the abnormalities of the vertebral column and lateral line observed in a specimen of saddle bream Oblada melanura *(Linnaeus, 1758) collected from the northern coast of Tunisia, and an anomaly of the head, i.e., pug-headedness, observed in a second* O. melanura *from the same area. Despite these morphological deformities, both abnormal specimens were able to live in the wild together with normal specimens. The origin of these abnormalities is commented on and discussed.*

Key words: *Oblada melanura*, hyperkyphosis, lordosis, environmental pollution, mouth asymmetry, length-weight relationship

DEFORMITÀ DI SCHELETRO E TESTA NELL'ORATA *OBLADA MELANURA* (OSTEICHTHYES: SPARIDAE) LUNGO LA COSTA TUNISINA (MEDITERRANEO CENTRALE)

SINTESI

L'articolo descrive le anomalie della colonna vertebrale e della linea laterale osservate in un esemplare di orata Oblada melanura *(Linnaeus, 1758) pescato lungo la costa settentrionale della Tunisia, e un'anomalia della testa, cioè la testa a carlino, osservata in una seconda* O. melanura *della stessa area. Nonostante queste deformità morfologiche, entrambi gli esemplari anomali sono stati in grado di vivere in natura assieme agli esemplari normali. L'origine di queste anomalie viene commentata e discussa.*

Parole chiave: *Oblada melanura*, ipercifosi, lordosi, inquinamento ambientale, asimmetria della bocca, rapporto lunghezza-peso

INTRODUCTION

The saddled bream *Oblada melanura* (Linnaeus, 1758) is known to inhabit shallow coastal waters of the eastern Atlantic from the Bay of Biscay to Angola and marine areas surrounding Madeira, the Cape Verde and Canary Islands (Bauchot & Hureau, 1986). *O. melanura* is very common in the wider Mediterranean Sea and rather rare in the Black Sea (Louisy, 2002).

The reproductive biology of *O. melanura* has been the object of various studies conducted in the Azores (Morato *et al.*, 2003) and different Mediterranean regions, such as Italian waters (Cefali *et al.*, 1987), the Egyptian coast (Zaki *et al.*, 1995), the Adriatic Sea (Pallaoro *et al.*, 2003) and the Syrian coast (Sobar & Lallh, 2017). The species is gregarious, semi-pelagic, commonly caught in shallow coastal waters not exceeding 30 m (Bauchot & Hureau, 1986), feeding on zooplankton and small invertebrates and fishes (Pallaoro *et al.*, 2003).

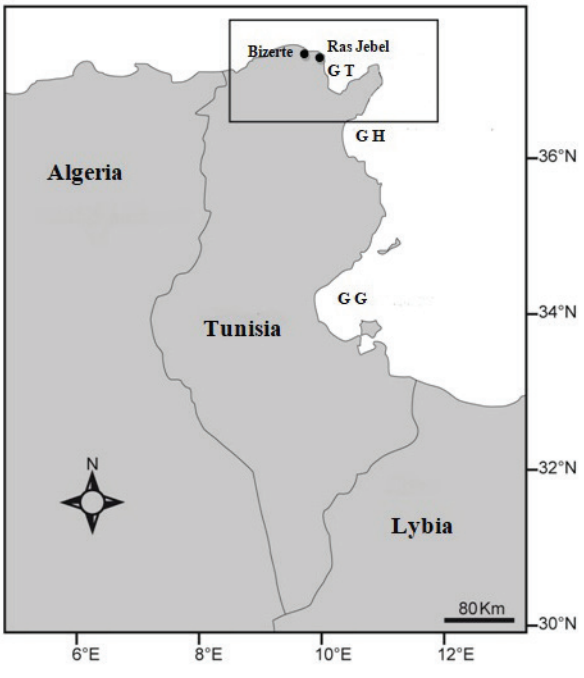

Fig. 1: Map of Tunisia indicating the capture area (rectangle) of* Oblada melanura *in the northern Tunisian coast. GT, Gulf of Tunis. GH, Gulf of Hammamet. GG, Gulf of Gabès.

Sl. 1: Zemljevid Tunizije z označeno lokaliteto (pravokotnik), kjer sta bila ujeta primerka črnorepke na severni tunizijski obali. GT, zaliv Tunis. GH, zaliv Hammamet. GG, zaliv Gabès.

O. melanura, like other sparid species occurring throughout the Tunisian coast, has commercial value (Khaldi & Chakroun-Marzouk, 2016; Rafrafi--Nouira, 2016). It is also the fifth most abundant wild fish inhabiting the waters around sea-cage fish farms in the Turkish Aegean Sea (Akyol *et al.*, 2020); specimens reaching up to 357 mm total length have been confirmed in a fish farming area located off Kokar Cove, in Turkish waters (Akyol *et al.*, 2014). The species is rather abundantly caught in northern areas, where it is targeted by fishermen, as its flesh appreciated by the local population (Rafrafi-Nouira, 2016). During investigations conducted in the northern Tunisian area since 2010, some specimens have been collected, with two of them displaying morphological deformities. Both abnormal specimens are described in the present article and comments on these abnormalities are provided.

MATERIAL AND METHODS

A total of 34 specimens of *Oblada melanura* were sampled between 2010 and 2017 off Ras Jebel, located on the northern Tunisian coast, of which two specimens found on 23 June 2017 presented physical abnormalities. All specimens were caught by a commercial gill net with 26 mm stretched mesh size, at 37°14'57.53"N and 10°11'52.85"E, on a sandy bottom together with other sparid and labrid species (Fig. 1). The fresh specimens were measured for total length (TL), recorded to the nearest millimetre, and weighed for total body weight (TBW) to the nearest 0.1 gram. Morphometric measurements and meristic counts followed Bauchot & Hureau (1986) and Akyol *et al.* (2014); they were recorded in both abnormal specimens and compared with the same parameters recorded in a normal specimen (see Tab. 1). The three specimens were fixed in 10% buffered formalin, preserved in 75% formaldehyde and deposited in the Ichthyological Collection of Institut Supérieur de Pêche et d'Aquaculture de Bizerte (Tunisia), under catalogue numbers: ISPAB-Obl-mel 01 for the normal specimen, ISPAB-Obl-mel 02 for the specimen exhibiting deformities of the vertebral column, and ISPAB-Obl-mel 03 for the pug-headed specimen. Abnormalities of the vertebral column were described following definitions by Elie & Girard (2014) and Jawad & Ibrahim (2018), such as scoliosis (lateral curvature), lordosis (ventral curvature), kyphosis (dorsal curvature), and ankylosis (fusion of vertebrae), reported in many cultured and wild species. Additionally, three body regions were taken into consideration, partially following Louiz *et al.* (2007): anterior or cephalic region, intermediate or abdominal region, and terminal or caudal region. The second abnormal specimen displayed pug-headedness. Such anomaly is characterised

Tab. 1: Morphometric measurements with percentages of standard length (% SL), meristic counts, and total body weight recorded in the three specimens of* Oblada melanura *collected off the northern Tunisian coast, the normal specimen (ref. ISPAB-Obl-mel 01), the specimen with skeletal deformities (ref. ISPAB-Obl-mel 02), and the pug-headed specimen (ref. ISPAB-Obl-mel 03).
Tab. 1: Morfometrične meritve, izražene v deležih glede na standardno dolžino (% SL), meristična štetja, in celokupna telesna masa treh primerkov črnorepke (*Oblada melanura*), ujetih ob severni tunizijski obali: normalni primerek (ref. ISPAB-Obl-mel 01), primerek s skeletnimi deformacijami (ref. ISPAB-Obl-mel 02), in primerek z buldoško glavo (ref. ISPAB-Obl-mel 03).

References	**ISPAB-Obl-mel 01**		**ISPAB-Obl-mel 02**		**ISPAB-Obl-mel 03**	
Morphometric measurements	**mm**	**%TL**	**mm**	**%TL**	**mm**	**%TL**
Total length	135	100	136	100.0	220.0	100.0
Fork length	115	85.2	115	84.6	195	88.6
Standard length	107	79.3	104	76.5	165	75.0
Head length	30.4	22.5	35	25.7	52	23.6
Eye diameter	16.4	12.1	13	9.6	15	6.8
Pre-orbitary length	12.3	9.1	10	7.4	17	7.7
Post-orbitary length	16.5	12.2	14	10.3	23	10.5
Dorsal fin length	56.2	41.6	56	41.2	95	43.2
Pectoral fin length	10.4	7.7	6	4.4	10	4.5
Pelvic fin length	11	8.1	8	5.9	8.2	3.7
Anal fin length	29.7	22	23	16.9	43	19.5
Caudal fin length	15.2	11.3	12	8.8	16	7.3
Snout length	14.9	11	12	8.8	20	9.1
Body height	43.8	32.4	49	36.0	60	27.3
Pre-dorsal fin length	44.6	33	42	30.9	64	29.1
Pre-pectoral fin length	35.3	26.1	36	26.5	55	25.0
Pre-pelvic fin length	41.01	30.4	41	30.1	66	30.0
Pre-anal fin length	66.6	49.3	68	50.0	110	50.0
Longest spine length of the pectoral	36.6	27.1	38	27.9	5.5	2.5
Thickness	19.9	14.7	18	13.2	23	10.5
Meristic counts	**ISPAB-Obl-mel 01**		**ISPAB-Obl-mel 02**		**ISPAB-Obl-mel 03**	
Scales on lateral line	67		74		67	
Vertebrae	27		36		27	
Dorsal fin rays	XI+14		XI+14		XI+14	
Pectoral fin rays	14		14		14	
Pelvic fin rays	II+10		II+10		II+10	
Anal fin rays	III+11		III+11		III+11	
Caudal fin rays	20		20		20	
Weight (g)	**25.2**		**36.73**		**104.2**	

by a malformation occurring on the upper jaw and associated bones of the head. As a result, the upper jaw is shorter than the lower jaw, but both jaws are in relation together (Catelani *et al.*, 2017).

A *t*-test was performed to point out the differences in the number of line scales and vertebrae between the abnormal and normal specimens of *O. melanura*. The relation between total length (TL) and total body weight (TBW) was used as a complement following Froese *et al.* (2011), including all specimens, normal and abnormal, to see if these latter could develop in the wild like other normal specimens. This LWR equalled TBW = $a\mathrm{TL}^b$, and was converted into its linear regression, expressed in decimal logarithmic co-ordinates, and correlations were assessed by least-squares regression as: log TBW = log a + b log TL. Significance of constant b differences was assessed against the hypothesis of isometric growth if $b = 3$, positive allometry if $b > 3$, negative isometry if $b < 3$ (Pauly, 1983). These two latter tests were performed using the STAT VIEW 5.0 logistic model.

RESULTS AND DISCUSSION

All the collected specimens were identified as *O. melanura* based on the combination of main morpho-

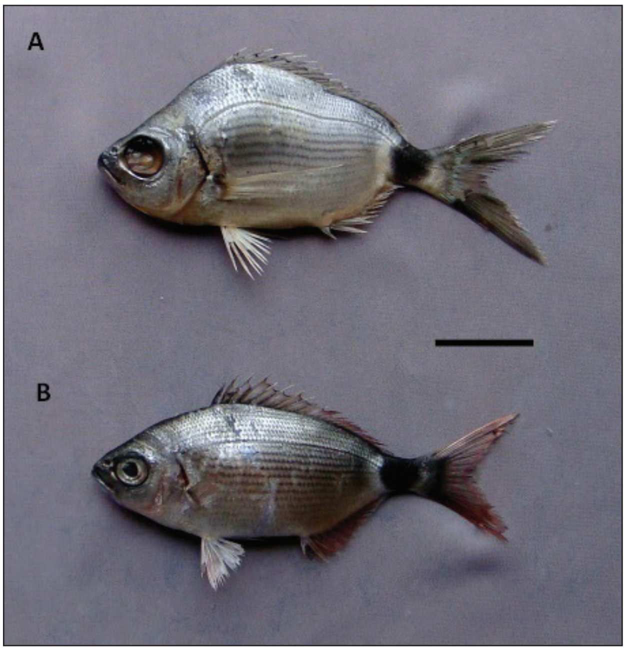

Fig. 2: *Oblada melanura* **from the northern Tunisian coast. A: Abnormal specimen (ref. ISPAB-Obl-mel 02). B: Normal specimen (ref. ISPAB-Obl-mel 01), scale bar = 40 mm.**
Sl. 2: *Oblada melanura* **iz severne tunizijske obale. A: Deformirani primerek (ref. ISPAB-Obl-mel 02). B: Normalen primerek (ref. ISPAB-Obl-mel 01), merilo = 40 mm.**

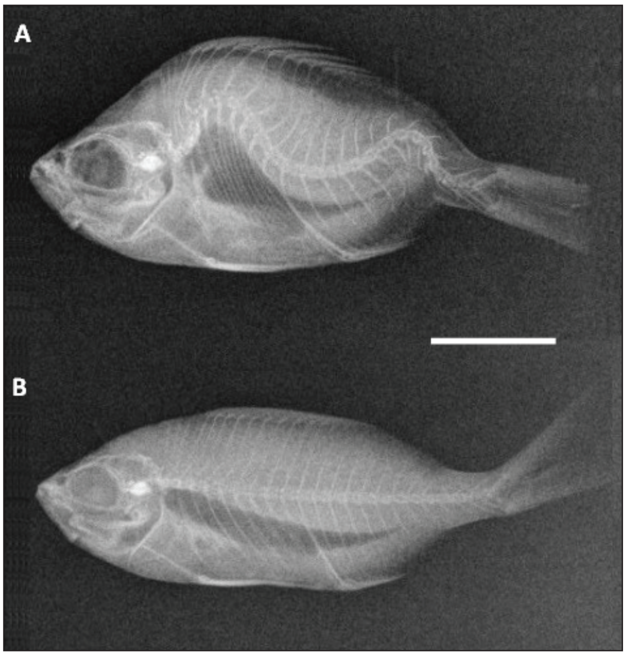

Fig. 3: X-ray of *Oblada melanura* **from the northern Tunisian coast. A: Abnormal specimen (ref. ISPAB-Obl-mel 02). B: Normal specimen (ref. ISPAB-Obl-mel 01), scale bar = 30 mm.**
Sl. 3: Rentgenski posnetek črnorepke, *Oblada melanura*, **iz severne tunizijske obale. A: Deformiran primerek (ref. ISPAB-Obl-mel 02). B: Normalen primerek (ref. ISPAB-Obl-mel 01), merilo = 30 mm.**

logical characters from Bauchot & Hureau (1986), Golani *et al.* (2006) and Akyol *et al.* (2014), such as: body elongated ovoid, snout short, eye large, scales on cheeks, mouth small, anterior margin preopercle and opercle; colour silvery grey, back darker; fine longitudinal dark lines on caudal peduncle, large black saddle surrounding white ring.

The 34 sampled specimens ranged between 135 and 220 mm TL and between 27.9 and 108.3 g TBW. The specimen exhibiting skeletal deformities (ref. ISPAB-Obl-mel 02) measured 136 mm TL and weighed 36.7 g (Fig. 2; Tab. 1). An X-ray of this abnormal specimen showed the upper margin to be strongly curved at the level of cephalic region, forming a hump. The lateral line was sinuous, more than it is generally observed in normal specimens, especially in the caudal region. At the level of cephalic and caudal regions, the vertebral column was strongly arched forming hyperkyphosis. The abdominal region displayed hyperlordosis with a similar arch as in the other two deformities (Fig. 3). Conversely, no scoliosis was observed. The lateral line deformation was the main consequence of the vertebral column's malformation. Jardas & Homen (1977) observed similar deformities in a whiting *Merlangius merlangus* (Linnaeus, 1758) and a bogue

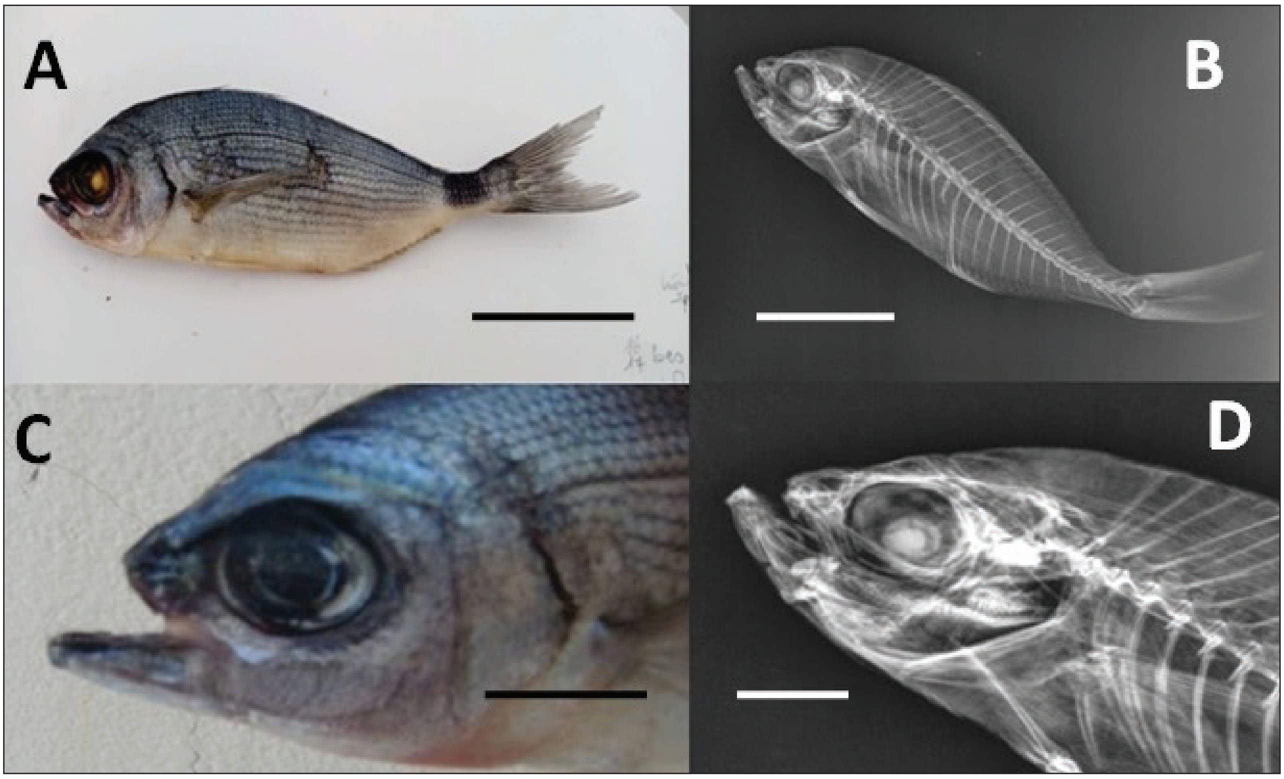

Fig. 4: A. Pug-headed specimen of** Oblada melanura **(ref. ISPAB-Obl-mel 03), scale bar = 60 mm. B. X-ray of the pug-headed specimen Oblada melanura, scale bar = 60 mm. C. Head of the same specimen, scale bar = 15 mm. D. X-ray of the head of the same specimen, scale bar = 15 mm.

Sl. 4: A. Primerek črnorepke** Oblada melanura **(ref. ISPAB-Obl-mel 03) s tako imenovano buldoško glavo, merilo = 60 mm. B. Njegov rentgenski posnetek, merilo = 60 mm. C. Glava, merilo = 15 mm. D. Rentgenski posnetek glave, merilo = 15 mm.

Boops boops (Linnaeus, 1758) from the Adriatic Sea and noted that such anomalies are very rare in teleost species from the Adriatic, suggesting that parasitic infection could be the cause of skeletal deformations.

On the other hand, Fatnassi *et al.* (2017) noted that spinal abnormalities found in specimens of greater weever *Trachinus draco* (Linnaeus, 1758) from the Bay of Bizerte were rather due to environmental conditions, such as high levels of pollutants in the wild. The area was affected by anthropogenic pollution from neighbouring agglomerations and industrial zones, reaching maximum values in the Lagoon of Bizerte (Mzoughi *et al*., 2002). This latter area is in direct communication with the sea through a navigation canal that spreads the flue of pollutants throughout the Bay of Bizerte (Fatnassi et *al*., 2017). Additionally, several papers have already pointed out the pollution of the Lagoon of Bizerte as conducive to the abundance of abnormal fishes inhabiting the area, such as gobiid fish species (Louiz *et al*., 2007), sparid species (Khenfech *et al*., 2011) and elasmobranch species (Mnasri *et al*., 2010) displaying abnormalities of the vertebral column. The pollution of the Bay of Bizerte could also be considered as the main cause of the abnormality observed in the present specimen of *O. melanura*. Additionally, Jardas & Homen (1977) noted that such skeletal anomalies are not very rare in teleost species from the Adriatic and suggested parasitic infection as another possible cause.

The pug-headed specimen of *O. melanura* measured 220 mm TL and weighed 104.2 g. An X-ray of this specimen revealed a large deformity of the upper jaw, with the suspensorium and all bones associated with the anterior portion of the neurocranium altered (Fig 4). The pre-maxilla was shorter than in normal specimens, its shape and disposition were deformed, and the snout was almost absent. The maxilla was almost normal, except in its distal end, where it was slightly altered. The branchial arches, however, appeared to be unaffected. The specimen exhibited an asymmetry between the upper and lower jaws. Following Palmas *et al.* (2020), the causes of such deformities remain rather obscure, but could be due to epigenetic factors,

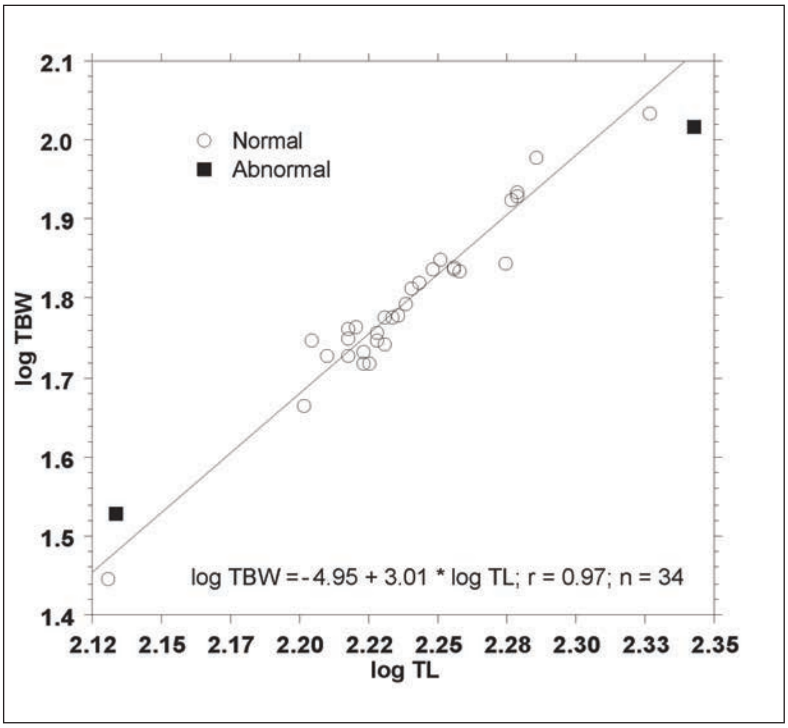

Fig. 5: The total length (TL) versus total body weight (TBM) relation expressed in logarithmic co-ordinates in the specimens of *Oblada melanura* ***collected off the northern Tunisian coast.***
Sl. 5: Odnos med celotno dolžino (TL) in celokupno telesno maso (TBM) primerkov črnorepke iz severne tunizijske obale, izražen v logaritemskih koordinatah.

such as temperature and oxygen fluctuations during egg incubation, prenatal stress of mature females, diet composition in larval stages, and, somewhat less likely, environmental pollution. In relation to the present specimen, a combination of these factors cannot be totally ruled out, however, the area of its capture allows us to consider the pollutants as the main cause of such deformity. On the other hand, Catelani *et al.* (2017) noted that pug-head deformity is more often observed in teleost species from freshwaters than in those from marine waters, probably due to chemical pollutants. However, Dawson & Heal (1971) reported that specimens in captivity are more affected by such deformity.

In accordance with the description by Bauchot & Hureau (1986), the number of scales disposed along the lateral line ranged from 64 to 67. As shown in Table 1, the scales counted in the specimen displaying skeletal deformities (74) significantly outnumbered those recorded in the normal specimen and the pug-headed specimen (67), with *t*-test = 29.7, df = 2, $p < 0.05$. Similarly, the number of vertebrae in the specimen with skeletal deformities (36) significantly outnumbered those recorded in the normal and the pug-headed specimens (27), with *t*-test =10, df = 2, $p < 0.05$. Rafrafi *et al.* (2019) noted that in *L. mormyrus* such increased numbers were probably due to the curves of the lateral line and the deformities of the vertebral column. It was also confirmed that the vertebrae were not fused and the specimen did not display an ankylosis. Similar patterns were observed in the present specimen. Conversely, deformities of the head played no role in these parameters, the numbers of vertebrae and scales on the lateral line were similar to those recorded in the normal specimen.

The deformities observed in the two abnormal specimens did not affect their health or development in the wild as a comparison with other normal specimens from the same size class has shown based on linear regression between total length *versus* total body weight (TM, in g) plotted in Fig. 3, with: log TBW = -4.95 + 3.01 * log TL; r = 0.97: n = 34 (Fig. 5) displaying positive allometry. Despite these deformities the residuals generated by this relation did not point out relevant differences between normal and deformed specimens, indicating that the latter were healthy and robust (Palmas *et al.*, 2020). Similar patterns were observed by Khenfech *et al.* (2011) in the annular sea bream *Diplodus annularis* (Linnaeus, 1758) and Rafrafi-Nouira *et al.* (2019) in the *L. mormurys* from Tunisian waters. Conversely, Matsuoaka (1987) and Boglione *et al.* (2006) noted a lethal effect of severe skeletal deformities in teleost species living in natural conditions. Jawad *et al.* (2010) showed that anomalies hinder the performance of the specimen affecting its capacity to get food and avoid predators.

Skeletal deformities are an important factor that downgrades fish production and has a high economic impact, since consumers are wary of purchasing abnormal fish (Panagiotis, 2015). Deformities are a complex mixture of various bone disorders, possibly induced by such unfavourable nutritional factors as phosphorus deficiency, vitamin C deficiency, vitamin K deficiency, and hypervitaminosis, which play an important role in their development in fish farming (Silverstone & Hammell, 2002), but slightly less so in the wild, where, on the other hand, the role environmental factors, such as current velocity, water temperature, and increased exposure to pollutants cannot be ruled out as possible causes (Panagiotis, 2015).

Following Jawad & Ibrahim (2018) the increasing temperatures of marine waters throughout the world could play a role in skeletal deformities as well. It is clear from the work of Francour *et al*. (1994) that the entire Mediterranean has been facing this ecological problem for several decades. Such trouble unfortunately also affects the northern coast of Tunisia, which has been progressively invaded by alien species, and cases of abnormalities in fish are more abundant than previously recorded in the area (Rafrafi-Nouira, 2016).

DEFORMACIJE SKELETA IN GLAVE PRI ČRNOREPKI, *OBLADA MELANURA* (OSTEICHTHYES: SPARIDAE) IZ TUNIZIJSKE OBALE (OSREDNJE SREDOZEMSKO MORJE)

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POVZETEK

Avtorji obravnavajo deformacije hrbtenice in pobočnice pri enem primerku črnorepke, Oblada melanura *(Linnaeus, 1758), in anomalijo na glavi (tako imenovana buldoška glava) pri drugem primerku; oba sta bila ujeta ob severni obali Tunizije. Kljub morfološkim deformacijam sta bila primerka sposobna življenja v divjini skupaj z normalnimi primerki. Avtorji razpravljajo o izvoru teh anomalij.*

Ključne besede: *Oblada melanura*, hiperkifoza, lordoza, onesnaževanje okolja, asimetrija ust, odnos med dolžino in maso

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UNCOMMON THERMOPHILIC FISHES FROM THE MARMARA AND BLACK SEAS

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ABSTRACT

The paper discusses the occurrences of three fish species in previously unrecorded localities in Turkey. Centrolophus niger *(Gmelin, 1789) is a new addition to the fauna of the Sea of Marmara, while* Alectis alexandrina *(Geoffroy Saint-Hilaire, 1817) and* Coryphaena hippurus *Linnaeus, 1758 are recorded for the first time in the Black Sea ecosystem. The range expansion of these taxa is most likely facilitated by increased seawater temperatures in the region.*

Key words: *Centrolophus niger*, *Alectis alexandrina*, *Coryphaena hippurus*, Sea of Marmara, Black Sea

PESCI TERMOFILI NON COMUNI DEL MAR DI MARMARA E DEL MAR NERO

SINTESI

Nell'articolo vengono presentate nuove segnalazioni di tre specie di pesci in località della Turchia dove precedentemente non erano state ritrovate. Centrolophus niger *(Gmelin, 1789) è una nuova aggiunta alla fauna del Mar di Marmara, mentre* Alectis alexandrina *(Geoffroy Saint-Hilaire, 1817) e* Coryphaena hippurus *Linnaeus, 1758 vengono ritrovati per la prima volta nell'ecosistema del Mar Nero. L'espansione dell'areale di questi taxa è molto probabilmente facilitata dall'innalzamento della temperatura dell'acqua marina nella regione.*

Parole chiave: *Centrolophus niger*, *Alectis alexandrina*, *Coryphaena hippurus*, Mar di Marmara, Mar Nero

INTRODUCTION

Several thermophilic fish species native to subtropical or tropical environments are extending their biogeographical ranges to northern sectors of the Mediterranean Sea, primarily as a result of seawater warming (Francour *et al.*, 1994; Azzurro, 2008; Azzurro *et al.*, 2011; Bianchi *et al.*, 2017). This phenomenon has also been observed along the Turkish coastline, especially in the Marmara and Black Seas, where rapid change in fish fauna has been observed during the past decade. The mean surface water temperature of both seas, which was 15.1°C during the 1970–1979 period, experienced a significant increase to 16.3 °C and 16.6 °C in the Black Sea and the Sea of Marmara, respectively, during the 2010–2019 period (TSMS, 2021). The change of hydrographical conditions of these two unique semi-enclosed seas is manifest in the influx to the region of an increasing number of non-native fish with warm water affinities. For example, *Trachinotus ovatus* (Linnaeus, 1758) has recently penetrated as far as the Strait of Istanbul, the entrance to the Black Sea, with possible indications of population establishment (Bilecenoglu & Öztürk, 2019). Likewise, occurrences of typical Mediterranean taxa, such as *Mustelus asterias* Cloquet, 1819 and *Serranus hepatus* (Linnaeus, 1758) in the Black Sea (Eryılmaz *et al.*, 2011; Dalgıç *et al.*, 2013), and *Dasyatis tortonesei* Capapé, 1975 and *Aetomylaeus bovinus* (Geoffroy Saint-Hilaire, 1817) in the Sea of Marmara (Yıldız *et al.*, 2016, Bilecenoglu, 2019) can be interpreted as a consequence of global warming.

In this paper, we are presenting new information on the distribution range expansion of three thermophilic fish species: *Centrolophus niger* (Gmelin, 1789), which was recorded for the first time in the Sea of Marmara, and *Alectis alexandrina* (Geoffroy Saint-Hilaire, 1817) and *Coryphaena hippurus* Linnaeus, 1758, which are new to Black Sea fauna.

MATERIAL AND METHODS

On 15 November 2020, a single specimen of *C. niger* measuring 79 cm in total length and weighing 6880 g was captured by trammel net off Hamzaköy (Çanakkale, Sea of Marmara, Fig. 1), at a depth of 2 m. Owing to the uncommon occurrence of this species, the fishermen immediately informed the local fisheries authorities (second author) and provided several photographs of the captured individual.

During regular screening of online Turkish newspapers for any uncommon marine fish reports, an occurrence of a large-sized *A. alexandrina* (8400 g in weight) captured from Sinop coasts (central Black Sea, Fig. 1) was unexpectedly encountered. The news appeared on 17 November 2020 in several local and national newspapers, and is worth including herein due to its taxonomical importance. The length of the fish was not mentioned, but the associated photograph indicated a total length of at least 80 cm.

On 3 January 2021, a skin diver captured a single individual of *C. hippurus* of an approximate total length of 50 cm, using a speargun at a depth of 10 m, in the Akçakoca coast of Zonguldak (western Black Sea, Fig. 1). The diver shared the photographs of the fish on the social media (Facebook) and later forwarded them to the first author for taxonomic identification.

RESULTS AND DISCUSSION

Based on the combination of characters including elongate body, large mouth, single dorsal fin (originating slightly behind the end of pectoral fin), very small scales, anteriorly arched lateral line, and uniformly dark brown body color, the Marmara specimen of *C. niger* was positively identified from the photograph (Fig. 2A), matching the description by Haedrich (1986). Previously regarded as rare in the Mediterranean Sea, based on several records from distant localities in recent years, *C. niger* has proved to be more common and widespread, and the increasing number of observations of the species is likely related to climate change (Capapé *et al.*, 2017). Adults of the species tend

Fig. 1: Capture and observation localities of *Centrolophus niger* ***(1),*** *Coryphaena hippurus* ***(2) and*** *Alectis alexandrina* ***(3) along the Turkish coast.***
Sl. 1: Lokalitete, kjer so bile ujete ali opažene vrste *Centrolophus niger* ***(1),*** *Coryphaena hippurus* ***(2) in*** *Alectis alexandrina* ***(3) vzdolž turških obal.***

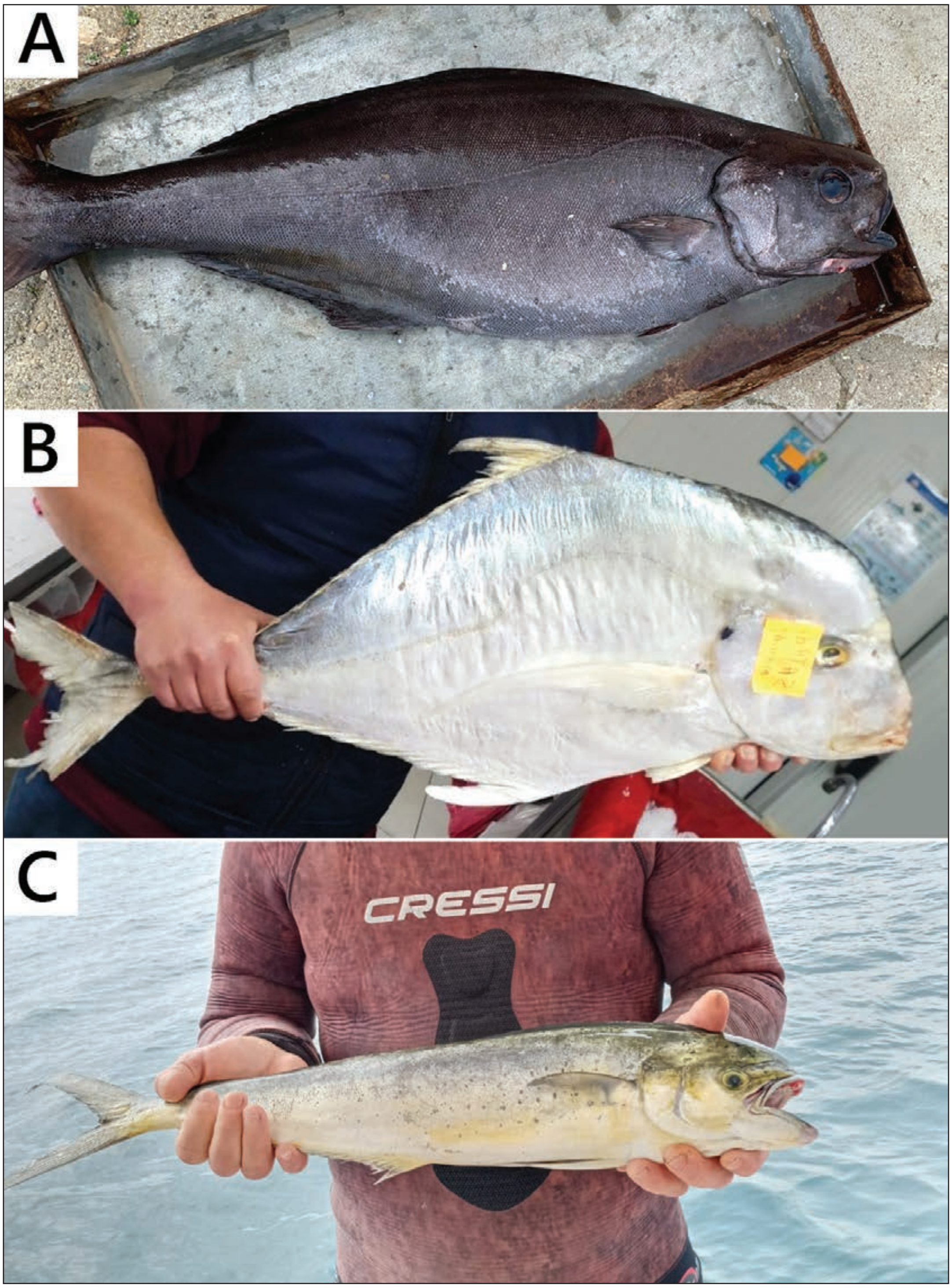

Fig. 2: A) The** Centrolophus niger **individual captured from Gelibolu coast, Sea of Marmara (photograph courtesy of C. Konur); B)** Alectis alexandrina **from Sinop, central Black Sea (source: https://www.haberler.com/sinop-ta-yakalanan-dev-iskender-baligi-gorenleri-13741950-haberi/), C)** Coryphaena hippurus **spearfished from the Akçakoca shore in the western Black Sea (photograph courtesy of V. Erdogan).

Sl. 2: A) Primerek črnuha,** Centrolophus niger**, iz obale pri Geliboli, Marmarsko morje (Foto: C. Konur); B) primerek vrste** Alectis alexandrina **iz Sinop, osrednje Črno morje (vir: https://www.haberler.com/sinop-ta-yakalanan-dev-iskender-baligi-gorenleri-13741950-haberi/), C) primerek delfinke,** Coryphaena hippurus**, ulovljen s podvodno puško na obali Akçakoca v zahodnem Črnem morju (Foto: V. Erdogan).

to inhabit deep waters (Haedrich, 1986), however, our recent finding is from a very shallow shore (2 m) in the Gelibolu coast, where maximum depths do not exceed 70 m. The hydrography of the Strait of Çanakkale is governed by a two-layered flow system, i.e., a surface layer flowing from the Black Sea towards the Aegean Sea, and a bottom layer comprising Mediterranean waters flowing towards the Black Sea (Beşiktepe *et al*., 1994). The most plausible explanation would thus be that the species has penetrated the Strait of Çanakkale from the Aegean Sea through the bottom flow layer and was incidentally captured at the southwestern margin of the Sea of Marmara.

Monitoring the distribution of marine taxa through data obtained from online newspapers is a quite new low-cost and non-destructive approach, which has proved to be efficient in providing valuable information, including existence of previously unknown species and/or significant range expansions (Kabasakal & Bilecenoglu, 2020). The occurrence data of an adult individual of *A. alexandrina* in the central Black Sea coast (Fig. 2B) are also provided accordingly. This thermophilic carangid is prevalent along the entire northern Levant shores extending as far as Gökova Bay in the southern Aegean coast of Turkey, but prior to this occurrence there were no observations in relation to the species from the northern Aegean or Marmara or Black Seas (Bilecenoglu *et al*., 2014). This recent occurrence in the Sinop coast, at least 900 nautical miles away from Gökova Bay, is therefore surprisingly interesting.

The unique coloration and, even more so, the body shape of *C. hippurus* captured from the western Black Sea were instrumental in the identification of the species based on the photograph (Fig. 2C), and its distinction from the congeneric *C. equiselis*, as the body depth equaled less than 25% of standard length in adults, and the pectoral fin represented over a half of the length of the head (Collette, 1986; Froese & Pauly, 2019). The epipelagic *C. hippurus* is distributed worldwide in tropical and subtropical seas, including the Mediterranean Sea (Collette, 1986). Naturally occurring in the Levant and Aegean Sea shores of Turkey (Bilecenoglu *et al*., 2014), the species has penetrated into the western part of the Sea of Marmara over the past decade (Artüz & Kubanç, 2015). Since the species displays a highly migratory behavior (Froese & Pauly, 2019), its influx into the Black Sea via the Strait of Istanbul is a reasonable explanation.

The Marmara and Black Seas have quite similar ichthyofaunas (56% similarity based on presence vs. absence of species, Bilecenoglu *et al*., 2002), which is to be expected considering that they evolved together during the same geological eras. The increasing number of thermophilic fish recorded from the region should be considered a serious threat that might lead to an undeterred biological homogenization, commonly known as "Mediterraneanization" (Boltachev & Karpova, 2014). Fish species near the limits of their thermal distribution are obvious candidates for range shifts given the rising temperatures (Campana *et al*., 2020), so we may assume that several other species have the potential to advance towards the colder sectors of the Mediterranean Basin. The monitoring of the distribution patterns of native fish taxa can therefore provide valuable bioecological information, which should be collected using all novel methodological means (i.e., citizen science, social media, print/online media, etc.) in addition to traditional methods.

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NENAVADNE TOPLOLJUBNE RIBE IZ MARMARSKEGA IN ČRNEGA MORJA

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POVZETEK

Avtorji poročajo o novih pojavih treh vrst rib iz lokalitet, na katerih doslej še niso bile potrjene v Turčiji. Centrolophus niger *(Gmelin, 1789) je nova vrsta v favni Marmarskega morja, medtem, ko sta bili vrsti* Alectis alexandrina *(Geoffroy Saint-Hilaire, 1817) in* Coryphaena hippurus *Linnaeus, 1758 prvič potrjeni v ekosistemu Črnega morja. Širjenje areala teh vrst je najverjetneje povezano z višjimi temperaturami vode v regiji.*

Ključne besede: *Centrolophus niger*, *Alectis alexandrina*, *Coryphaena hippurus*, Marmarsko morje, Črno morje

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FIRST SUBSTANTIATED RECORD OF ARMLESS SNAKE EEL *DALOPHIS IMBERBIS* (OSTEICHTHYES: OPHICHTHIDAE) FROM THE SYRIAN COAST (EASTERN MEDITERRANEAN SEA)

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ABSTRACT

The present note reports the first record of armless snake eel Dalophis imberbis *(Delaroche, 1809) from the coast of Syria. It describes the specimen and provides comments about its distribution. This record marks the easternmost extension range of the species in the Mediterranean Sea, but the establishment of a viable population in the Levant Basin remains questionable; more captures are needed to confirm this hypothesis.*

Key words: *Dalophis imberbis*, description, morphometric measurements, extension range, eastern Levant Basin

PRIMO RITROVAMENTO DOCUMENTATO DELLA BISCIA DI MARE MEZZANA *DALOPHIS IMBERBIS* (OSTEICHTHYES: OPHICHTHIDAE) LUNGO LA COSTA SIRIANA (MEDITERRANEO ORIENTALE)

SINTESI

La presente nota riporta il primo ritrovamento della biscia di mare mezzana Dalophis imberbis *(Delaroche, 1809) lungo la costa della Siria. Gli autori descrivono l'esemplare e commentano la distribuzione della specie. Questo ritrovamento rappresenta il punto più orientale dell'estensione della specie nel Mar Mediterraneo, ma la presenza di una popolazione vitale nel bacino del Levante rimane discutibile. Saranno necessarie ulteriori catture per confermare questa ipotesi.*

Parole chiave: *Dalophis imberbis*, descrizione, misure morfometriche, range di estensione, bacino orientale del Levante

INTRODUCTION

The armless snake eel *Dalophis imberbis* (Delaroche, 1809) is reported from the eastern North Atlantic as far north as Portugal (Quéro *et al.*, 2003) and south of the Strait of Gibraltar, off Morocco (Lloris & Rucabado, 1998) and Mauritania (Maurin & Bonnet, 1970). Southward, the species is unknown between Senegal (Cadenat, 1951; Diatta, *pers. comm.*, 2021) and the Gulf of Guinea (Blache *et al.*, 1970; Leiby, 1990).

Following Bauchot (1986) the species is recorded in the wider Mediterranean, is probably rare off the French coast (Bauchot & Pras, 1980; Béarez *et al.*, 2017), but quite common in Italian waters (Bonifazi *et al.*, 2019). Likic *et al.* (2015) noted that *D. imberbis* is caught in low densities in the Adriatic Sea. Southward, the species spawned in the Bay of Algiers (Bauchot, 1986) but generally remains poorly known off the Maghreb shore, Algeria (Dieuzeide *et al.*, 1954; Refes *et al.*, 2010) and Tunisia (Bradaï *et al.*, 2004).

Eastward, the species is reported in Greek waters (Papaconstantinou, 2014) and in the Turkish coasts (Bilecenoğlu *et al.*, 2014), and the Levant Basin constitutes its easternmost extension range in the Mediterranean Sea (El Sayed *et al.*, 2017; Golani, 2005; Bariche & Fricke, 2019). Routine monitoring has been conducted for several decades to assess the fish diversity in Syrian marine waters and several species unknown among the local ichthyofauna have periodically been found and described (Saad, 2005; Ali, 2018). Recently, a specimen of *D. imberbis* was collected for the first time in this area. The specimen is presented in this note and some comments are provided concerning its distribution in the local area and in the wider Mediterranean Sea.

MATERIAL AND METHODS

On 25 April 2020, a specimen of armless snake eel *Dalophis inberbis* (Delaroche, 1809) was caught with a hand fishing net off Tartous Beach, at 35 86’93’’E and 34°90’39’’N, at a depth of 13 metres, on rocky bottom (Fig. 1). It was delivered

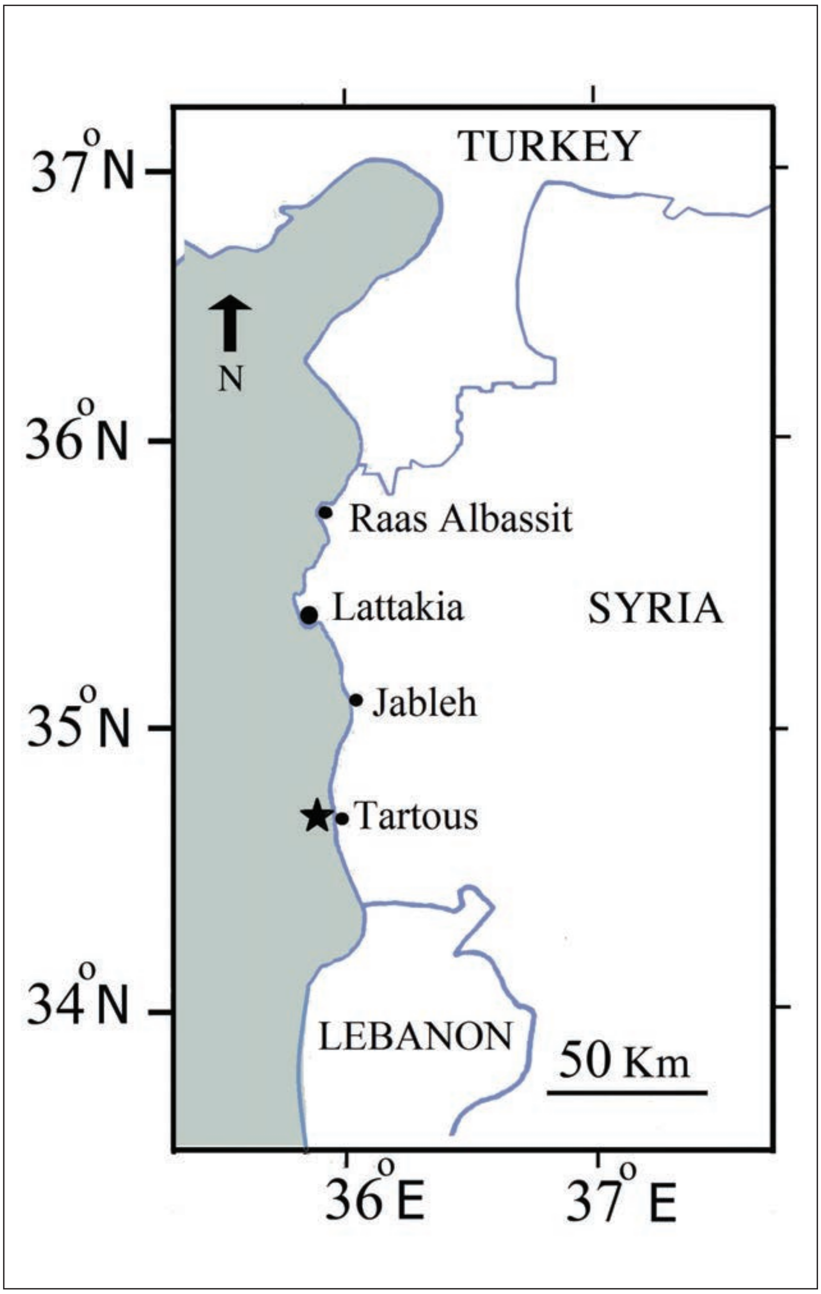

Fig. 1: Map of the Syrian coast indicating (black star) the capture site of *Dalophis imberbis* ***(off Tartous Beach).***
Sl. 1: Zemljevid sirske obale z označbo lokalitete, kjer je bil ujet primerek kačaste jegulje (*Dalophis imberbis****), ujete ob plaži Tartous Beach.***

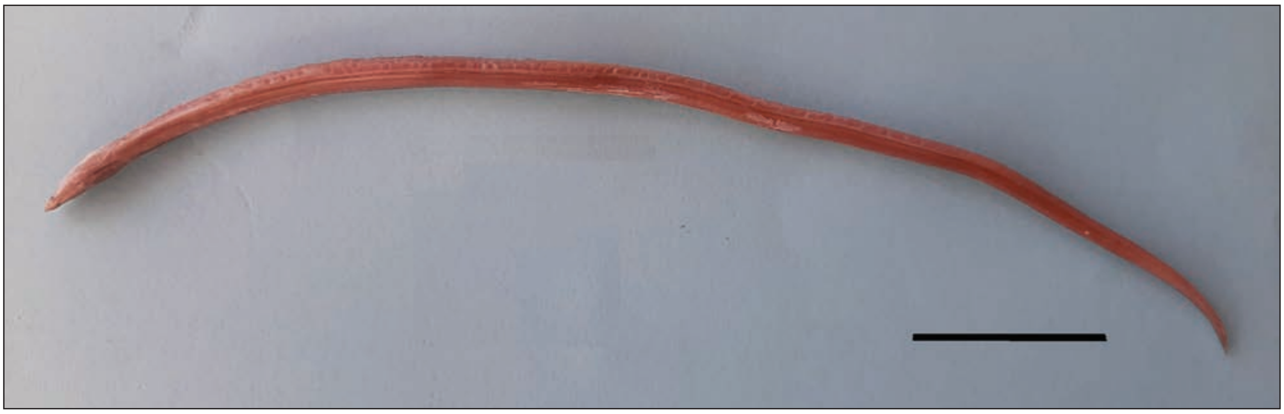

Fig. Specimen of* Dalophis imberbis *(caught off Tartous Beach), Syrian coast, scale bar = 50 mm.
Sl. 2: Primerek kačaste jegulje (*Dalophis imberbis*), ujete ob plaži Tartous Beach (sirska obala), merilo = 50 mm.

to the laboratory for thorough examination following Bello *et al.* (2014). Some morphological measurements of the specimen were made and recorded to the nearest millimetre and the nearest gram (see Tab. 1). The specimen was fixed in 10 % buffered formalin, preserved in 75% ethanol and deposited in the Ichthyological Collection of the Laboratory of Marine Sciences and Aquatic Environment at Tishreen University, in Lattakia (Syria) under catalogue number MSL 23-2020-D. imb.

RESULTS AND DISCUSSION

The Syrian specimen (Fig. 2) was identified as *D. imberbis via* a combination of the following main morphological characters: body very elongate, snake-like and cylindrical, with similar thickness from head to tail, and scaleless; vent in anterior region of body; snout short conical, eye small compared to the head, dorsal part of head and lips covered with villosities; teeth slightly curved and conical; gill openings latero-ventral; caudal and pelvic fins absent, pectoral fins rudimentary, dorsal and anal fins low, placed in a deep dermal groove; colour of head, back and base of dorsal fin grey-violet, dotted with black, belly and underside of head yellowish.

The description of the species, including morphological characters, colour and morphometric measurements (see Tab. 1), is in total accordance with Tortonese (1970), Bauchot (1986), Quéro et *al*. (2003) and Bonifazi *et al*. (2019). *D. imberbis* could be added to the list of fish species recorded in the Syrian coast, completing the previous works of Saad (2005) and Ali (2018). Following Bonifazi *et al*. (2019), the scarcity of the species throughout its capture areas is probably due to its low economical interest. The species is rather considered as common by-catch by fishermen (Busalacchi *et al*., 2010). However, Bonifazi *et al*. (2019) reported records of massive beaching of *D. imberbis* from the coast of Ostia (central Mediterranean Sea), observed on 6 March 2017, after a huge wintry storm. Such a phenomenon

Tab. 1: Morphometric measurements and total body weight of* Dalophis imberbis *(caught off Tartous Beach).
Tab. 1: Morfometrične meritve in celokupna telesna masa kačaste jegulje (*Dalophis imberbis*), ujete ob plaži Tartous Beach.

Reference	MSL-23-2020-D. imb	
Morphometric characters (mm)	mm	%TL
Total length (TL)	260	100
Preanal length (LPA)	97.5	37.5
Predorsal length (LPD)	25.2	9.7
Prepectoral length (LPP)	21.9	8.4
Dorsal fin length (LD)	229.1	88.1
Anal fin length (La)	167.7	64..5
Pectoral fin length (Lp)	4.8	1.8
Body depth (H)	4.8	1.8
Head length (C)	20.1	7.7
Eye diameter (O)	1.3	0.5
Preorbital length (PO)	6.2	2.4
Interorbital length (Io)	1.5	0.6
Length of lower jaw	12.7	4.8
Total body weight (gram)	10.16	

could occur anywhere in the Mediterranean Sea because *D. imberbis* is commonly hiding in burrows in the sand and mud of shallow coastal waters at up to 80 m of depth (Bauchot, 1986).

The present capture of *D. imberbis* confirms the presence of the species in the Levant Basin, and together with the captures reported by Golani (2005) and Bariche & Fricke (2019) marks the easternmost extension range of the species in the Mediterranean Sea. However, more records are required to establish the occurrence of a viable population of *D. imberbis* in the region.

PRVI DOKUMENTIRAN PRIMER POJAVLJANJA KAČASTE JEGULJE, *DALOPHIS IMBERBIS* (OSTEICHTHYES: OPHICHTHIDAE), VZDOLŽ SIRSKE OBALE (VZHODNO SREDOZEMSKO MORJE)

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POVZETEK

Avtorji poročajo o prvem primeru pojavljanja kačaste jegulje Dalophis imberbis *(Delaroche, 1809) iz sirske obale. Opisujejo ujeti primerek in razpravljajo o razširjenosti vrste. Gre za najbolj vzhodno pojavljanje te vrste v Sredozemskem morju. Kljub temu je prisotnost vitalne populacije te vrste v Levantskem bazenu vprašljiva. Za potrditev te hipoteze bi potrebovali več primerov pojavljanja te vrste.*

Ključne vrste: Dalophis imberbis, opis, morfometrične meritve, širjenje areala, vzhodni Levantski bazen

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LENGTH-WEIGHT RELATIONSHIPS AND METRIC CHARACTERS OF THE ATLANTIC HORSE MACKEREL, *TRACHURUS TRACHURUS* (PERCIFORMES: CARANGIDAE), CAUGHT IN BÉNI-SAF BAY, WESTERN MEDITERRANEAN (ALGERIA)

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ABSTRACT

The present study is to describe the morphometric characteristics of the Atlantic horse mackerel, Trachurus trachurus *(Linnaeus, 1758), from Béni-Saf Bay (Algeria). A total of 355 specimens were investigated, sampled between November 2016 and October 2017, and consisting of 47.04% males, 44.79% females, and 8.17% undetermined individuals. The total length of the observed fish ranged from 7.4 to 35.4 cm. Seventeen measurements were carried out for each specimen. The length-weight relationship was investigated, and the results showed that the increase in size is proportional to the increase in weight (isometric allometry). The analysis of 17 metric characters allowed us to determine the type of growth allometry; all the characters presented a lowering allometry, with six characters displaying sexual dimorphism, five in favor of the males and one in favor of females.*

Key words: Atlantic horse mackerel, *Trachurus trachurus*, length-weight relationship, metric characters, Béni-Saf Bay, Algeria

RELAZIONI LUNGHEZZA-PESO E CARATTERI METRICI DEL SUGARELLO, *TRACHURUS TRACHURUS* (PERCIFORMES: CARANGIDAE), CATTURATO NELLA BAIA DI BÉNI-SAF, MEDITERRANEO OCCIDENTALE (ALGERIA)

SINTESI

L'articolo riporta le caratteristiche morfometriche del sugarello, Trachurus trachurus *(Linnaeus, 1758), proveniente dalla baia di Béni-Saf (Algeria). Un totale di 355 esemplari sono stati campionati tra novembre 2016 e ottobre 2017, con il 47,04 % di maschi, il 44,79 % di femmine e l'8,17 % di indeterminati. La lunghezza totale degli esemplari variava da 7,4 a 35,4 cm. Sono state eseguite 17 misure per ogni esemplare. In merito al rapporto lunghezza-peso è stato evidenziato che l'aumento della taglia è proporzionale all'aumento del peso (allometria isomerica). L'analisi di 17 caratteri metrici ha permesso di determinare il tipo di allometria di crescita. Tutti i caratteri presentano un'allometria decrescente. Sei caratteri sono legati al dimorfismo sessuale, cinque a favore dei maschi e uno a favore delle femmine.*

Parole chiave: sugarello, *Trachurus trachurus*, rapporto lunghezza-peso, caratteri metrici, baia di Béni-Saf, Algeria

INTRODUCTION

The Atlantic horse mackerel, *Trachurus trachurus* (Linnaeus, 1758), is a gregarious species of the Carangidae family. It can be found in circa-littoral bottoms and even in the higher horizon of the bathyal zone (Athanassios & Konstantinos, 2015). The species is common in shallow coastal waters of the north-eastern Atlantic, from Iceland to the Islands of Cape Verde. It is also found in the Mediterranean, including the Sea of Marmara and, more rarely, in the Black Sea (Polonsky, 1969; Arneri, 1983), the Eastern Channel, and the North Sea. *T. trachurus* is a migratory species; it lives and hunts in shoals. Usually, it migrates towards the coast in summer, and returns to offshore waters in winter; it can be found close to the sea bottom, where it lives between 50 and 400 m of depth; the species also has the capacity to adapt to brackish water (Santic *et al*., 2003). In the Mediterranean Basin, *T. trachurus* is very common (Fezzani *et al*., 2002), living in open water and near sandy bottoms; it feeds primarily on fish, such as gobies, anchovy, sardine, and only on certain shellfish (Ameri, 1983; Kerstan, 1985).

Horse mackerel has been the subject of several studies on reproduction (Korichi, 1988; Tahari, 2011; Aydin & Erdo an, 2018; Gherram, 2019; Rahmani & Koudach, 2020; Rahmani *et al*., 2020a), growth (Karlou-Riga & Sinis, 1997; Moutopoulos *et al*., 2002; Abaunza *et al*., 2003; Jardas *et al*., 2004; lkyaz *et al*., 2008; Ak *et al*., 2009; Costa, 2010; Torres *et al*., 2012; Kerkich *et al*., 2013; Erdoğan *et al*., 2016; Bensahla *et al*., 2017; Azzouz *et al*., 2018; Gherram, 2019; Rahmani, 2020), and diet (Olaso-Toca *et al*., 1999; Cabral & Murta, 2002; Jardas *et al*., 2004; Šantić *et al*., 2005; Bahar & Tuncay, 2009; Bayhan *et al.,* 2013; Shawket *et al.,* 2015; Rahmani *et al*., 2020b).

This paper focuses on the growth of the Atlantic horse mackerel, *T. trachurus*, living in Béni-Saf Bay (North-West Algeria), with an emphasis on the length-weight relationship and metric characters, aiming to complete the gaps in the life cycle of this Carangidae fish species and help manage this resource better in that part of the Algerian coast.

MATERIAL AND METHODS

A total of 355 specimens of Trachurus trachurus were collected from Béni-Saf trawl fishery, captured by trawlers operating between 30–130 m of depth (Fig. 1), from November 2016 to October 2017. The specimens sampled were subjected to biometric analysis. For each specimen, we recorded 17 measurements (Fig. 2). The biometric data were recorded in the laboratory, the different lengths measured using a caliper to the nearest mm, and the sex was determined macroscopically based on the morphology and the color of gonads (Rahmani *et al.,* 2020).

Sex-ratio

The sex ratio is defined as the share of male or female individuals in the total number of individuals. It also gives an idea on the balance of the sexes within the population. It generally translates as the rate of femininity or masculinity in the population:

$$SR = F / (M+F) \times 100$$

F= number of females;
M = number of males.

The length-weight relationship (LWR)

The Length-weight relationship (LWR) was calculated from the equation:

$$Wt = a\ Lt^{b} \quad \text{(Korichi, 1988)}$$

where: Wt = fish body weight in grams, Lt = fish total length in centimeters, a = intercept or constant, b = slope or length exponent, and r = correlation coefficient.

Isometric growth means that an organism's body shape does not change as it grows, and that weight increases as the third power of length, i.e., the allometric parameter (b) is 3. A b < 3 value indicates negative allometric growth, which means the fish becomes more slender as it grows longer. A b > 3 value indicates positive allometric development, which means the fish becomes stouter or deeper-bodied as it increases in weight. It should be remembered that the coefficient a is only a rough indicator of shape

Fig. 1: Geographical location of the Beni-Saf Bay (western coast of Algeria).
Sl. 1: Zemljevid obravnavanega območja zaliva Béni-Saf (zahodna obala Alžirije).

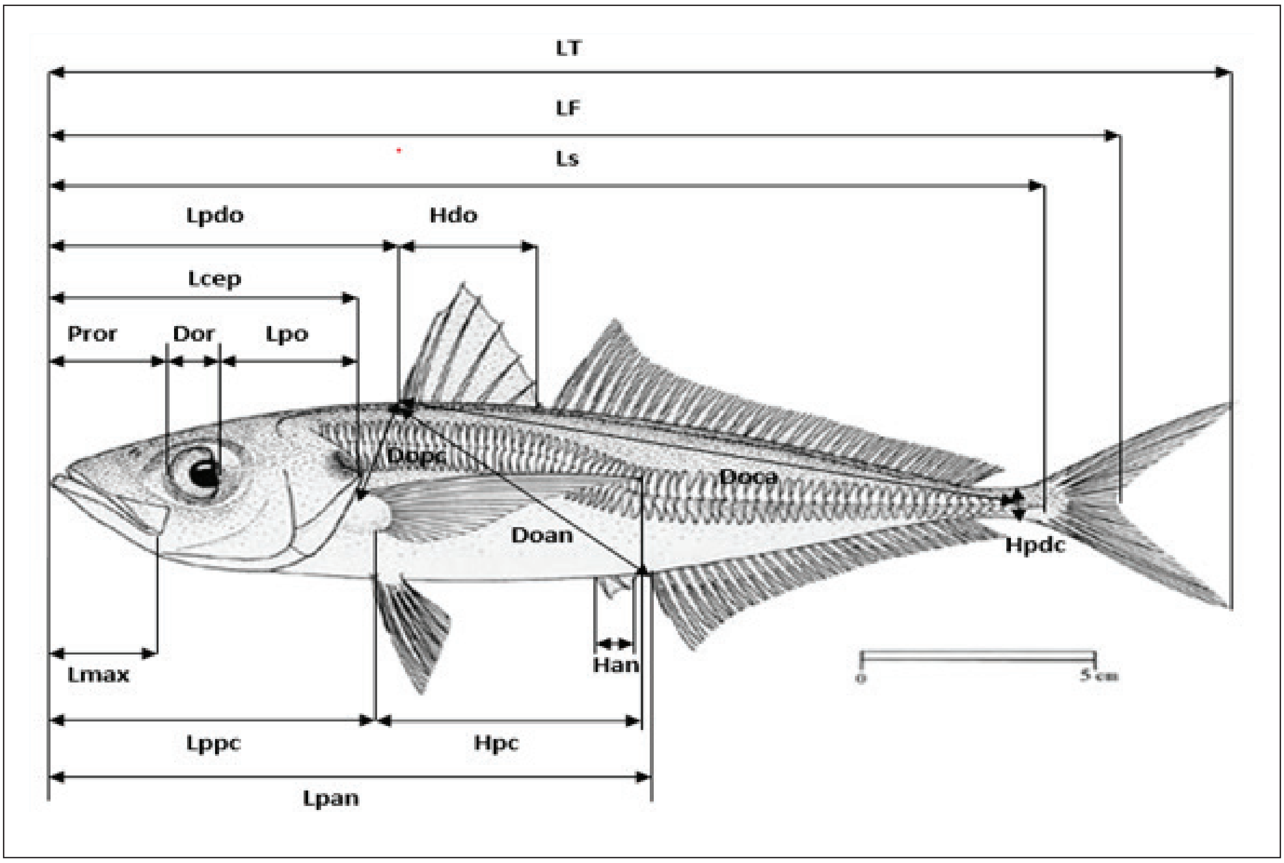

Fig. 2: Morphometric measurements taken on each fish. (Lt: *Total length;* ***LF:*** *At fork length;* ***Ls:*** *Standard length;* ***Lpdo:*** *Length pre-dorsal;* ***Lpan:*** *Length pre-anal;* ***Lcep:*** *Cephalic length;* ***Lppc:*** *Length pre-pectoral;* ***Doan:*** *Dorsal / anal distance;* ***Doca:*** *Dorsal / caudal distance;* ***Lmax:*** *Maxillary length;* ***Dor:*** *Diameter orbital;* ***Pror:*** *Length pre-orbital;* ***Hpc:*** *Pectoral Height;* ***Hdo:*** *Dorsal Height;* ***Han:*** *Anal Height;* ***Hpdc:*** *Peduncle Height;* ***Dopc:*** *Distance dorsal / pectoral).*
Sl. 2: Morfometrične meritve na vsakem primerku rib. (Lt: *Skupna dolžina;* ***LF:*** *dolžina do vilice;* ***Ls:*** *standardna dolžina;* ***Lpdo:*** *dolžina do hrbtne plavuti;* ***Lpan:*** *dolžina do zadnjične plavuti;* ***Lcep:*** *cefalična dolžina;* ***Lppc:*** *dolžina do prsne plavuti;* ***Doan:*** *hrbtna / analna razdalja;* ***Doca:*** *dorzalna / kavdalna razdalja;* ***Lmax:*** *maksilarna dolžina;* ***Dor:*** *premer očesa;* ***Pror:*** *predorbitalna dolžina;* ***Hpc:*** *dolžina prsne plavuti;* ***Hdo:*** *dolžina baze hrbtne plavuti;* ***Han:*** *dolžina baze analne plavuti;* ***Hpdc:*** *višina pedunkla;* ***Dopc:*** *oddaljenost med hrbtno in prsno plavutjo).*

when growth is not isometric, or of shape variation when two species or sexes have different allometric parameters. The degree to which one species or sex is considered slender or stouter than another would change with length in the latter case. The a value is directly interpretable as the weight of a fish in grams when it is one centimeter in length, as measured here (Riedel *et al.*, 2007).

Metric characters

To characterize the morphology of T. trachurus, the various parameters measured are expressed as a function of the total length by the following regression formula:

$$\mathbf{Y = a\ Lt^{b}}$$

Polynomial regression was applied to the examination of morphometric relations compared to increase in total length (Kováč et *al*., 1999).

RESULTS

Sex Ratio

In total, 355 specimens of *Trachurus trachurus* were collected, 167 males (47.04%), 159 females (44.79%), and 29 unsexed (8.17%). The length frequency distribution of the entire population is shown in Fig. 3. Male length range was 9.3 to 33.5 cm; female length range 8.8 to 35.4 cm. Male weight ranged from 5.55 to 292.83 g, female weight from 5.24 to 312.78 g (Fig. 3). The variations of sex ratio according to size, verified by the khi2 test, revealed significant differences

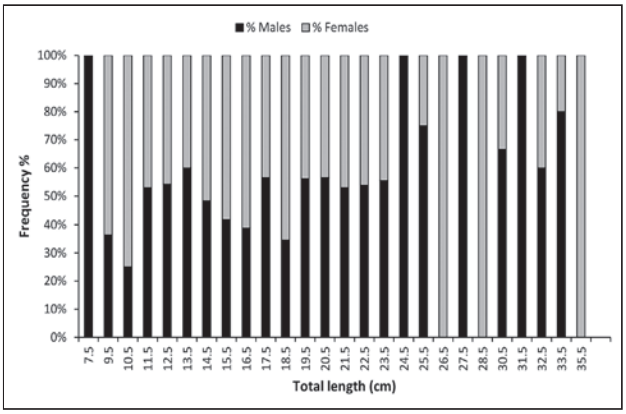

Fig. 3: Length frequency distribution of** Trachurus trachurus **caught in Béni-Saf Bay.
Sl. 3: Dolžinska razporeditev primerkov šnjura** (Trachurus trachurus) **ujetih v zalivu Béni-Saf.

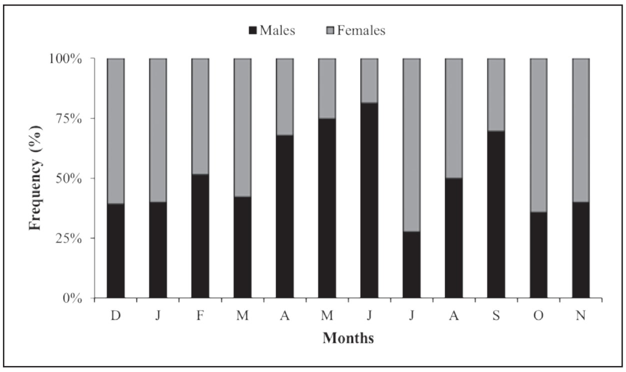

Fig. 4: Monthly evolution of Sex ratio of** Trachurus trachurus **caught in Béni-Saf Bay.
Sl. 4: Mesečna dinamika spolnega deleža primerkov šnjura** (Trachurus trachurus), **ujetih v zalivu Béni-Saf.

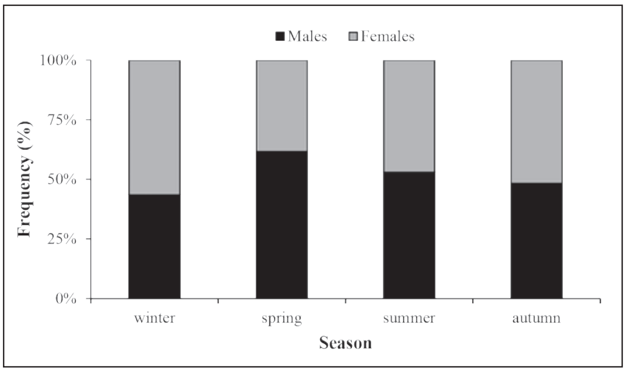

Fig. 5: Evolution of Sex ratio by seasons of T**rachurus trachurus **caught in Béni-Saf Bay.
Sl. 5: Sezonska dinamika spolnega deleža primerkov šnjura** (Trachurus trachurus), **ujetih v zalivu Béni-Saf.

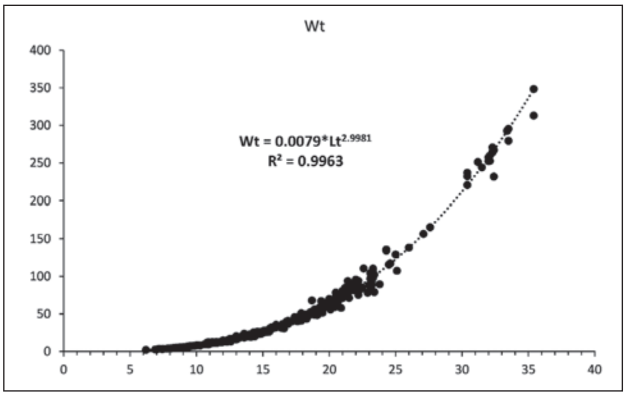

Fig. 6: Weight-length relationships for** Trachurus trachurus **(total population).
Sl. 6: Odnos med maso in dolžino telesa pri šnjuru** (Trachurus trachurus) **(celotna populacija).

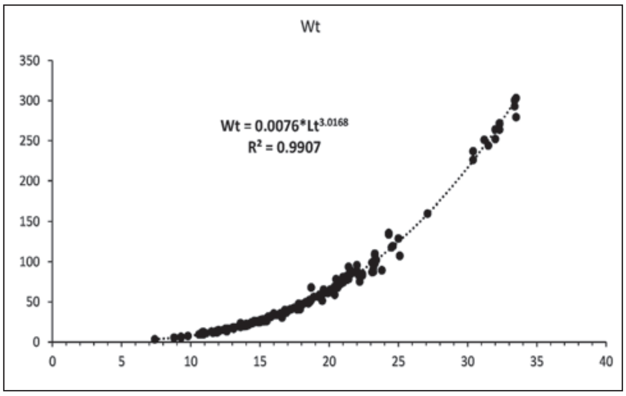

Fig. 7: Weight-length relationships for T**rachurus trachurus **(Males).
***Sl. 7: Odnos med maso in dolžino telesa pri samcih šnjura** (Trachurus trachurus).*

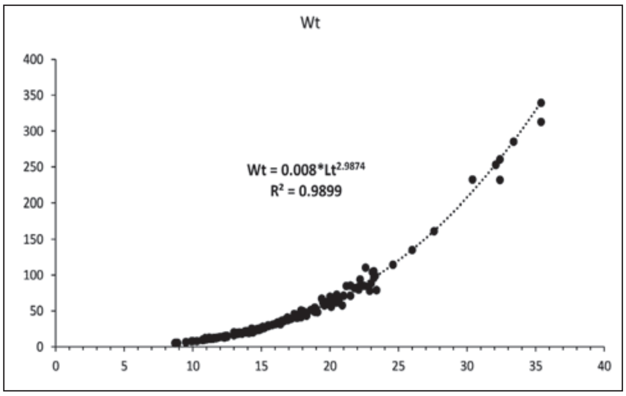

Fig. 8: Weight-length relationships for** Trachurus trachurus **(Females).
***Sl. 8: Odnos med maso in dolžino telesa pri samicah šnjura** (Trachurus trachurus).*

Tab. 1: Estimated parameters of the weight-length relationship for *Trachurus trachurus* ***- males, females and the two sexes combined.***
Tab. 1: Ocenjeni parametri odnosa med maso in dolžino telesa za samce in samice šnjurov *(Trachurus trachurus)* ***ter ne glede na spol.***

T. trachurus	n	Lt (min-max)	Wt (min-max)	a	b	R^2	Growth
total	355	7.4-35.4	3.11-312.78	0.0079	2.9981	0.9963	isometric
males	167	12-33.5	5.55-292.83	0.0076	3.0168	0.9907	isometric
females	158	8.7-35.4	5.24-312.78	0.0085	2.9874	0.9899	isometric

in favor of females for length classes between 9.5 and 11 cm of TL (χ^2=11 > $\chi^2_{t,0.05}$=3.84); beyond the 16.5 cm of total length, males have the advantage, but without significance (khi2). Beyond the 34.5 cm of TL females are dominant.

Monthly variations of sex ratio (Fig. 4) reveal that females dominate during the months of November, October, December, January, March, and July. Males outnumbered females during April, May, June and September, with numerical equality in August and February.

Evolution of sex ratio related to seasons (Fig. 5) showed that females outnumbered males during the autumn-winter period, while males outnumbered females during the spring-summer period (χ^2=5.54 > $\chi^2_{t,0.05}$=3.84) corresponding to the spawning period of *T. trachurus* in Béni-Saf Bay.

The length-weight relationship (LWR)

Model parameters for the Wt =f(Lt) relations of *T. trachurus* are given in Table 1 and Figures 6, 7, and 8.

Tab. 2: Correlation coefficients and regression equations of the various parameters measured as a function of total length in *Trachurus trachurus* ***(female sex, n = 158).***
Tab. 2: Koeficienti korelacije in regresijske enačbe raznih parametrov, povezanih s celotno dolžino pri šnjuru *(Trachurus trachurus)* ***(število samic, n = 158).***

Y=f(Lt)	Equation	R^2	Growth Type	Range
Ls=f(Lt)	$Ls = 0.8457Lt^{0.9871}$	0.9946	Allometric (-)	$7 \leq Ls \leq 28.6$
Lpdo=f(Lt)	$Lpdo = 0.4268Lt^{0.906}$	0.9038	Allometric (-)	$2.8 \leq Lpdo \leq 10.8$
Lpan=f(Lt)	$Lpan = 0.5349Lt^{0.9702}$	0.9923	Allometric (-)	$4.2 \leq Lpan \leq 17$
Lcep=f(Lt)	$Lcep= 0.2684Lt^{0.9659}$	0.9836	Allometric (-)	$2.1 \leq Lcep \leq 8.3$
Lppc=f(Lt)	$Lppc = 0.3371Lt^{0.9037}$	0.987	Allometric (-)	$2.3 \leq Lppc \leq 8.5$
Doan=f(Lt)	$Doan = 0.2489Lt^{1.0564}$	0.9941	Allometric (-)	$2.4 \leq Doan \leq 10.8$
Doca=f(Lt)	$Doca= 0.4713Lt^{1.0293}$	0.9979	Allometric (-)	$4.4 \leq Doca \leq 18.5$
Lmax=f(Lt)	$Lmax = 0.1409Lt^{0.8626}$	0.9105	Allometric (-)	$0.9 \leq Lmax \leq 3.1$
Dor=f(Lt)	$Dor = 0.0914Lt^{0.8864}$	0.9543	Allometric (-)	$0.6 \leq Dor \leq 2.2$
LF=f(Lt)	$LF = 0.9841Lt^{0.9682}$	0.9949	Allometric (-)	$8 \leq LF \leq 31.1$
Pror=f(Lt)	$Pror = 0.0946Lt^{0.9802}$	0.9879	Allometric (-)	$0.8 \leq Pror \leq 3.1$
Hpc=f(Lt)	$Hpc = 0.1258Lt^{1.1604}$	0.9736	Allometric (-)	$1.5 \leq Hpc \leq 8.2$
Hdo=f(Lt)	$Hdo = 0.1113Lt^{1.0639}$	0.9606	Allometric (-)	$1.1 \leq Hdo \leq 4.8$
Han=f(Lt)	$Han = 0.1004Lt^{0.9856}$	0.9376	Allometric (-)	$0.8 \leq Han \leq 3.6$
Hpdc=f(Lt)	$Hpdc = 0.0301Lt^{1.022}$	0.8548	Allometric (-)	$0.3 \leq Hpdc \leq 1.2$
Dopc=f(Lt)	$Dopc = 0.1085Lt^{1.0766}$	0.9802	Allometric (-)	$1.1 \leq Dopc \leq 5$

Tab. 3: Correlation coefficients and regression equations of the various parameters measured as a function of total length in *Trachurus trachurus* ***(male sex, n = 167).***
Tab. 3: Koeficienti korelacije in regresijske enačbe raznih parametrov, povezanih s celotno dolžino pri šnjuru *(Trachurus trachurus)* ***(število samcev, n = 167).***

Y=f(Lt)	Equation	R^2	Growth Type	Range
Ls=f(Lt)	$Ls = 0.9048Lt^{0.9612}$	0.9971	Allometric (-)	6.2 ≤ Ls ≤ 27.1
Lpdo=f(Lt)	$Lpdo = 0.4737Lt^{0.8658}$	0.9058	Allometric (-)	2.7 ≤ Lpdo ≤ 9.9
Lpan=f(Lt)	$Lpan = 0.5631Lt^{0.9524}$	0.9892	Allometric (-)	3.8 ≤ Lpan ≤ 16.1
Lcep=f(Lt)	$Lcep= 0.2819Lt^{0.9485}$	0.9806	Allometric (-)	1.9 ≤ Lcep ≤ 7.9
Lppc=f(Lt)	$Lppc = 0.3382Lt^{0.9052}$	0.9827	Allometric (-)	2.1 ≤ Lppc ≤ 8.1
Doan=f(Lt)	$Doan = 0.2922Lt^{1.0003}$	0.9903	Allometric (-)	2.2 ≤ Doan ≤ 10.1
Doca=f(Lt)	$Doca= 0.496Lt^{1.0111}$	0.9964	Allometric (-)	3.8 ≤ Doca ≤ 17.9
Lmax=f(Lt)	$Lmax = 0.0954Lt^{0.9909}$	0.9575	Allometric (-)	0.7 ≤ Lmax ≤ 3.1
Dor=f(Lt)	$Dor = 0.1121Lt^{0.8183}$	0.9211	Allometric (-)	0.6 ≤ Dor ≤ 2
LF=f(Lt)	$LF = 0.9844Lt^{0.9772}$	0.9868	Allometric (-)	7.1 ≤ LF ≤ 31.9
Pror=f(Lt)	$Pror = 0.1065Lt^{0.9286}$	0.9644	Allometric (-)	0.7 ≤ Pror ≤ 2.8
Hpc=f(Lt)	$Hpc = 0.1034Lt^{1.2343}$	0.9887	Allometric (-)	1.2 ≤ Hpc ≤ 8.1
Hdo=f(Lt)	$Hdo = 0.0702Lt^{1.2147}$	0.9771	Allometric (-)	0.8 ≤ Hdo ≤ 5
Han=f(Lt)	$Han = 0.0721Lt^{1.0912}$	0.9541	Allometric (-)	0.6 ≤ Han ≤ 3.3
Hpdc=f(Lt)	$Hpdc = 0.0218Lt^{1.138}$	0.9145	Allometric (-)	0.2 ≤ Hpdc ≤ 1.3
Dopc=f(Lt)	$Dopc = 0.099Lt^{1.1093}$	0.9841	Allometric (-)	0.9 ≤ Dopc ≤ 5.1

The best fit was for male *Trachurus* (R^2=0.9907) and the poorest for female *Trachurus* (R^2=0.9899). *T. trachurus* presented an isometric allometry (b≈3), the weight increasing slightly less rapidly than the length.

Metric characters

The regression equations of observed values of all measurements are represented in Tables 2 and 3, and plotted in Figures 9, 10, 11, and 12. The proximity of observed values indicates that the regression equations obtained for each of the different morphometric measurements have a good fit.

Whatever the sex, all parameters show a lower growth allometry (negative allometry). The high values of correlation coefficient of all measurements with total length confirm the close coincidence between them.

DISCUSSION

The sex ratio is slightly in favor of the males, the evolution of this index does not have phrenological regularity and is close to 1 for the March-June period, whereas females dominate in July. The Atlantic mackerel is a pelagic fish living in dense fish benches. It is possible that certain fish populations display a predominance of males or females. According to Carbonara *et al*. (2012) and Wahbi et *al*. (2015), fluctuations of the sex ratio are due to ethological phenomena (stray species, demographic segregations) responsible for over-dispersion and segregated distribution of the sexes. Due to several factors, such as behavior of the species, spawning period, mortality, sampling procedure, and aggregation of same sex individuals, the changes of this ratio are not readily understood.

The present study shows that the values of parameter b remain close to 3 regardless of the sex, the small differences indicating that the weight increases slightly faster than the height. The size-weight relationship of *T. trachurus* shows isometric type allometric growth for females, males, and for the total population. The values of the coefficient of determination (R^2) is close to 1, which confirms a strong correlation between the two variables (Lt, Wt).

We find that our results are relatively close to those published in literature (Tab. 4): Anadon (1960)

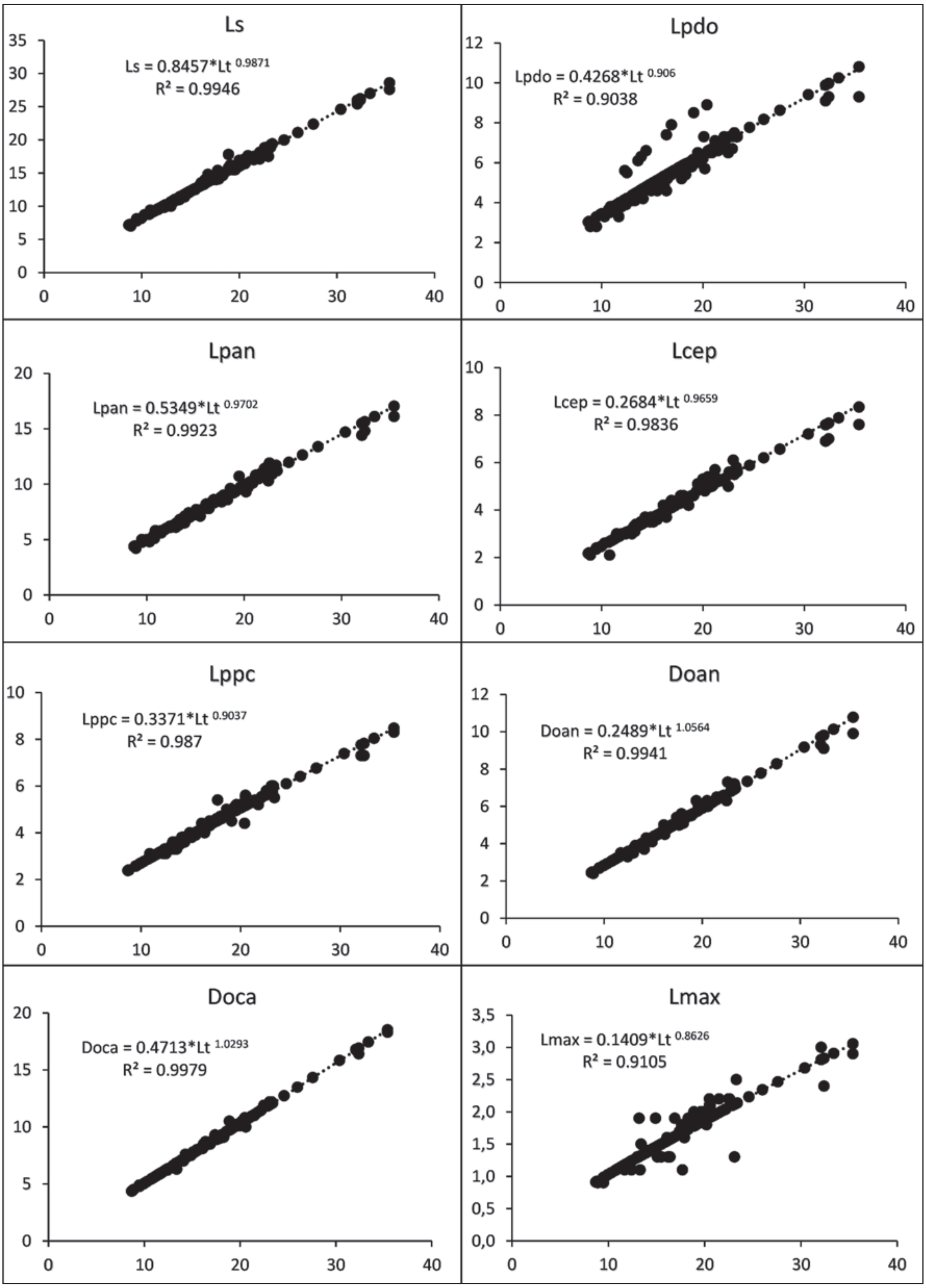

Fig. 9: Relationship of total length and different morphometric indices for females *Trachurus trachurus* ***(Ls, Lpdo, Lpan, Lcep, Lppc, Doan, Doca, Lmax).***

Sl. 9: Odnos med celotno dolžino in različnimi morfometričnimi indeksi za samice šnjura *(Trachurus trachurus)* ***(Ls, Lpdo, Lpan, Lcep, Lppc, Doan, Doca, Lmax).***

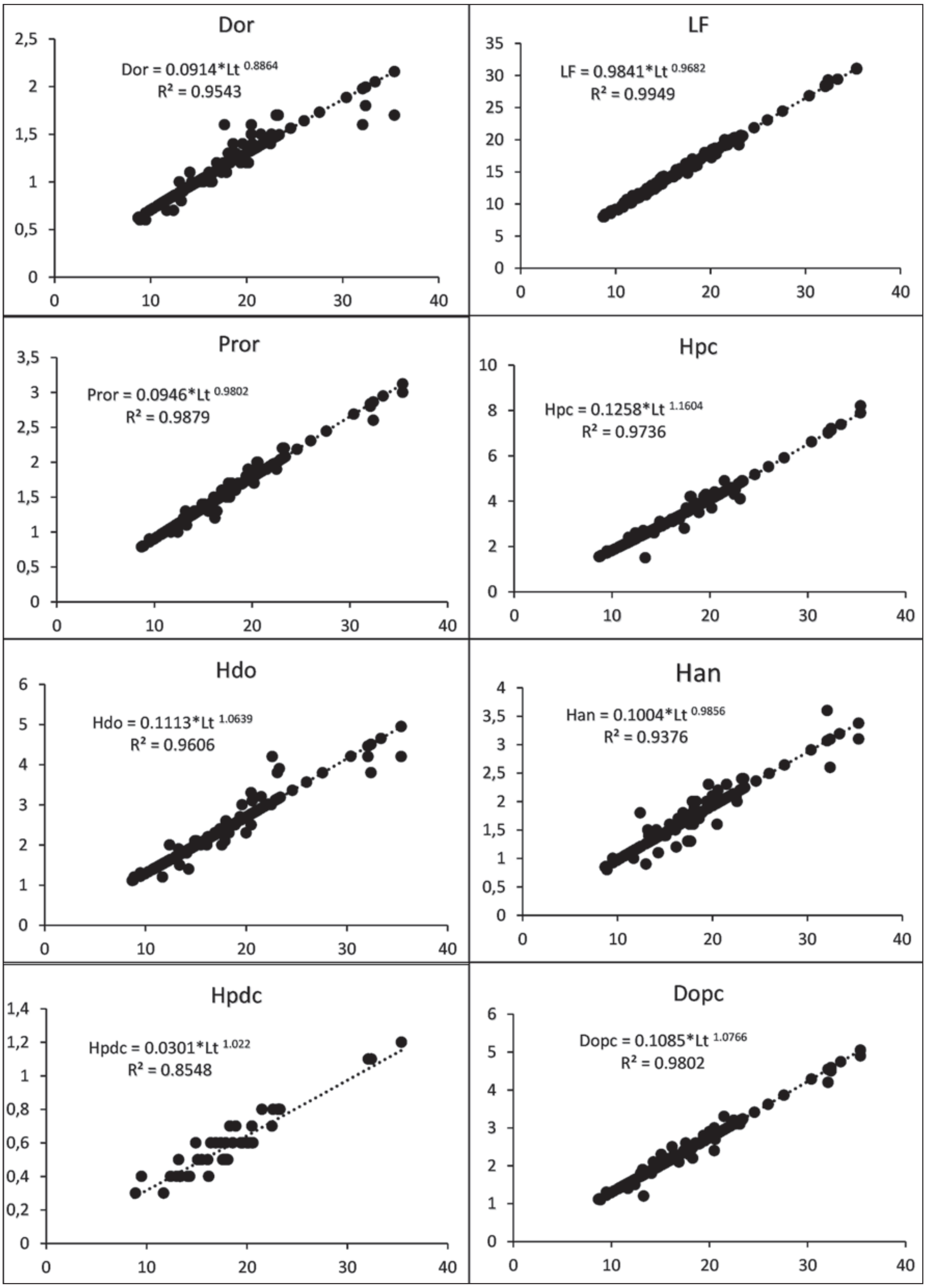

Fig. 10: Relationship of total length and different morphometric indices for females** Trachurus trachurus **(Dor, LF, Pror, Hpc, Hdo, Han, Hpdc, Dopc).
Sl. 10: Odnos med celotno dolžino in različnimi morfometričnimi indeksi za samice šnjura** (Trachurus trachurus) **(Dor, LF, Pror, Hpc, Hdo, Han, Hpdc, Dopc).

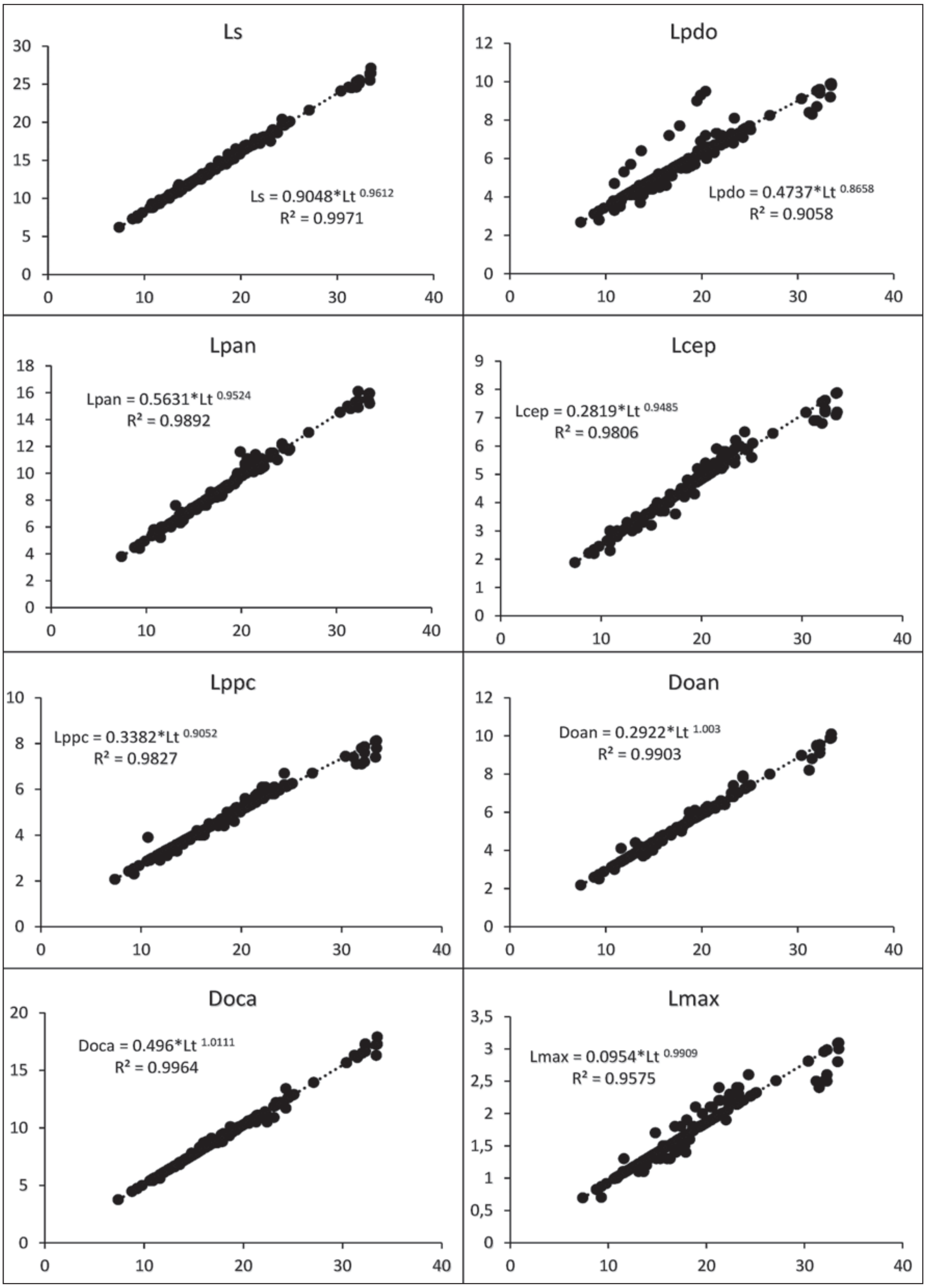

Fig. 11: Relationship between total length and different morphometric indices in males** Trachurus trachurus **(Ls, Lpdo, Lpan, Lcep, Lppc, Doan, Doca, Lmax).

Sl. 11: Odnos med celotno dolžino in različnimi morfometričnimi indeksi za samce šnjura** (Trachurus trachurus) **(Ls, Lpdo, Lpan, Lcep, Lppc, Doan, Doca, Lmax).

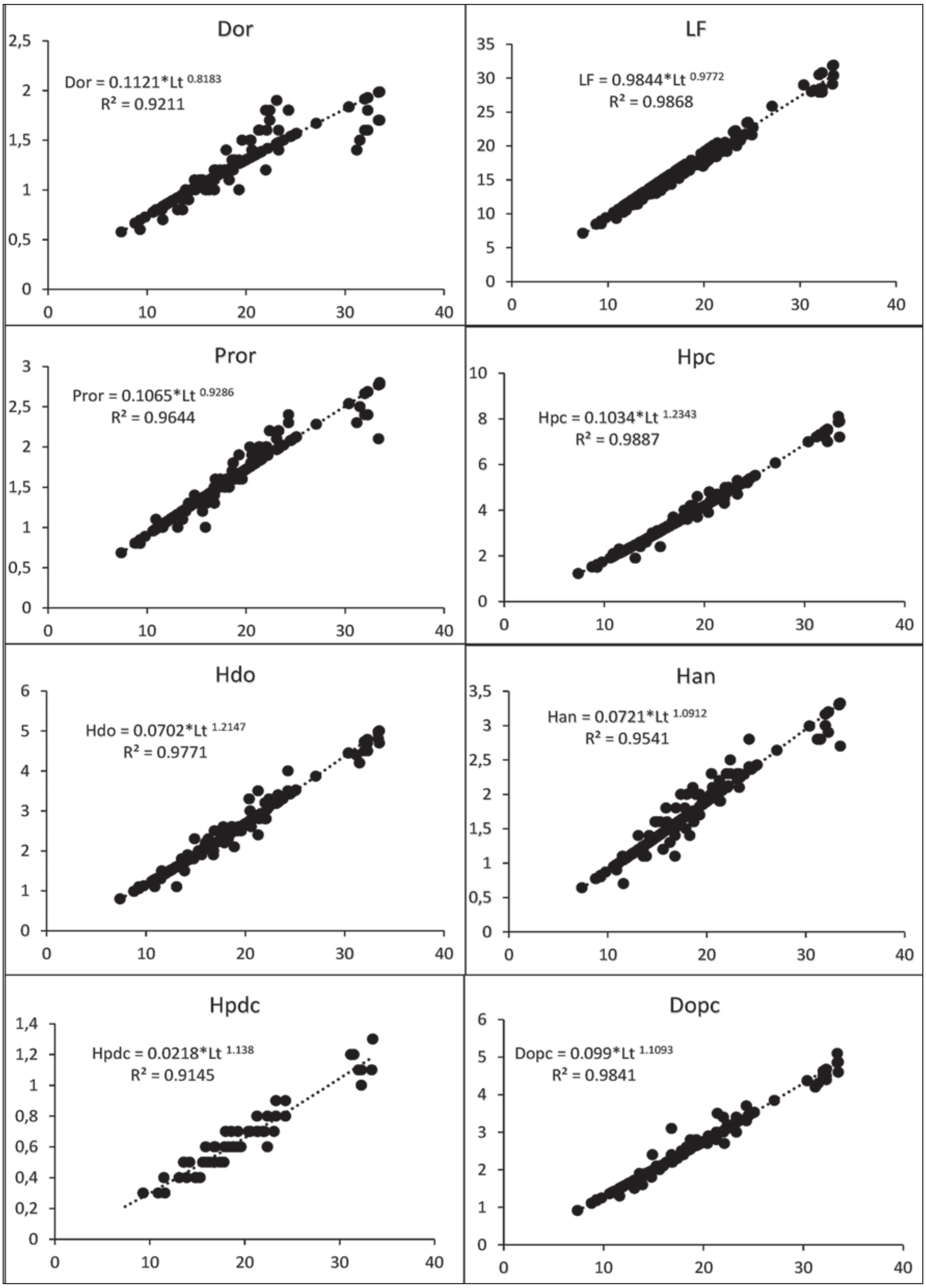

Fig. 12: Relationship between total length and different morphometric indices in males *Trachurus trachurus* ***(Dor, LF, Pror, Hpc, Hdo, Han, Hpdc, Dopc).***
Sl. 12: Odnos med celotno dolžino in različnimi morfometričnimi indeksi za samce šnjura *(Trachurus trachurus)* ***(Dor, LF, Pror, Hpc, Hdo, Han, Hpdc, Dopc).***

Tab. 4: Parameters of the height-weight relationship and weight in** Trachurus trachurus **obtained by various authors.
Tab. 4: Parametri odnosa med masno-višinskim odnosom in maso pri šnjuru (**Trachurus trachurus**) na podlagi objavljenih zapisov.

Author (year)	**Region**	**a**	**b**	**Growth**
Anadon (1960)	Espagne	0.00816	3.023	0 allometric
Wengrzyn (1975)	NW Afrique	0.0049	3.14	+ allometric
Trouvery (1977)	Golf de Gascogne	0.158	1.83	- allometric
Borges *et al.* (1977)1976	Côtes Portugaise Central Port. Côtes Portugaise		2.931 2.936 2.962	0 allometric 0 allometric 0 allometric
Carrillo (1978)	NW Meditérrannée	0.0102	2.945	- allometric
Nazarov (1978)	Gascogne	0.00585	3.087	0 allometric
Farina-Pérez (1983)	NW Espagne	0.01291	2.8545	- allometric
Arruda (1983)a	Portugal (Matosinhos)	0.0199	2.885	- allometric
Arruda (1983)b	Portugal (Peniche)	0.0173	2.927	0 allometric
Arruda (1983)c	Portugal (Portimão- Sagres)	0.0135	3.005	0 allometric
Kerstan (1985)	Irland et Royaum unit (Atlantique est)	0.00431	3.1251	+ allometric
Korichi (1988)	Baie Bou-Ismail	0.0125	2.979	0 allometric
Lucio & Martin (1989)	Baie de Biscaye	---	3.061	0 allometric
Borges & Gordo (1991)	Portugal	0.009224	2.957	0 allometric
Maxim (1995)	NW Afrique	0.0139	2.961	0 allometric
Šantić (2002)	Adriatique	0.008	3.019	0 allometric
Charef-Belifa (2009)	Oran	0.00373	3.13	+ allometric
Šantić (2011)	Adriatique	0.008	3.001	0 allometric
Itchir & Merine (2018)	Bassin algérien	0.011	2.906	- allometric
Gharram (2019)	Baie d'Oran	(♂+♀) 0.0143 (♂) 0.0140 (♀) 0.0143	3.347 3.322 3.409	+ allometric + allometric + allometric
Present study	Béni-Saf Bay	(♂+♀) 0.0079 (♂) 0.0076 (♀) 0.0085	2.9981 3.0168 2.9874	0 allometric 0 allometric 0 allometric

for Spain, Borges and Gordo (1991), Santic (2002 and 2011) for the Adriatic. While our findings were very close to those recorded by Wengrzyn (1975) in Northwest Africa, Borges et *al*. (1977) in the coasts of Portugal, Kerstan (1985) in Ireland and the United Kingdom, Korichi (1988) in the Bay of Bou-Ismail, Lucio and Martin (1989) in the Bay of Biscay, Maxim (1995) in Northwest Africa, and Charef-belifa (2009) in the Bay of Oran, they do not agree with those cited by Trouvery (1977) for the Bay of Biscay, Fariña Perez (1983) for NW Spain, Arruda (reference within Gherram, 2019) for Portugal (Matosinhos), Itchir and Merine (2018) for the Algerian Basin, and Gherram (2019) for the Bay of Oran.

The length-weight relationship parameters can vary between stocks and even between areas as mentioned by Andrade and Campos, 2002. These differences in b values can be attributed to the combination of one or more of the following factors: a) differences in the number of specimens examined, b) area/season effect, and c) differences in the observed length ranges of the specimens caught. Dulčić and Kraljević (1998) stated that temperature, food quantity, size, sex, and stage of maturity are responsible for the differences in parameters of relationship. In addition, Froese (2006) stated that small specimens have a different WLR relationship than larger ones.

All the metric characters studied (17 parameters) evolve in a minor way compared to the total length, i.e., less rapidly than the total length of the fish. Only a few of the 17 measurements allow us to suggest a slightly more or less marked sexual dimorphism, which is in agreement with Geldenhuys, 1973; Macer, 1977; and Borges *et al*., 1977; 1991. Certain metric parameters do not develop in the same way in the two sexes. On the other hand, six (6) characters present sexual dimorphism, five (5) in favor of males (Lmax, Hpc, Hdo, Hpdc and Dopc), and one (1) in favor of females (Doan).

CONCLUSIONS

The results of our study on the length-weight relationships and morphometry of *Trachurus trachurus* of Béni-Saf Bay supplements the work already conducted on this species in the Mediterranean, and allows for a better management of the exploitable resource. Our findings can be a useful tool for scientists, administrators, and professionals in the fisheries sector, aiding the regulation of the fishing effort and the update of minimum landing sizes for this species. There are still many points to be elucidated in relation to the fishery of this species in the Mediterranean Basin, and Algerian waters especially, and these will be subject of future research.

ACKNOWLEDGMENTS

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ODNOS MED DOLŽINO IN MASO IN METRIČNI ZNAKI NAVADNIH ŠNJUROV, *TRACHURUS TRACHURUS* (PERCIFORMES: CARANGIDAE), UJETIH V ZALIVU BÉNI-SAF, ZAHODNO SREDOZEMSKO MORJE (ALŽIRIJA)

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POVZETEK

V pričujočem delu avtorji opisujejo morfometrične značilnosti navadnega šnjura, Trachurus trachurus *(Linnaeus, 1758), iz zaliva Béni-Saf Bay (Alžirija). Analizirali so 355 primerkov, vzorčenih med novembrom 2018 in oktobrom 2017, od katerih je bilo 47,04% samcev in 44,79% samic, 8,17% pa ni bilo določenih do spola. Celotna dolžina preiskanih rib je bila od 7,4 do 35,4 cm. Na vsakem primerku je bilo opravljenih sedemnajst meritev. Raziskali so odnos med dolžino in maso, ki je pokazal, da je porast v velikosti proporcionalen porastu v masi (izomerična alometrija). Analiza sedemnajstih metričnih znakov je omogočila ugotavljanje tipa rastne alometrije. Vsi znaki so pokazali upadajočo alometrijo, šest znakov pa je kazalo na spolno dvoličnost, od katerih se je 5 nanašalo na samce in eden na samico.*

Ključne besede: navadni šnjur, *Trachurus trachurus*, odnos med dolžino in maso, metrični znaki, zaliv Béni-Saf, Alžirija

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ON THE OCCURRENCE OF *POMADASYS INCISUS* (HAEMULIDAE) IN THE TURKISH AEGEAN SEA (EASTERN MEDITERRANEAN SEA)

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ABSTRACT

This paper aims to complement and update the data regarding the distribution of rare Pomadasys incisus*, specifically by revealing the extension of its distribution in the eastern Mediterranean Sea. On 1 November 2020, a single specimen of* P. incisus *was captured by an angler on a sandy/rocky bottom at a depth of 3 m in Akyaka, Gökova Bay, in the south-eastern Aegean Sea. This thermophilic fish is still very rare in the eastern Mediterranean Sea (about 142 specimens reported to date). However, it is obvious that populations of* P. incisus *are gradually expanding towards the northern latitudes of the eastern as well as western Mediterranean basin.*

Key words: Bastard grunt, additional record, measurements, Gökova Bay

PRESENZA DI *POMADASYS INCISUS* (HAEMULIDAE) NEL MAR EGEO TURCO (MEDITERRANEO ORIENTALE)

SINTESI

L'articolo mira a completare e aggiornare i dati relativi alla distribuzione del pesce arabo, Pomadasys incisus*, riportando l'estensione della distribuzione di questa specie nel Mediterraneo orientale. Il 1° novembre 2020, un singolo esemplare di* P. incisus *è stato catturato da un pescatore su un fondo sabbioso/roccioso ad una profondità di 3 m, ad Akyaka, nella baia di Gökova, nel Mar Egeo sud-orientale. Questo pesce termofilo è ancora molto raro nel Mediterraneo orientale (circa 142 esemplari segnalati finora). Tuttavia, è ovvio che le popolazioni di* P. incisus *si stiano gradualmente espandendo verso le latitudini settentrionali del bacino orientale e occidentale del Mediterraneo.*

Parole chiave: pesce arabo, ritrovamento aggiuntivo, misurazioni, Baia di Gökova

INTRODUCTION

The bastard grunt, *Pomadasys incisus* (Bowdich, 1825), lives in coastal waters on sandy/muddy bottoms and/or close to rocky habitats as well as in sea meadows at depths of up to 50 m (Golani *et al.*, 2006). Reproduction occurs from July to October (Fehri-Bedoui & Gharbi, 2008).

Pomadasys incisus is distributed in the eastern Atlantic coast from Madeira and Morocco, and mainly in the southern Mediterranean, but has also been reported from Seté, France, and from Italy (Ben-Tuvia & McKay, 1986; Golani *et al.*, 2006; Froese & Pauly, 2020). The species entered the Mediterranean Sea through the Strait of Gibraltar. The prevailing currents, sea warming, and the availability of suitable soft substrate in relatively shallow waters allowed this species to first establish itself in the NW Mediterranean basin (Francour *et al.*, 1994; Bodilis *et al.*, 2013). While *P. incisus* gradually increased its abundancy in Malaga, the Catalan coast, Spain, and the Gulf of Lion, France (Serena & Silvestri, 1996; Bodilis *et al.*, 2013; Villegas-Hernandez *et al.*, 2018), it remains rather rare in the north-eastern Mediterranean Sea (Kapiris *et al.*, 2008).

This paper presents a new report of the presence of *P. incisus* in an area of the Aegean Sea in order to supplement the information about its distribution in the eastern Mediterranean Sea.

MATERIAL AND METHODS

On 1 November 2020, a single specimen of *Pomadasys incisus* (Fig. 1) was captured by an angler on a sandy/rocky bottom at a depth of 3 m in Akyaka, Gökova Bay (37º03.01 N - 28º19.11 E, Fig. 2) in the south-eastern Aegean Sea. The bait was bogue (*Boops boops*) flesh. The specimen was fixed in a 6% formaldehyde solution and deposited in the fish collection of Muğla University, Faculty of Fisheries (MUSUM/PIS/108).

RESULTS AND DISCUSSION

The specimen was measured to the nearest millimetre. The morphometric measurements as percentages of total length (TL%) and the meristic counts recorded in the *P. incisus* caught in Gökova Bay, Aegean Sea, are shown in Tab. 1. All the established measurements, counts, proportions, and colour

Fig. 1: *Pomadasys incisus* **caught in Gökova Bay, SE Aegean Sea (photo: T. Çoker).**
Sl. 1: Primerek vrste *Pomadasys incisus*, **ujet v zalivu Gökova, JV Egejsko morje (Foto: T. Çoker).**

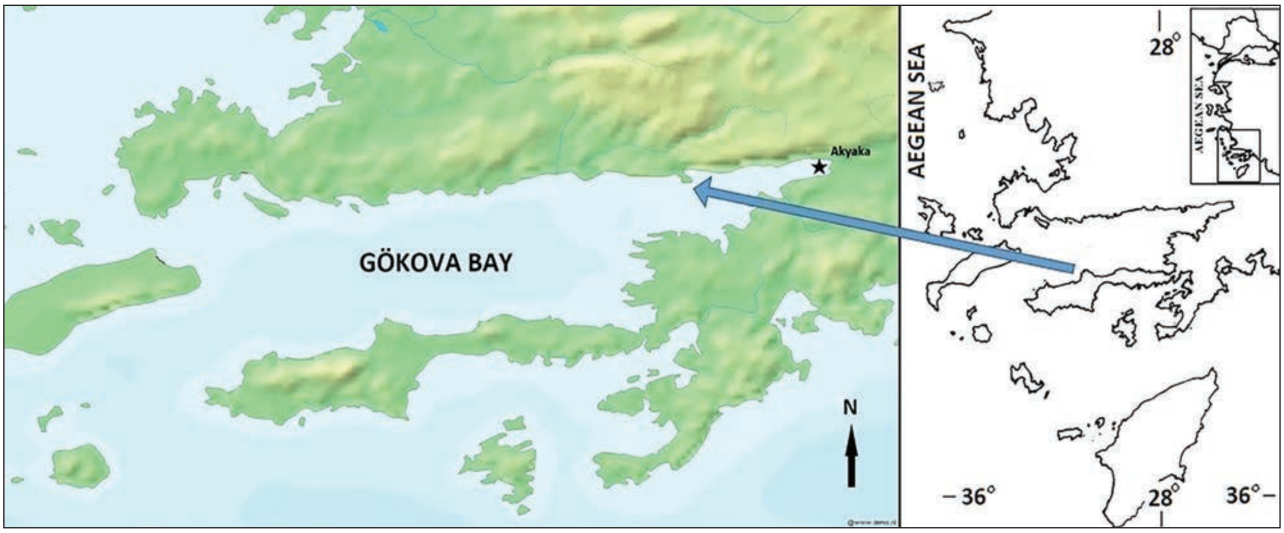

Fig. 2: Capture location of *Pomadasys incisus* ***in the Aegean Sea.***
Sl. 2: Lokaliteta, kjer je bila ujeta vrsta *Pomadasys incisus* ***v Egejskem morju.***

patterns are in accordance with the descriptions of Ben-Tuvia & McKay (1986), Golani *et al*. (2006), and Froese & Pauly (2020).

Pomadasys incisus is a native species of the eastern Atlantic and Mediterranean Seas. This species entered the Mediterranean Sea through the Gibraltar Strait in the early 19th century. The first report of *P. incisus* from the Italian seas dates to the early 1990s (Bilecenoğlu *et al*., 2013). The earliest report of the presence of *P. incisus* in the Ionian Sea was given by Kaspiris only in 1970, even though the first records for the Mediterranean waters were confirmed for the Algerian coast by Guichenot as early as 1850 and for Séte, France, by Corus in 1893 (Serena & Silvestri, 1996). After that, *P. incisus* was reported off the Tuscan coast in 1992 (Serena & Silvestri, 1996), and in June 2001, a specimen was caught by gillnet outside Anzio harbour in the central Tyrrhenian Sea (Psomadakis *et al*., 2006). Lastly, two specimens were recorded off the coast of Avola in Sicily, in the Ionian Sea, in August 2013 (Bilecenoğlu *et al*., 2013). On the other hand, this species seems abundant in the Gulf of Tunis (Chakroun-Marzouk & Ktari, 1995; Fehri-Bedoui & Gharbi, 2008), and between Malaga, Spain, as pointed out by Serena & Silvestri (1996), the Catalan coast (Villegas-Hernandez *et al*., 2018), and the Gulf of Lion, France (Bodilis *et al*., 2013). Recently, on 15 August 2015, a specimen of *P. incisus* was captured off the Pelješac Peninsula in the southern Adriatic Sea (Karachle *et al*., 2016). This was the first record for the Adriatic Sea. It clearly proves that this thermophilic species has been moving northwards, as it has so far reached the Balearic, Tyrrhenian, Ligurian and Adriatic Seas.

Tab. 1: Morphometric measurements as percentages of total length (TL%) and meristic counts recorded in the *Pomadasys incisus* ***captured in Gökova Bay, Aegean Sea.***
Tab. 1: Morfometrične meritve, izražene kot delež celotne dolžine (TL%), in meristična štetja na primerku vrste *Pomadasys incisus****, ujetega v zalivu Gökova, Egejsko morje.***

Measurements	**Size (mm)**	**Proportion (TL%)**
Total length (TL)	169	
Fork length (FL)	151	89.3
Standard length (SL)	143	84.6
Maximum body depth	51	30.2
Pectoral fin length	48	28.4
Pre-dorsal fin length	49	29.0
Pre-anal fin length	92	54.4
Pre-pectoral length	50	29.6
Head length	42	24.9
Eye diameter	13	7.7
Preorbitary length	12	7.1
Meristic counts		
Dorsal fin rays	XII+16	
Anal fin rays	III+12	
Pectoral fin rays	17	
Ventral fin rays	I+5	
Weight (g)	71.8	

Tab. 2: Sporadic records of* Pomadasys incisus *in the eastern Mediterranean Sea.
Tab. 2: Sporadični zapisi o pojavljanju vrste* Pomadasys incisus *v vzhodnem Sredozemskem morju.

Area	Date	n	TL (mm)	Depth (m)	References
Iskenderun Bay, NE Mediterranean	Dec.1994-Nov.1996	3	162-178	15-20	Başusta & Erdem (2000)
Turkey, NE Mediterranean	2001-2003	23	119-190	5-100	Sangun *et al.* (2007)
Gulf of Antalya, NE Mediterranean	May2005-Apr.2006	23	126-182	10	Beğburs & Kebapçıoğlu (2013)
Argolikos Gulf, Aegean Sea	May-Aug.2008	39	?	10-15	Kapiris *et al.* (2008)
SE Aegean Sea	Dec.2009-Nov.2010	51	121-163	30-325	Bilge *et al.* (2014)
Morfou Bay, Cyprus	30 Sep.2019	1	?	2	Doumpas *et al.* (2020)
Limni Beach, Cyprus	20 May 2020	1	130	?	Doumpas *et al.* (2020)
Gökova Bay, Aegean Sea	01 Nov.2020	1	169	3	This study

In the eastern Mediterranean Sea, *P. incisus* has been reported sporadically, as shown in Table 2. In some previous fish checklists for the Levant Basin *P. incisus* was mentioned by name only, i.e., in reports from Israel (Ben-Tuvia, 1971), the eastern Levant (Golani, 1996), Mersin Bay, the NE Levant, (Gücü & Bingel, 1994), Syria (Saad, 2005), Egypt (Akel & Karachle, 2017), and the Lebanon coast (Bariche & Fricke, 2020).

As it appears, this thermophilic fish is still very rare in the eastern Mediterranean Sea (about 142 specimens have been reported to date). However, it is obvious that populations of *P. incisus* are gradually establishing themselves and expanding into the northern latitudes of the eastern and western Mediterranean Sea (Francour *et al*., 1994; Serena & Silvestri, 1996; Bodilis *et al*., 2013; Villegas-Hernandez *et al*., 2018). According to fishermen in Gökova Bay (SE Aegean Sea), the populations of this fish species have become larger in the recent years. Francour *et al*., (1994) stated that captures of thermophilic species, including *P. incises*, have been increasing in the northern Mediterranean due to global warming. As evidence of the warming of the marine environment, Azzurro (2008) provided a list of thermophilic subtropical fish species that have expanded their distribution range in the Mediterranean, which also includes *P. incisus*.

On the other hand, since *P. incisus* has been acknowledged as an example of latitudinal extension or demographic increase of thermophilic fish in response to the current climate change (Psodomakis *et al.,* 2012), *P. incisus* could be taken as an indicator of changing sea conditions due to global warming. To confirm that, however, further research is necessary which will study the overlap between exotic/thermophilic and endemic fish fauna and their competition, e.g., between salemas and siganids, red mullets and goatfishes.

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O POJAVLJANJU VRSTE *POMADASYS INCISUS* (HAEMULIDAE) V TURŠKEM EGEJSKEM MORJU (VZHODNO SREDOZEMSKO MORJE)

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POVZETEK

Avtorja poročata o novih in dopolnjenih podatkih o razširjenosti redke vrste Pomadasys incisus*, s posebnim ozirom na širjenje njenega areala v vzhodnem Sredozemskem morju. Prvega novembra 2020 je bil na trnek ujet primerek te vrste, na globini 3 m na skalnato-peščenem dnu, na lokaliteti Akyaka v zalivu Gökova v jugovzhodnem Egejskem morju. Ta toploljubna vrsta je še vedno zelo redka v vzhodnem Sredozemskem morju (do sedaj so poročali o 142 primerkih). Kakorkoli že, očitno je, da se vrsta* P. incisus *postopno širi proti severnim geografskim širinam tako vzhodnega kot tudi zahodnega Sredozemskega bazena*.

Ključne besede: vrsta prašičevke, novi zapis o pojavljanju, meritve, zaliv Gökova

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FIRST SUBSTANTIATED RECORD OF OPAH, *LAMPRIS GUTTATUS* (OSTEICHTHYES: LAMPRIDIDAE), FROM THE TUNISIAN COAST (CENTRAL MEDITERRANEAN SEA)

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ABSTRACT

The authors report on the capture of a specimen of opah, Lampris guttatus *(Brünnich, 1788), from the northern coast of Tunisia. It measured 1.40 m in total length and weighed 47.65 kg, and is, probably, among the largest and the heaviest* L. guttatus *to date reported from the Mediterranean Sea. The species is endothermic, and thus able to live in cool waters and migrate to warmer regions. This finding represents the first record of the species for Tunisian waters and the central Mediterranean Sea. At the same time, it defines the extension of the southernmost range limit of the species in this sea.*

Key words: Lampris guttatus, total length, total body weight, distribution, endothermy, extension range

PRIMO RITROVAMENTO DOCUMENTATO DI OPAH, *LAMPRIS GUTTATUS* (OSTEICHTHYES: LAMPRIDIDAE), LUNGO LA COSTA TUNISINA (MEDITERRANEO CENTRALE)

SINTESI

Gli autori riportano la cattura di un esemplare di opah, Lampris guttatus *(Brünnich, 1788), lungo la costa settentrionale della Tunisia. Il pesce misurava 1,40 m di lunghezza totale e pesava 47,65 kg, ed è, probabilmente, tra i più grandi e più pesanti esemplari di* L. guttatus *fino ad oggi riportati per il Mediterraneo. La specie è endotermica, quindi in grado di vivere in acque fredde e migrare verso regioni più calde. Questa cattura rappresenta il primo ritrovamento della specie per le acque tunisine ed il Mediterraneo centrale. Definisce inoltre l'estensione del limite più meridionale della specie in questo mare.*

Parole chiave: Lampris guttatus, lunghezza totale, peso corporeo totale, distribuzione, endotermia, range di estensione

INTRODUCTION

The opah, *Lampris guttatus* (Brünnich, 1788), is an oceanic species distributed worldwide in tropical and temperate waters, well-known in the Atlantic and eastern Pacific (Palmer, 1986). It is a mid-water pelagic species, dwelling between 100 and 400 m of depth (Palmer, 1986). *L. guttatus* has also been known in the Mediterranean Sea, where it used to be considered very rare, with less than 25 specimens reported in the literature (Francour *et al*., 2010). However, an updated review of records from the western Mediterranean Basin now indicates that a least 23 specimens have recently been recorded in the French coast (Francour *et al*., 2010).

L. guttatus is reported from the Adriatic Sea, where previous and recent captures of single specimens are listed by Dulčić *et al*. (2005) and Sulić Šprem *et al*. (2014). Eastward, the species is recorded in the Greek seas (Sinis, 2004) and reported in the check-list of marine fishes from Turkey (Bilecenoğlu *et al*., 2014). However, the first substantiated record of *L. guttatus* from Turkish marine waters was reported by Ergüden *et al*. (2019). Conversely, the species has not yet been recorded in the Levant Basin (Golani, 2005; Ali, 2018; Bariche & Fricke, 2019).

Lloris & Rucabado (1998) noted the occurrence of *L. guttatus* in the Moroccan shore, but did not furnish any data on the capture area, Atlantic or Mediterranean. Similarly, no record of the species has been

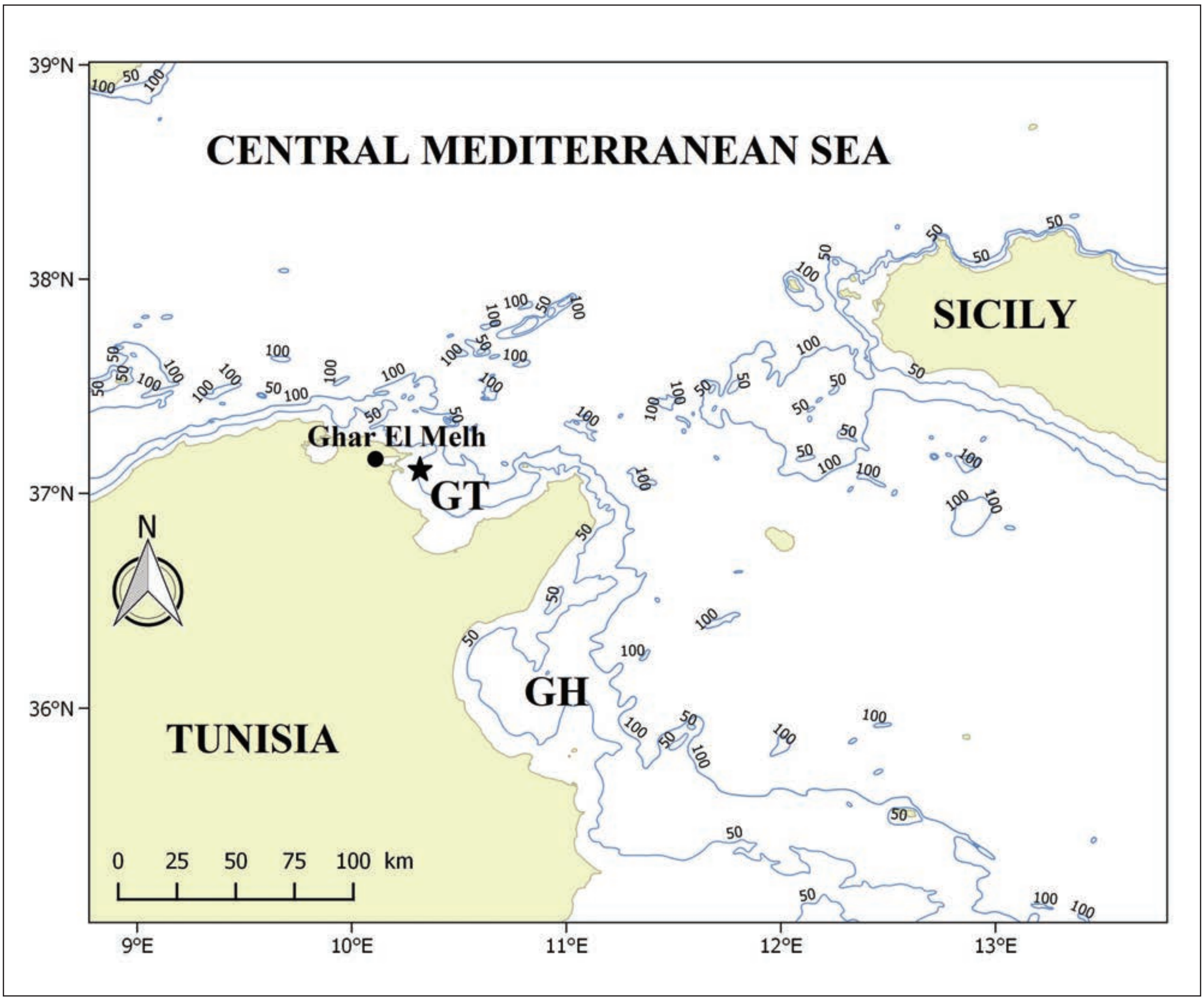

Fig. 1: Map of northern Tunisia with the site where** Lampris guttatus **was caught (black star). GH: Gulf of Hammamet. GT: Gulf of Tunis.

Sl. 1: Zemljevid obravnavnega območja z označeno lokaliteto, kjer je bil ujet primerek svetlice** (Lampris guttatus) **(črna zvezdica). GH: zaliv Hammamet. GT: zaliv Tunis.

Fig. 2:** Lampris guttatus **captured off Coco Beach, close to Ghar El Melh, aboard the small vessel.
Sl. 2: Primerek svetlice (**Lampris guttatus**) na krovu manjšega plovila, ujet pri plaži Coco Beach, blizu Ghar El Melh.

provided from the Tunisian coast (Bradai *et al.*, 2004; Rafrafi-Nouira *et al.*, 2015; Rafarafi-Nouira, 2016; Ounifi-Ben Amor *et al.*, 2016). To date, only one substantiated capture has been reported from the Maghreb shore. The capture occurred in the central Algerian coast (Francour *et al.,* 2010). Regular routine monitoring conducted throughout the Tunisian coast with the assistance of experienced fishermen allowed us to collect the specimen described in the present paper.

MATERIAL AND METHODS

On 18 May 2021, a specimen of *L. guttatus* was captured in the fishing area of Ghar El Melh, in Coco Beach (Fig. 1), located in northern Tunisia (37°08′58.66″ N, 10°16′37.03″ E), at a depth of 20 metres, on sandy bottom, together with several blotched picarel, *Spicara maena* (Linnaeus, 1758). It was caught by a fisherman using a small vessel and an 80 m long commercial gill with 20 mm stretched mesh size (Fig. 2). The specimen was delivered to the fish market of Ghar El Melh (Fig. 3) and rapidly sold, therefore it was only possible for us to record its total length (TL) and total body weight (TBW).

RESULTS AND DISCUSSION

The present specimen was identified as *L. guttatus* via a combination of main morphological characters: body oval, large and compressed, dorsal and anal fins long and simple, both retractable into deep grooves, first dorsal fin rays forming anterior falcate lobe; pelvic fins and dorsal fins long and falcate; anal fin long-based, without anterior lobe; caudal fin broadly lunate; back blue shading to green, belly silvery with whitish spots, fins reddish.

This identification is in complete agreement with previous descriptions of *L. guttatus* by, among others, Palmer (1986), Dulčić *et al.* (2005), Francour *et al.,* (2010), Underkoffler *et al.* (2018), and Ergüden *et al.* (2019). Therefore, the present findings constitute the

Fig. 3: *Lampris guttatus* ***captured off Coco Beach, at the fish market of Ghar El Melh, scale bar = 300 mm.***
Sl. 3: Primerek svetlice *(Lampris guttatus)****, ujet pri plaži Coco Beach, na ribji tržnici v Ghar El Melh, merilo = 300 mm.***

first substantiated record of *L. guttatus* from Tunisian waters. The species can be included in the list of Tunisian ichthyofauna, enlarging the number of fish species to date reported from the area (Bradai *et al*., 2004; Ounifi-Ben Amor *et al*., 2016; Rafrafi-Nouira *et al*., 2016). Additionally, the present constitutes the second record of the species from the southern Mediterranean Sea. The first record was made off Gouraya, from the central Algerian coast, and concerned a small specimen of 385 mm TL and 1.281 kg TBW (Francour *et al*., 2010). The specimen discussed in the present study measured 1.40 m TL and 47.65 kg in TBW (Fig. 4), ranking among the largest and heaviest *L. guttatus* known to date in the Mediterranean Sea. However, a maximum length of 2 m and a maximum weight of 270 kg have been reported by Gon (1990, in Ergüden, 2019).

Tortonese (1970) noted that the species was rare in the Mediterranean Sea and only sporadically caught in Italian waters. Such observation is in congruence with the fact that *L. guttatus* is a rather solitary species (Palmer, 1986). Conversely, Dulčić *et al.* (2005) noted an increase of captures in the Adriatic Sea, and Francour *et al.* (2010) along the French Mediterranean coast, probably due to the warming of Mediterranean marine waters (Francour *et al*., 1994). The relative abundance of captures in some areas of the western Mediterranean basin suggests possible establishments of viable populations. However further records are needed for more accurate evaluations of the real status of the species in the Mediterranean Sea.

L. guttatus also inhabits the cold waters of the eastern Atlantic Ocean (Palmer, 1986); such occurrence is probably made possible by the fact that the species displays a whole-body form of endothermy (Wegner *et al*., 2015). Unlike other fish, in *L. guttatus* the warm blood is distributed throughout the body, including the heart, enhancing the animal's physiological performance during foraging in cold areas (Wegner *et al*., 2015). Therefore, migrations from northern to southern Atlantic areas are feasible, and since these are followed by further advancement to

Fig. 4: *Lampris guttatus* ***captured off Coco Beach, at the fish market of Ghar El Melh, white arrow indicating the total body weight of the specimen, scale bar = 150 mm.***
Sl. 4: Primerek svetlice *(Lampris guttatus)****, ujet pri plaži Coco Beach, na ribji tržnici v Ghar El Melh. Bela puščica označuje celokupno maso primerka, merilo = 150 mm.***

the Mediterranean Sea through the Strait of Gibraltar, we may consider *L. guttatus* a Herculean migrant (*sensu* Quignard & Tomasini, 200). It is an unusual case of migration, as generally such migrants come from the warmer waters of south-eastern Atlantic.

The Tunisian coast is a transition area between the eastern and western Mediterranean Basins, and migration of alien species has frequently been reported from the same area (Rafarafi-Nouira *et al*., 2015, 2016; Ounifi-Ben Amor *et al*., 2016). The present record confirms similar previous observations; interestingly, it also constitutes the first record for the central Mediterranean Sea and, concomitantly, defines the extension of the southernmost range limit of *L. guttatus* in the wider sea.

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PRVI DOKUMENTIRAN ZAPIS O POJAVLJANJU SVETLICE, *LAMPRIS GUTTATUS* (OSTEICHTHYES: LAMPRIDIDAE), IZ TUNIZIJSKE OBALE (OSREDNJE SREDOZEMSKO MORJE)

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POVZETEK

Avtorji poročajo o ulovu primerka svetlice, Lampris guttatus *(Brünnich, 1788), iz severne tunizijske obale. Meril je 1,40 m v dolžino in tehtal 47,65 kg. Verjetno gre za enega izmed največjih in najtežjih primerkov dosedaj opaženih v Sredozemskem morju. Gre za endotermno vrsto, ki lahko naseljuje hladne vode in se seli v toplejše predele. Ta primer predstavlja prvi podatek o pojavljanju te vrste v tunizijskih vodah in v osrednjem Sredozemskem morju, obenem pa kaže na razširjanje areala v smeri skrajne južne meje razširjenosti.*

Ključne besede: *Lampris guttatus*, celotna dolžina, celokupna masa, razširjenost, endotermija, širjenje areala

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FIRST REPORT OF *CYSTOSEIRA AURANTIA* (SARGASSACEAE, FUCOPHYCEAE) FROM THE LAGOON OF STRUNJAN (GULF OF TRIESTE, NORTHERN ADRIATIC)

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ABSTRACT

The authors report the first record of the brown alga Cystoseira aurantia *Kützing, found in the Stjuža Lagoon of Strunjan (Gulf of Trieste, Slovenia). During field surveys conducted in March 2021, dense free-floating hanks of this alga were observed on the water's surface along the eastern margins of the lagoon, at depths not exceeding 0.5 m. These acropleustophytic hanks were composed of abundantly branched single thalli and fragments of thalli firmly intertwined and entangled. Branches of every order were cylindrical, slender (1–2 mm in diameter), omnidirectional, with no leafy branchlets or thorny appendages. No fertile specimens were found. Among the possible factors leading to the formation of free-floating masses of* C. aurantia*, mechanic processes due to a constant water movement under the action of winds and tidal currents were considered. The habitat and the morphological characters of the specimens studied are described.*

Key words: *Cystoseira aurantia,* Stjuža lagoon Strunjan, Slovenia, northern Adriatic

PRIMA SEGNALAZIONE DI *CYSTOSEIRA AURANTIA* (SARGASSACEAE, FUCOPHYCEAE) NELLA LAGUNA DI STRUGNANO (GOLFO DI TRIESTE, ALTO ADRIATICO)

SINTESI

Gli autori riportano la prima segnalazione dell'alga bruna Cystoseira aurantia *Kützing, trovata nella Laguna Schiusa di Strugnano (Golfo di Trieste, Slovenia). Durante le indagini sul campo, condotte nel marzo 2021, sono state osservate delle dense masse di quest'alga fluttuanti sulla superficie dell'acqua lungo il margine orientale della laguna, a profondità non superiore a 0,5 m. Le masse acropleustofitiche liberamente flottanti in superficie, si presentano composte da singoli talli abbondantemente ramificati e saldamente intrecciati. Non sono stati riscontrati esemplari fertili. Tra i possibili fattori responsabili della formazione delle masse fluttuanti di* C. aurantia*, assume un carattere particolarmente rilevante la costante variazione delle correnti superficiali, all'interno della Laguna, dovuta alla marea. Vengono descritti l'habitat e i caratteri morfologici degli esemplari studiati.*

Parole chiave: *Cystoseira aurantia*, laguna Schiusa Strugnano, Slovenia, Alto Adriatico

INTRODUCTION

The brown alga *Cystoseira aurantia* (Sargassaceae, Fucophyceae) is a perennial free-living species forming free-floating hanks. Since its description by Kützing (1843), based on specimens collected in 1835 at the Gulf of Trieste (type locality), it has been reported from both Black Sea and Mediterranean coastal areas. In the latter area, it was reported from the Balearic Islands (Spain) (Ribera *et al*., 1996), the Adriatic Sea (Giaccone 1978; Ribera *et al*., 1992; Taskin *et al*., 2012), Corsica (France) (Taskin *et al.,* 2012), Sardinia, Sicily, and Tuscany (Italy) (Ribera *et al*., 1992; Furnari *et al*., 1999; Rindi *et al*., 2002; Taskin *et al*., 2012), Turkey (Taskin *et al*., 2012), the Bay of Cadiz (Spain) (Gallardo *et al.*, 2016), Tunisia (Bouafif *et al*., 2016), and more recently from the Mediterranean coast of Morocco (Ramdani *et al*., 2021). The species, reduced to a form of *C. barbata* (Stackhouse) C. Agardh [= *Gongolaria barbata* (Stackhouse) Kuntze] by Giaccone in Amico *et al.* (1986) as *C. barbata* f. *aurantia* (Kützing) Giaccone, was recently reinstated as a distinct species by Orellana *et al*. (2019).

According to literature, *C. aurantia* was reported from the northern Adriatic Sea by Giaccone (1974) as *C. barbata* C. Agardh var. *aurantia* (sic!); from Ferrara by Amico *et al*., [1986, as *C. barbata* (Goodenough & Woodward) J. Agardh f. *aurantia* (Kützing) Giaccone]. Gómez Garreta *et al*. (2001) considered *C. barbata* f. *aurantia* to be synonymous with *C. barbata* f. *repens* Zinova & Kalugina, but erroneously so, since the former form takes precedence over the latter (Cormaci *et al*, 2012). Interestingly, there are no records of this species from the eastern Adriatic Sea (Antolić *et al*., 2010), except that from the Middle Adriatic Sea (the Island of Palagruža) by Giaccone (1978). In this paper, we report the occurrence of *C. aurantia* from the Stjuža marine lagoon of Strunjan (Slovenia). It represents the first record of this species from Slovenian coastal waters.

MATERIAL AND METHODS

Study area

The Strunjan Lagoon is a shallow, semi-enclosed oligotrophic brackish coastal lagoon situated in the eastern part of the Strunjan Bay (45°31′30″ N, 13°36′20″ E) (Figs. 1a–1b), about 10 hectares in surface area and divided into two sub-basins: a smaller discharge lagoon and the larger Stjuža Lagoon. Geologically, it represents a large area of the Late-Glacial and Holocene estuary of the Strunjan stream, formed during the last transgression of the sea into that area (Šmuc, 2020). It is the only Slovene marine lagoon, and not entirely natural. For about half a century it has been an abandoned fish farm. The newly created lagoon has remained connected with the sea only by an entrance channel of about 20 meters in width and 5–6 meters in depth, and three much smaller tidal channels (Fig. 1b), which allow for a better circulation of water masses in the lagoon and a reduced organic pollutant load (Avčin *et al.*, 1973; Avčin *et al*., 1974; Vrišer, 2002). The Stjuža Lagoon is characterised by *Cymodocea nodosa* (Ucria) Ascherson and *Zostera noltei* Hornemann meadows on its margins. It is mostly very shallow, with some of its areas breaking the surface at the lowest tide (Šajna & Kaligarič, 2005; Lipej *et al.,* 2019). Seagrass meadows host a diverse lagoon fish fauna and demersal invertebrates (Avčin *et al*., 1973; Šajna & Kaligarič, 2005; Lipej *et al*., 2019).

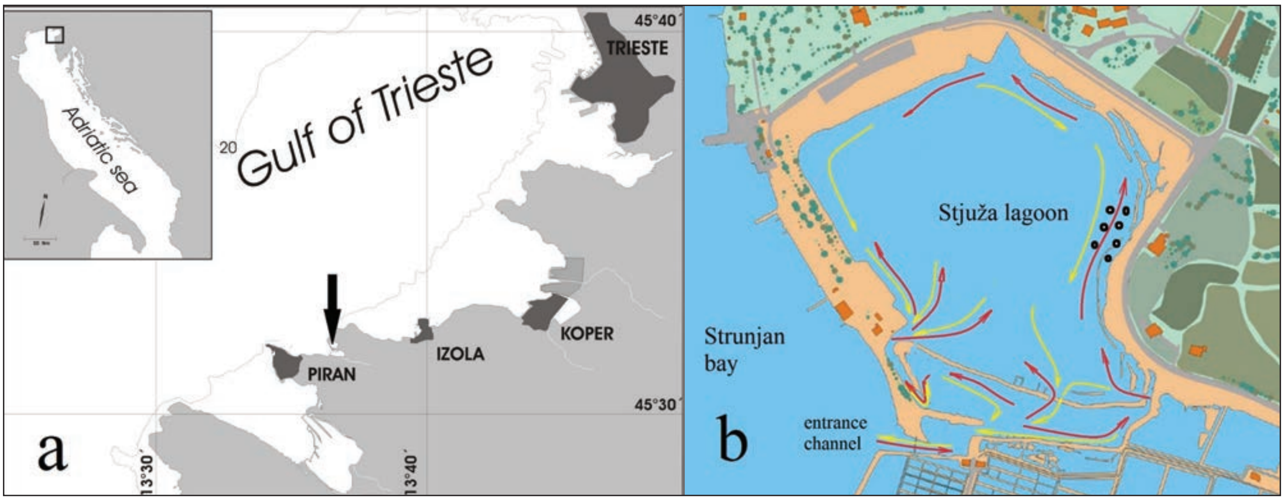

Fig. 1: a) Maps of the study area; b) Stjuža Lagoon of Strunjan, indicating sampling site of *Cystoseira aurantia* ***(black circles), and the direction of seawater currents during the tide (after Avčin*** *et al*.***, 1973). The yellow arrows indicate the output flow, the red arrows the entry flow.***

Sl. 1: a) Karta raziskovalnega območja; b) Laguna Stjuža Strunjan z vzorčevalnimi postajami alge *Cystoseira aurantia* ***(črni krogci), in smer toka morske vode med plimovanjem. Rumene puščice predstavljajo smer izhoda in rdeče smer vhoda morske vode med bibavico (po Avčin*** *et al*.***, 1973).***

Today, the lagoon area is an important part of the Strunjan Stjuža Nature Reserve, falling within the Natura 2000 network, the primary objective of which is to preserve biodiversity.

The study area is also characterised by the presence of a diverse fish fauna, demersal invertebrates closely associated with the environment of seagrasses: numerous molluscs (bivalves, gastropods), benthic crustaceans (mysids, amphipods, decapods, isopods), echinoderms (brittlestars, starfishes), and many species of polychaetes. Recently a total of 15 macroalgal taxa, both substrate--attached and free-floating, were recorded (Lipej *et al*., 2004; 2019; Battelli & Gregorič, 2020).

Environmental parameters

Because of its shallow depth (only about 0.5–1 m), the thermal conditions in the Stjuža Lagoon seasonally move from one extreme to the other: ranging between 5 ºC and 10 ºC in wintertime and between 24 ºC and 27 ºC during the summer; during the other seasons the water temperatures are similar to the atmospheric temperatures. The salinity, oxygen content, and thermal conditions in the Stjuža Lagoon are related to the large water exchange and usually similar to those of Strunjan Bay (Avčin *et al*., 1973). The lagoon receives freshwater inputs through small canals from agricultural areas (Vrišer, 2002). The average tidal amplitude is 67 cm, with high tide 35 cm above mean sea level, and low tide 31 cm below mean sea level (Slovenian Environment Agency (ARSO): (www.arso.gov.si/water/sea; http://www.arso.gov.si/vode/podatki/amp/H9350_g_1.html).

Sampling procedure and data analysis

The fieldwork was carried out in March 2021, when dense free-floating hanks of *Cystoseira aurantia* were observed in the lagoon. The study was conducted along the eastern margins of the lagoon, as showed in Fig. 1b, since this was the only site where free-floating aggregates of the studied alga occurred in high abundance. The substrate of the research site consisted of a soft sediment composed of compact-fine argillaceous silt with a slight admixture of sand, with a thin (0.5–1 cm) yellowish brown layer of flocculent organic detritus (Vrišer, 2002; Šmuc, 2020).

The salinity, pH, oxygen content (O_2), and water temperature were measured in the Stjuža Lagoon and Strunjan Bay, using a Hanna HI98194 multiparameter waterproof meter.

Ten thalli of *C. aurantia* were randomly collected during the sampling period. Fresh samples were manually collected at the survey site, immediately placed in plastic bags containing water, and transported to the Laboratory of the Faculty of Mathematics, Natural Sciences and Information Technologies (FAMNIT) of Koper for further observation. Some samples were dried, pressed, and preserved in the personal herbarium of one of the authors (C.B.). The algal material collected was carefully sorted and examined using an Olympus SZ61 stereo microscope with a XC50 digital camera for morphological observation and measurements. The following measurements were carried out: thallus length from the basal part to the apex; length and diameter of main axes; length and diameter of primary axes. The occurrence of aerocysts, their length, diameter, and position, were recorded. The different positions of the conceptacles were described; in addition, the sizes of the ostioles of the conceptacles present either along the thalli or on aerocysts, were measured. The averages of all the conducted measurements were calculated.

Species were identified based on papers by Maggs & Hommersand (1993), Bressan & Babbini (2003), Brodie *et al*. (2007), Sfriso (2010), Cormaci *et al*. (2012, 2014). The nomenclature follows Guiry & Guiry (2021).

RESULTS AND DISCUSSION

Samples of *Cystoseira aurantia* were collected in the eastern part of the Stjuža Lagoon (Fig. 1b), the only site of its occurrence. The alga was found unattached on the mobile substrate, between 0 and 0.5 m depth, forming a free-floating hank of thalli of various shapes and sizes (Fig. 2a). These aggregates were composed by abundantly branched fragments of the alga, firmly intertwined and dispersedly arranged. Individual thalli in the aggregations were entangled with each other; consequently, branches growing in different directions (Fig. 2b) were observed within the hank.

Morphological characteristics of *Cystoseira aurantia*

The axes were cylindrical, reaching up to 20.77 cm in length, and 1.0 mm in diameter. The alga was white-brown in colour, non-iridescent; holdfast absent; primary branches cylindrical, without thorny appendages, up to 7.21 cm long and 0.9 mm in diameter; secondary branches cylindrical, without spinose appendages; ultimate branches filiform. In some thalli abundant aerocysts occurred, fairly regularly arranged on the branches, ovoid, 6.68 mm long and 1.73 mm in diameter, isolated or in short series of 2–3 (Fig. 2c). Cryptostomata were abundant in all branches. The ostioles of the conceptacles present along the branches were fusiform, 0.23 mm long and 0.09 mm width, with a l/w ratio of 2.64, while those on aerocysts were more ovoid, 0.22 mm long and 0.14 mm width, with a l/w ratio of 1.62 (Tab. 1). Despite the large number of conceptacles present on the thalli, the specimens examined were still infertile; in fact, we observed no sexual cells within the conceptacles. Our specimens agree well with previous descriptions and illustrations of the taxon (Cormaci *et al.,* 2012; Bouafif *et al*., 2016; Ramdani *et al*., 2021).

Algal vegetation in the Stjuža Lagoon

In the Stjuža Lagoon, many algal species were present in both attached and unattached forms. *C. aurantia* was always present in free-floating form. It was collected mainly between

Fig. 2: a) Free-floating hanks of alga in the natural habitat; b) habit of** Cystoseira aurantia**; c) aerocysts isolated and in short series, indicated by arrows.
Sl. 2: a) Prosto plavajoči skupki alge v naravnem okolju); b) steljka alge** Cystoseira aurantia**; c) posamezne aerociste in v zaporedju, označene s puščicami.

the water surface and 0.5 m of depth and over soft substrate. The soft bottom is clearly unsuitable for the development of a highly diverse attached macroalgal vegetation. The spatial formation of free-floating hanks of *C. aurantia* (Fig. 2a) was probably owed to an accumulation and aggregation of many intertwined thalli caused by winds and tidal currents flowing during the tidal switch, as illustrated in Fig. 1b, where the yellow and red arrows indicate, respectively, the outflow and inflow of seawater during the change of tides.

According to Fritsch (1965) and Smith (1950), the phenomenon of the aggregation of free-floating algae can be considered the result of a dynamic action of the waves' motion caused by winds or water currents.

Pleustophyte populations, typical of lagoon environments of the Mediterranean Sea, are mainly characterised by *Valonia aegagropila* C. Agardh, *Rytiphlaea tinctoria* (Clemente) C. Agardh, *Lychaete echinus* (Biasoletto) Wynne, and *Chaetomorpha linum* (O.F. Müller) Kützing (Calvo *et al*., 1980; Orestano & Calvo, 1985; Cecere *et al*., 1992).

The most abundant unattached algal species found in the Stjuža Lagoon were green algae of the genus *Ulva*, *U. rigida* C. Agardh, and *U. australis* Areschoug. Together with *Enteromorpha*-type forms of *Ulva* (*U. compressa* Linnaeus and *U. intestinalis* Linnaeus), *Chaetomorpha linum* (O.F. Müller) Kützing, *Lychaete echinus*, *Cladophora lehmanniana* (Lindenberg) Kützing, and *C. liniformis* Kützing, they formed mostly unattached aggregates. Some red algae, such as *Ceramium* sp., *Polysiphonia* sp., and *Polysiphonia spinosa* (C. Agardh) J. Agardh, were also present. The long thallus in the free-floating form of *C. aurantia* facilitates the formation of dense aggregations and consequently the colonisation of the lagoon habitat.

Some species of macroalgae were found as epiphytes on the thalli of *C. aurantia*, but they were very rare. Among them we observed *Ceramium* spp., *Titanoderma pustulatum* (J.V. Lamouroux) Näegeli, *Cladophora* spp, and *Cladosiphon zosterae* (J. Agardh) Kjlin. We did not observe any species of invertebrates within *C. aurantia* free-floating hanks, except for a single occurrence of *Asterina gibbosa* (Pennant, 1777).

Water quality of the Stjuža Lagoon of Strunjan

Judging from the information available for other parts of the Mediterranean, we believe that certain environmental conditions characteristic of the Stjuža Lagoon favour the formation of free-floating forms of *C. aurantia*, namely: (i) shallowness (an average depth of about 0.5–1 m), which allows for continuous exposure to sunlight and, consequently, the growth of algal thalli in all directions; (ii) superficial and bottom water currents produced by winds blowing from the North-North-East (bora) and from the South-East (sirocco); (iii) a wide tidal range of about 67 cm; and (iv) a soft sedimentary bottom unfavourable to the development of attached macroalgae.

During the sampling period, the values of salinity, temperature, and pH of the sampling site were very similar to those of the open sea (Strunjan Bay), while greater differences were observed when comparing the oxygen values of the sampling site (9.98 ppm) with those of the waters of the Strunjan Bay (12.08 ppm) (Tab. 2). The results obtained from our measurements are prevalently in agreement with those obtained in previous studies (Avčin *et al*., 1873; Vrišer, 2002; Lipej *et al*., 2019).

C. aurantia clearly thrives as the lagoon ecosystem conditions improve, possibly because of its sensitivity to water quality and the hydrodynamic environment. The eastern part of the Stjuža Lagoon, where that alga is most common, is probably least exposed to less favourable environmental conditions and displaying conditions very similar to those of the water of Strunjan Bay (Tab. 2).

The connections with the sea through the entrance and the tidal channels, favouring water circulation, have probably facilitated the colonisation and spread of *C. aurantia*. Also, since this alga is unattached, water circulation patterns in the lagoon undoubtedly influence its distribution towards the eastern part of the Stjuža Lagoon. On the other hand, the sea connections ensure a better circulation of water masses in the lagoon and reduced organic pollution.

Tab. 1: Average values of some morphological measurements of brown alga *Cystoseira aurantia* ***from the Stjuža Lagoon of Strunjan.***
Tab. 1: Povprečne vrednosti nekaterih morfoloških meritev pri rjavi algi *Cystosera aurantia* ***iz Lagune Stjuža v Strunjanu.***

	Thallus		**Primary branches**		**Aerocysts**		**Ostioles of conceptacles along the branches**			**Ostioles of conceptacles on aerocysts**		
	length/ cm	diam./ mm	length/ cm	diam./ mm	length/ cm	diam./ mm	length/ cm	diam./ mm	ratio l/w	length/ cm	diam./ mm	ratio l/w
mean	20.77	1.00	7.21	0.90	6.68	1.73	0.23	0.09	2.64	0.22	0.14	1.62
stdev	7.46	0.11	2.59	0.13	0.96	0.18	0.02	0.02	0,55	0.02	0.01	0.25

Impact on the environment

Information on the presence in the Stjuža Lagoon of brown algae, which indicates a good status of water, are very scarce. From literature data, a total of 15 macroalgal taxa, attached and free-floating, were recorded in the lagoon (Lipej *et al*., 2004, 2019; Battelli & Gregorič, 2020). Most of the macroalgal species found by Lipej *et al*. (2019) are ESG II class (Orfanidis *et al*., 2011) and as such not indicative of good ecological status. From papers in Lipej *et al*. (2004) and Lipej *et al*. (2019) it results that brown algae *Cystoseira compressa* (Esper) Gerloff & Nizamuddin and *Fucus virsoides* J. Agardh, both indicators of good ecological status, were at times present in the Stjuža Lagoon, but we did not encounter those species during our study. It is interesting to note that *F. virsoides* disappeared from the entire Slovenian coast a few years ago due to reasons still unknown (Battelli, 2016). Orlando-Bonaca & Rotter (2018) observed a certain regression of *Cystoseira* species in recent years in the coastal waters of Slovenia. Recently, Battelli and Gregorič (2020) reported the occurrence of *Cystoseira foeniculacea* (Linnaeus) Greville f. *tenuiramosa* (Ercegović) Gómez Garreta, Barceló, Ribera et Rull Lluch in the lagoon, attached to hard substrata and as epiphyte on a ball-like form of *Rytiphlaea tinctoria*, which is certainly evidence to the species diversity of the lagoon.

Tab. 2: Comparisons among the values of salinity, temperature, pH and oxygen recorded at the sampling site and in Strunjan Bay during the sampling period (March 2021).
Tab. 2: Primerjava vrednosti slanosti, temperature, pH in kisika na vzorčevalni postaji in v Strunjanskem zalivu, v obdobju vzorčenja (marec 2021).

Location	**salinity**	**T (°C)**	**pH**	**O_2 (ppm)**
Stjuža lagoon	34.00	19.64	7.87	9.98
Strunjan bay	34.46	15.05	8.25	12.08

Unfortunately, up to now, there have been no studies about the ecological conditions that could somehow explain the occurrence of *C. aurantia* in the lagoon. Further investigation regarding the causes that have led to the presence of only two species of *Cystoseira* is desirable and necessary.

The present observations were limited to a single sampling period. Unfortunately, we did not have additional data on the environmental conditions that may have favoured the unusual formation of the free-floating form of this brown alga in the Stjuža Lagoon of Strunjan. Our assumptions are based exclusively on the observations made during the short research period and the study of the available literature. It is therefore evident that further investigations, repeated in time, will be necessary for a deeper understanding of this phenomenon.

CONCLUSIONS

On the basis of the cited literature and observations made during this study, we suppose that the formation of the free-floating forms of the unattached brown alga *Cystoseira aurantia* in the Stjuža Lagoon of Strunjan may be a consequence of (i) mechanic processes due to a consistent movement of water under the action of winds and tidal currents between high and low tides, and (ii) characteristics intrinsic to the species which allow the growth of the thallus in any direction and thereby an ever-changing exposure to light.

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PRVO POROČILO O VRSTI *CYSTOSEIRA AURANTIA* (SARGASSACEAE, FUCOPHYCEAE) V STRUNJANSKI LAGUNI (TRŽAŠKI ZALIV, SEVERNI JADRAN)

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POVZETEK

Avtorja poročata o pojavu rjave alge Cystoseira aurantia *iz morske lagune Stjuža v Strunjanu (Tržaški zaliv, severni Jadran), ki predstavlja prvi zapis o tej vrsti v obalnem morju Slovenije. Študija je bila izvedena marca 2021, na vzhodnem delu lagune, kjer je bila ugotovljena večja gostota prosto plavajočih prepletenih mas te alge, na globini, ki ni presegala 0,5 m. Opisani so življenjski prostor, morfološki znaki preučenih vzorcev. Ugotovljeno je bilo, da je mehko dno lagune očitno ugodno za razvoj nepritrjene vegetacije alg, katerih predstavnik je* C. aurantia. *Avtorja domnevata, da je nastanek prosto plavajočih mas te alge v Strunjanski laguni Stjuža mogoče razlagati kot posledico dinamičnega delovanja valov zaradi vetrov in plimskih tokov ter kot rezultat aktivne vloge alge, ki omogočajo rast steljke v vse smeri, saj nima pritrdilnih struktur, in s tem nenehno spreminja izpostavljenost svetlobi.*

Ključne besede: *Cystoseira aurantia*, laguna Stjuža Strunjan, Slovenija, severni Jadran

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LE ORCHIDACEAE DI PINGUENTE (BUZET)

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SINTESI

Pinguente (Buzet, Croazia) è situato nell'Istria nord occidentale. Il territorio si estende su una superficie di circa 167 km². Il presente lavoro, basato su osservazioni dirette, una ricerca bibliografica e segnalazioni inedite, riporta una check-list aggiornata di tutte le Orchidaceae presenti in tale territorio che comprende 41 taxa specifici e infraspecifici e 3 ibridi. Inoltre è stata eseguita l'analisi corologica di questa florula da cui risulta la prevalenza dell'elemento Mediterraneo seguito da quello Eurasiatico.

Parole chiave: Pinguente, Buzet, Orchidaceae, check-list, spettro corologico

THE ORCHIDACEAE OF BUZET (HR)

ABSTRACT

Buzet (HR) is located in north-western Istria and its territory covers an area of ca 167 km². This work, based on direct study in the field, on a bibliographic research and unpublished reports presents an updated check-list of all Orchidaceae including 41 specific and infraspecific taxa and 3 hybrids. Furthermore, a chorological analysis of this florula was carried out: it highlights the prevalence of the Mediterranean element followed by the Eurasian.

Key words: Pinguente, Buzet, Orchidaceae, check-list, chorological spectrum

INTRODUZIONE

La famiglia delle Orchidaceae Juss. è costituita da circa 27.800 specie ripartite in 880 generi (Givnish *et al*., 2016) e, dopo le *Asteraceae* Martinov, è la più ricca del mondo vegetale. Essa, pur raggiungendo la maggiore abbondanza e diversità nelle zone tropicali, ha colonizzato con successo quasi ogni bioma terrestre. In Europa e nel bacino del Mediterraneo sono segnalati oltre 600 taxa (Delforge, 2016); nella Repubblica di Croazia ne sono segnalati 181 (Nikolić, 2015) mentre nella penisola istriana 82 (Pezzetta, 2018a). Tale famiglia suscita un notevole fascino per cui numerosi gruppi, associazioni e o semplici appassionati le studiano, coltivano e ricercano. Il presente studio, in linea con tale tendenza, ha per finalità la compilazione di una check-list comprendente le specie, le sottospecie e gli ibridi di orchidacee presenti nel Comune di Pinguente per il quale sinora non è stato pubblicato nessun lavoro specifico su tale argomento.

Inquadramento dell'area d'indagine

Il Comune di Pinguente (in croato Buzet) è situato nell'Istria nord-occidentale, tra la Repubblica di Slovenia e la valle del fiume Quieto. Confina con i Comuni di Portole-Oprtalj a ovest; Capodistria-Koper (Repubblica di Slovenia) a nord-ovest, Lanischie (Lanišće) a nord-est, Lupogliano (Lupoglav) ad est; Montona-Motovun, Cerreto (Cerovlje) e Pisino (Pazin) a sud.

Il territorio comunale nei suoi confini attuali occupa una superficie di 167 km²; è situato in una fascia altitudinale che va da circa16 metri s.l.m. nella valle del Quieto a oltre 500 metri s.l.m. del ciglione carsico; è costituito da colline, aree più o meno pianeggianti e valli di diverso aspetto e composizione rocciosa che contribuiscono a formare un paesaggio morfologicamente molto differenziato. La sua popolazione complessiva è di oltre 6200 abitanti sparsi in 71 insediamenti, mentre la densità media è di 37,2 abitanti per km².

Il centro cittadino di Pinguente, d'origine medioevale, è situato sulla cima di una collina alta 158 metri s.l.m che s'innalza isolata in una valle delimitata nella sua parte settentrionale dal ciglione carsico della Cicceria (Ćićarija), una subregione montuosa dell'Istria nord-orientale.

Il territorio pinguentino fu abitato fin dall'epoca preistorica e durante l'età del Bronzo, popolazioni di origine illirica si stabilirono nell'area costruendo insediamenti collinari circondati da mura (Alberi, 1997).

Il corso d'acqua più importante che attraversa l'ambito di studio è il Quieto (in croato Mirna), dalla lunghezza totale di circa 53 km. L'area è attraversata anche da altri brevi corsi d'acqua talvolta occasionali che affluiscono nel Quieto o che, a contatto con le rocce calcaree s'infiltrano nel sottosuolo: Draga (Pivka), Rečina, Bulaž, Butoniga, Bračana, Sušak, Gregorički potok, Senjski potok, Senica, etc. (Prostorni plan Grada Buzeta, 2005).

Nel territorio pinguentino è presente anche un lago artificiale ottenuto dallo sbarramento del Butoniga, il più importante affluente del Quieto.

La geologia

L'area di studio è caratterizzata da terreni che derivano da rocce di origine sedimentaria: rocce calcaree, rocce marnoso-arenacee e depositi alluvionali del Quaternario presenti nelle valli del Quieto, del Brazzana (Bračana) e del Bottonega (Butoniga). I sedimenti più antichi iniziarono a depositarsi durante il Cretaceo Superiore e continuarono nelle epoche successive (Pleničar *et al*., 1969, 1973; Šikić *et al*., 1972; D'Ambrosi, 1976; Forti, 1996; Alberi, 1997; Perković, 2017).

Le principali aree con rocce calcaree sono presenti nella Cicceria, a sud-est di Pinguente tra i torrenti Rečina e Draga, presso Kuk, Ročko polje, il canyon del fiume Quieto tra le Porte di Ferro (Kameni Vrata) e Bagni di Santo Stefano (Istarske Toplice) e, tra Brnobić e la sorgente di San Giovanni (Sv. Ivan). A causa della natura permeabile del terreno in tali ambiti non sono presenti corsi d'acqua superficiali.

Le aree marnoso-arenacee a loro volta sono presenti nel resto del territorio. Essendo impermeabili, su di esse riaffiorano le sorgenti e scorrono i corsi d'acqua. Tali ambiti sono caratterizzati da varie colline che si elevano più o meno dolcemente dal fondovalle e raggiungono quote comprese tra 200 e 454 metri.

Lungo il letto del Quieto, Brazzana (Bračana), Bottonega (Butoniga) e altri torrenti si rinvengono depositi alluvionali con argille, sabbie ed altri materiali.

Il clima

Il clima del pinguentino è condizionato dalla sua morfologia territoriale e dalla sua posizione nell'entroterra istriano. In particolare la sua conformazione favorisce sia la penetrazione della bora che accentua la continentalizzazione climatica, sia quella delle correnti d'aria calda attraverso la valle del Quieto che, a loro volta favoriscono l'espansione del clima mediterraneo nelle zone interne della penisola istriana.

Nell'area di studio, quindi, variando l'esposizione ai venti e alle correnti d'aria si possono originare diversi microclimi locali. In particolare, il Piano Regolatore della Città di Buzet (Prostorni Plan Grada Buzeta, 2005) individua due particolari tipologie climatiche.

La prima, definita "temperato calda", copre l'area con altitudine inferiore a 500 metri ed è caratterizzata dai seguenti parametri: temperatura media mensile del mese più caldo superiore a 22 °C: precipitazioni con un massimo principale in autunno (ottobre o novembre) e uno secondario tra maggio e giugno; temperatura media annua registrata a Pinguente di 12.8 °C; temperature massima assoluta +38,6 °C e minima assoluta -14,1 °C (Tomić, 1981).

La seconda tipologia climatica comprende la zona pedemontana e montana posta oltre 500 m. Le sue caratteristiche principali, secondo il Prostorni Plan sono: estati fresche con temperatura media del mese più caldo inferiore a 22 °C e precipitazioni con distribuzione mensile più uniforme.

I modelli di classificazione di Köppen (1936) e Šegota & Filipić (2003) applicati all'ambito di studio confermano l'esistenza di due tipologie climatica e precisano che:

- l'area della valle del Quieto in cui si sviluppa la foresta di Montona, rientra nel tipo climatico caldo-umido temperato senza stagione secca che è definito "Cfa" ed è caratterizzato dalla temperatura media del mese più caldo che supera 22 °C e le precipitazioni annue comprese tra 700 mm e 1500 mm;
- le colline circostanti sono caratterizzate da un clima più fresco che rientra nel tipo "Cfb", a sua volta caratterizzato dalla temperatura media della stagione estiva inferiore a 22 °C.

Aspetti floristici, vegetazionali e fitogeografici

Nell'area in esame, le varietà paesaggistiche, la bassa densità di popolazione, l'andamento climatico e la pressione antropica attuale e del passato hanno creato le premesse per lo sviluppo di formazioni vegetali molto varie. Infatti, il pinguentino si può considerare un grande mosaico caratterizzato da piccoli centri abitati, infrastrutture stradali, aree coltivate, zone umide, boschi di varie tipologie, aree incolte, prati-pascolo e pinete artificiali.

Gli ambiti boschivi della zona occupano circa 7.335 ha (Prostorni Plan Grada Buzeta 2005), un dato corrispondente a oltre la metà della superficie indagata. Attualmente essi sono in espansione sui terreni e pascoli abbandonati.

Le principali tipologie vegetali presenti nell'area di studio sono le seguenti:

- radure prative e prati-pascolo secondari inquadrabili in diverse associazioni vegetali in cui generalmente si rinvengono *Carex humilis* Leys, *Centaurea rupestris* L., *C. weldeniana* Rchb., *Chryspogon grillus (*L.) Trin., *Crocus reticulatus* Stev ex Adam, *Euphorbia nicaensis* All., *Danthonia alpina* Vest., *Dianthus sylvestris* Wulfen *subsp. tergestinus* (Rchb.) Hayek, *Fritillaria orientalis* J.M.F. Adams, *Lathyrus pannonicus* (Jacq.) Garcke, *Lotus corniculatus* L.**,** *Narcissus radiiflorus* R.A. Sal., *Onosma javorkae* Simk., *Plantago media* L., *Polygala nicaeeensis* Risso ex W.D.J. Koch, *Pulsatilla montana* (Hoppe) Reich. subsp. *montana*, *Salvia pratensis* L., *Scorzonera villosa* Scop., *Linum narbonense* L. ed altre entità;
- associazioni sinantropiche con composizioni floristiche molto variabili che attecchiscono presso i centri abitati, le abitazioni sparse, i bordi stradali, i campi coltivati e i terreni incolti;
- arbusteti e formazioni arboreo-arbustive in fase di espansione sui pascoli e terreni abbandonati, alla cui composizione generalmente concorrono *Carpinus orientalis* Mill., *Cornus mas* L., *Cornus sanguínea* L., *Cotinus coggygria* Scop., *Crataegus monogyna* Jacq., *Juniperus communis* L., *Ligustrum vulgare* L, *Paliurus spina-christi* Mill., *Rosa canina* L, *Spartium junceum* L., etc.;
- lembi di bosco submediterraneo (anch'essi in fase di espansione), presenti sia sui terreni marnoso-arenacei sia su quelli calcarei composti dalle seguenti essenze arboree: *Acer monspessulanus*, *A. campestre* L., *Fraxinus ornus* L., *Ostrya carpinifolia* Scop., *Quercus pubescens* Willd.
- associazioni erbacee, prative, arboreo-arbustive e forestali rinvenibili presso i corsi d'acqua ed altri ambienti umidi con *Alisma plantago-aquatica* L., *Baldellia ranunculoides* (L.) Parl, *Equisetum arvense* L., *Frangula alnus* Mill., *Gentiana pneumonanth*e L., *Lemna gibba* L, *Phragmites communis* Trin., *Ranunculus lingua* L., *Symphytum officinale* L., *Stachys palustris* L., varie specie di carici, giunchi, salici ed altre entità;
- lembi di castagneto presenti nella valle del Quieto presso Zrenje, nella valle del Bottonega e in altre località (Galant, 2017) composti da *Acer obtusatum* W. & K, ex Willd., *Castanea sativa* Mill., *Fraxinus ornus*, *Helleborus multifidus* Vis., *Quercus cerris* L.,

Sesleria autumnalis (Scop.) F.W. Schultz, ed altro;
- lembi dal bosco misto mediterraneo (*Orno-Quercetum-ilicis* Horvatić) presenti nei pressi di Istarke Toplice e in altri ambiti esposti a sud-ovest e molto riparati dalla bora (Galant, 2017) con *Asparagus acutifolius* L., *Fraxinus ornus*, *Laurus nobilis* L., *Quercus ilex* L. *Phyllirea latifolia* L., *Pistacia terebinthus* L., etc.;
- boschi artificiali di pino nero (*Pinus nigra* J.F. Arnold) presenti in varie località;
- formazioni tipiche di ambienti rocciosi presenti presso il ciglione carsico, tra Kameni Vrata e Istarske Toplice ed altre località ove nel complesso si rinvengono *Arabis hirsuta* (L.) Scop., *Asperula aristata* Linnaeus f. subsp. *oreophila* (Briquet) Hayek, *Asplenium ceterach* L., *Campanula pyramidalis* L., *Euphorbia fragifera Jan, Moehringia tommasinii* Marchesetti, *Salvia officinalis* L., *Sedum dasyphyllum* L., *S. sexangulare* L., *Stipa eriocaulis* Borb. ed altre entità.

Nel territorio di Pinguente, in particolare tra Istarke Toplice e la valle del Bottonega si sviluppa un lembo del cosiddetto "bosco di S. Marco o di Montona", un importante gioiello naturalistico noto anche per le sue essenze tartutifere e protetto dalla Repubblica di Venezia sino al 1797, quando l'Istria era sotto la sua sovranità. Si tratta di un esempio di bosco planiziale che un tempo era molto diffuso lungo le pianure alluvionali europee che oggi è conservato solo in poche aree risparmiate dall'espansione dei terreni coltivati, delle aree urbane e delle infrastrutture di trasporto.

Il complesso forestale recentemente è stato oggetto di molti studi floro-vegetazionali (Bertović, 1975; Korijan, 2016; Vukelić *et al.*, 2018) in cui si dimostra che alla sua composizione concorrono associazioni vegetali azonali e rare per la penisola istriana. Infatti, Korijan (2016), segnala nella foresta di Montona le seguenti associazioni vegetali: *Leucojo aestivi-Fraxinetum angustifoliae* Glavač 1959, *Pruno padi-Fraxinetum angustifoliae* Glavač 1960, *Genisto elatae-Quercetum roboris* Horvat 1938, *Fraxino angustifoliae-Ulmetum laevis* Slavinić 1952 e *Carpino betuli-Quercetum roboris* (Anić 1959) Rauš 1971. Le principali essenze arboree presenti nelle aree più umide del bosco sono: *Carpinus betulus* L., *Fraxinus angustifolia* Vahl, *F. excelsior* L., *Prunus padus* L., *Quercus robur* L., *Ulmus laevis* Pall. e *U. minor* Mill (Vukelić et al., 2018).

Al generale corteggio floristico del pinguentino concorrono anche le orchidacee che in seguito saranno analizzate e discusse.

MATERIALI E METODI

L'elenco floristico è stato realizzato tenendo conto delle ricerche sul campo dell'autore e dei dati ricavati dalle consultazioni bibliografiche. Esso comprende le specie, le sottospecie e gli ibridi mentre non sono state prese in considerazione le varietà cromatiche e morfologiche.

Le prime estemporanee e personali osservazioni nell'area iniziarono circa una decina di anni fa e si sono protratte con cadenze più o meno settimanali sino al 2019. Nel 2020 a causa della pandemia si sono interrotte.

Accanto ad ogni taxon sono riportati: il tipo corologico, gli autori che l'hanno segnalato, le località di presenza in lingua croata e le eventuali osservazioni sul rango tassonomico.

Per la nomenclatura si è seguita quella adottata nel recente volume del GIROS (2016) mentre per le specie non riportate in tale testo Delforge (2016). In diversi casi, alla nomenclatura sono aggiunte varie precisazioni riportate nelle osservazioni.

Per l'assegnazione dei tipi corologici si è tenuto conto di quanto riportato in: Delforge (2016), Pignatti (2017) e Pezzetta (2018b).

Sono riportate nel testo anche le segnalazioni di orchidacee che nel sito internet "Flora Croatica" di Nikolić (2015) ricadono all'interno dei confini del territorio appartenente alla città di Pinguente.

Nell'elenco floristico per ogni taxon sono riportati tutti i siti di ritrovamento seguiti dal punto esclamativo per indicare le osservazioni personali e da sigle costituite da lettere maiuscole che si riferiscono agli autori delle segnalazioni. Esse hanno il seguente significato:

AX: Teschner (1987); BX: Starmühler (2000); CX: Biel (2001); DX: Hertel S. & K., (2002); EX: Romolini (2002); FX: Šmiták (2002); *GX:* Kranjčev (2005); HX: Nikolić (2015); IX: Nikolić & Topić (2005); LX: Delforge (2006); MX: Starmühler, (2007); NX: Griebl (2009); OX: Starmühler (2010); PX: Grabner & Grabner (2013); PY: Rottensteiner (2014); QX: Rottensteiner (2015); QY: Tout & Harmes (2018): QY: Rottensteiner (2018); RX: Rottensteiner (2019); SX: John e Gerry's (2018).

RISULTATI E DISCUSSIONE

Elenco floristico

1. *Anacamptis coriophora* (L.) R.M. Bateman, Pridgeon & M.W. Chase subsp. *coriophora* – Eurimediterraneo. (NX). Vrh.

2. *Anacamptis coriophora* (L.) R.M. Bateman, Pridgeon & M.W. Chase subsp. *fragrans* (Pollini) R.M. Bateman, Pridgeon & M.W. Chase – Eurimediterraneo. (DX, FX*, GX, HX, NX*, PX, SX). Bartolići!, Barušići, Buzet, Krti!, Krušvari!, Penićiće!, Sv. Donat!, Svi Sveti!, Vrh.
3. *Anacamptis laxiflora (*Lam.) R.M. Bateman, Pridgeon & M.W. Chase – Eurimediterraneo. (CX, EX, FX*, GX, PX*). Barušići!, Bračana, Buzet, Hum, Krti!, Veli Mlun!
4. *Anacamptis morio* subsp. *morio* (L.) R.M. Bateman, Pridgeon & M.W. Chase – Europeo-Caucasico. (CX, DX, GX, HX, NX, PX, QY). Bartolići!, Barušići, Buzet!, Erkovčići!, Gornja Nugla!, Hum!, Krti!, Marinci!, Prodani!, Ročko Polje!, Sv. Donat!, Svi Sveti!, *Žonti*!
5. *Anacamptis papilionacea* (L.) R.M. Bateman, Pridgeon & M.W. Chase – Eurimediterraneo. (HX). Krti.
6. *Anacamptis pyramidalis* (L.) Rich. subsp. *pyramidalis* – Eurimediterraneo. (CX, DX, FX, GX, HX, LX, NX, OX, PX, QX). Bartolići!, Barušići, Bračana!, Buzet, Gornja Nugla!, Hum!, Krti!, Krušvari!, Marinci!, Prodani!, Roč, Ročko Polje!, Sv. Donat!, Svi Sveti!, Štrped, Veli Mlun!, Vrh.
7. *Cephalanthera damasonium* (Mill.) Druce – Eurimediterraneo. (CX, HX, NX). Barušići, Buzet!, Erkovčići, Hum!, Krušvari!, Sv. Donat!
8. *Cephalanthera longifolia* (L.) Fritsch – Eurasiatico. (CX, DX, FX, *GX, HX, PX*). Bartolići!, Barušići, Butoniga. Buzet!, Hum!, Krti!, Marinci!, Prodani!, Svi Sveti!, Vrh!
9. *Coeloglossum viride* (L.) Hartm. – Circumboreale. (GX). Buzet, Hum.
10. *Dactylorhiza incarnata* (L.) Soó – Eurosiberiano. (CX, EX). Buzet, Krti, Veli Mlun!
11. *Dactylorhiza maculata* (L.) Soó subsp. *fuchsii* (Druce) Hyl . – Eurasiatico. (HX). Bračana!
12. *Dactylorhiza sambucina* (L.) Soó – Europeo. (NX). Buzet.
13. *Epipactis atrorubens* (Hoffm.) Besser – Europeo. (PX). Sv. Donat!
14. *Epipactis helleborine* subsp. *helleborine* (L.) Crantz – Paleotemperato. (DX, HX, PX). Bračana!, Buzet, Hum, Ročko Polje!, Sv. Donat.
15. *Epipactis microphylla* (Ehrh.) Sw. – Europeo-Caucasico. (PX, SX). Sv. Donat.
16. *Epipactis muelleri* Godfery – Centro-Europeo. (CX, DX, FX, PX). Bračana!, Buzet!, Krti, Prodani!, Sv. Donat, Vrh.
17. *Epipactis palustris* (L.) Crantz – Circumboreale. (CX, DX, GX, HX). Hum, Krti, Svi Sveti!, Vrh.
18. *Gymnadenia conopsea* (L.) R. Br. in W.T. Aiton susbp. *conopsea* – Eurasiatico. (CX, DX, FX, GX, HX, LX, MX, PX). Bartolići!, Bračana, Buzet!, Hum, Krti!, Marinci!, Prodani!, Ročko Polje!, Sv. Donat!, Svi Sveti!, *Žonti*.
19. *Gymnadenia odoratissima* (L.) Rich. – Europeo. (PX, SX). Roč, Sv. Donat.
20. *Himantoglossum adriaticum* H. Baumann – Eurimediterraneo. (CX, DX, FX,GX, HX, LX, NX, PX, RX). Bartolići!, Barušići, Butoniga Buzet!, Gornja Nugla!, Hum!, Krti!, Krušvari!, Mandalenići!, Marinci!, Podkuk, Roč, Sv. Donat!, Svi Sveti!, Veli Mlun!
21. *Limodorum abortivum* (L.) Sw. – Eurimediterraneo. (CX, DX, FX, GX, HX, PX, QX, SX). Barušići, Butoniga!, Buzet, Erkovčići, Gornja Nugla!, Hum, Krti, Krušvari!, Ročko Polje!, Sv. Donat!, Vrh.
22. *Listera ovata* (L.) R. Br. – Eurasiatico. (BX, CX, DX, FX*, GX, HX, PX, QY*). Bartolići!, Barušići, Buzet, Butoniga, Gornja Nugla, Hum, Krti, Sv. Donat.
23. *Neotinea tridentata* (Scop.) R.M. Bateman, Pridgeon & M.W. Chase – Eurimediterraneo. (CX, DX, GX, HX, SX). Buzet!, Krti, Krušvari!, Marinci!, Prodani!, Roč!, Sv. Donat!, Sv. Ivan!, Vrh!
24. *Neotinea ustulata* (L.) R.M. Bateman, Pridgeon & M. W. Chase – Europeo-Caucasico. (HX, SX). Krti!
25. *Neottia nidus-avis* (L.) Rich. – Eurasiatico. (CX, GX, HX). Buzet!
26. *Ophrys apifera* Huds. – Eurimediterraneo. (CX, DX, EX, FX, GX, HX, IX, LX, PX, SX). Bartolići, Barušići!, Butoniga!, Buzet!, Gornja Nugla!, Hum, Klarići, Krti!, Krušvari!, Mandalenići!, Penićiće!, Sv. Donat!, Veli Mlun!, Žonti!
27. *Ophrys holosericea* (Burm. f.) Greuter subsp. *holosericea*. – Eurimediterraneo. (FX, GX, PX). Barušići, Buzet, Krti, Marinci, Sv. Donat!
28. *Ophrys holosericea* (Burm. f.) Greuter subsp. *tetraloniae* (W.P. Teschner) Kreutz – Appennino-Balcanico. (AX, CX, DX, GX, HX, NX, PX, PY, SX). Bartolići!, Buzet!, Krti!, Krušvari, Marinci!, Prodani!, Sv. Donat!, Svi Sveti!, Vrh! Osservazioni. Il taxon ha il suo locus classicus nel territorio di Buzet.
29. *Ophrys holosericea* (Burm. f.) Greuter *subsp. untchjii (*M. Schulze) Kreutz – Subendemico. (NX, SX). Barušići!, Krti!, Marinci!, Svi Sveti!, *Žonti*!
30. *Ophrys incubacea* Bianca subsp. *incubacea* – Stenomediterraneo.(DX). Buzet.

31. *Ophrys insectifera* L. – Europeo. (CX, GX, HX, NX, PX, SX). Buzet!, Erkovčići!, Hum!, Krti, Kruševari!, Marinci, Svi Sveti, Vrh!
32. *Ophrys sphegodes* subsp. *sphegodes* Mill. – Eurimediterraneo. (CX, DX, NX, PX). Bartolići!, Barušići, Buzet!, Erkovčići!, Hum!, Krti!, Krušvari!, Marinci!, Penićiće!, Prodani!, Sv. Donat!, Veli Mlun!, Svi Sveti!, Vrh!
33. *Ophrys sphegodes* subsp. *tommasinii (*Vis.) Soó – Appennino-Balcanico. (SX). Krti.
34. *Orchis mascula* L. subsp. *speciosa* (Mutel) – Centro-Europeo. (SX). Buzet!, Hum, Krti, Krušvari!, Marinci!, Ročko Polje!, Sv. Donat, Svi Sveti, Veli Mlun!
35. *Orchis militaris* L. – Eurasiatico. (CX, DX, GX, HX, SX). Barušići, Bračana!, Buzet. Hum, Krti!, Marinci!, Sv. Donat, *Žonti*!
36. *Orchis purpurea* Huds. – Eurasiatico. (CX, DX, FX, GX, HX, NX, PX, QY, SX). Bartolići!, Barušići, Butoniga, Buzet!, Erkovčići!, Gornja Nugla!, Krti!, Mandalenići!, Marinci!, Ročko Polje!, Sv. Donat!, Vrh!, *Žonti!*
37. *Orchis simia* Lam. – Eurimediterraneo. (DX, HX, PX, SX). Butoniga, Buzet, Hum!, Krti, Prodani!, Sv. Donat!, Svi Sveti.
38. *Platanthera bifolia* (L.) Rchb. subsp. *bifolia* – Paleotemperato. (CX, DX, FX, GX, HX, LX, PX, QY). Bartolići!, Butoniga, Buzet!, Hum, Krti!, Krušvari!, Mandalenići!, Marinci!, Penićiće!, Prodani!, Sv. Donat!, Svi Sveti.
39. *Platanthera chlorantha* (Custer) Rchb. – Eurosiberiano. (DX, LX). Buzet, Krti, Sv. Donat, Vrh.
40. *Serapias bergonii* Camus – Mediterraneo-Orientale. (GX). Krušvari.
41. *Serapias vomeracea* (Burm.f.) Briq. subsp. *vomeracea* – Eurimediterraneo. (CX, DX, FX*, GX*, HX, NX, PX, QY). Bartolići!, Butoniga, Buzet, Krti!, Krušvari!, Penićiće!, Prodani!, Sv. Donat!, Svi Sveti, Škuljari, Vrh, *Žonti!*

Ibridi

1. *Ophry*s x*hybrida* Pokorny & R. (*O. insectifera* x O. *sphegodes*). Hum!
2. *Orchis* x*beyrichii* (Reich. Fil.) A. Kern. (*O. militaris* x O. *simia*). (PX). Butoniga.
3. *Platanthera* x*hybrida* Brügger (*P. bifolia* x *P. chlorantha*). (LX). Sv. Donat.

L'elenco floristico comprende 41 taxa specifici e infraspecifici. Tale numero costituisce il 50 % delle *Orchidaceae* presenti nella penisola istriana e circa il 23 % della Repubblica di Croazia. A tale insieme si aggiungono 3 ibridi per cui l'ammontare complessivo delle entità presenti è 44, un valore numerico che, tenendo conto di quanto riportato in Pezzetta (2018a), colloca il territorio di Buzet tra i Comuni istriani più ricchi di orchidacee.

L'elenco comprende molte segnalazioni di località e stazioni inedite che contribuiscono ad allargare l'areale di diffusione dei singoli taxa nel territorio istriano.

Il geoportale della flora croatica (Nikolić, 2015) riporta la presenza di 24 taxa nel territorio della città di Buzet. Quindi con tale saggio, l'ambito di studio si arricchisce di 17 taxa specifici e infraspecifici e 3 ibridi.

Dalla Tabella 1 emerge che le varie entità si ripartiscono in 15 generi tra cui il più rappresentato è il genere *Ophrys* con 8 taxa. Seguono i generi: *Anacamptis* con 6; *Epipactis* con 5; *Orchis* con 4, *Dactylorhiza* con 3; *Cephalanthera, Gymnadenia*, *Neotinea*, *Platanthera* e *Serapias* con 2; tutti gli altri con un taxon ciascuno.

La Tabella 2 mostra che l'insieme dei taxa è presente in 26 località. Il maggior numero di segnalazioni si registra nei dintorni di Buzet con 30 taxa, Krti con 29 e Sv. Donat con 26. Un discreto numero di taxa si rinviene presso Hum (21), Barušići (15), Marinci (15), Svi Sveti (15), Krušvari (14) e Bartolići (13). Riassumendo si può dire che in tutto il territorio comunale le Orchidaceae sono relativamente diffuse poiché il loro sviluppo è favorito dalla bassa pressione antropica e dalle varietà delle nicchie ecologiche.

Le entità segnalate nel maggior numero di località e quindi più diffuse sono le seguenti:

Tab. 1: Biodiversità dei Generi delle Orchidaceae di Pinguente.
Tab. 1: Biodiverziteta in rodovi kukavičevk v Buzetu.

Genere	**Numero taxa**	**Genere**	**Numero taxa**
Anacamptis	6	*Listera*	1
Cephalanthera	2	*Neotinea*	2
Coeloglossum	1	*Neottia*	1
Dactylorhiza	3	*Ophrys*	8
Epipactis	5	*Orchis*	4
Gymnadenia	2	*Platanthera*	2
Himantoglossum	1	*Serapias*	2
Limodorum	1		

Tab. 2: Località di Pinguente con presenza di orchidacee.
Tab. 2: Lokalitete Buzeta in okolice ter število taksonov kukavičevk.

Località	Taxa totali	Località	Taxa totali
Bartolići	13	Marinci	15
Barušići	15	Penićiće	5
Bračana	7	Podkuk	1
Butoniga	10	Prodani	11
Buzet	30	Roč	4
Črnica	1	Ročko polje	6
Erkovčići	6	Sv. Donat	26
Gornja Nugla	7	Svi Sveti	15
Hum	21	Škuljari	1
Klarići	1	Štrped	1
Krti	29	Veli Mlun	7
Krušvari	14	Vrh	14
Mandalenići	4	Žonti	7

Anacamptis pyramidalis (17), *Himantoglossum adriaticum* (15), *Ophrys apifera* (14), *O. sphegodes* subsp. *sphegodes* (14), *Anacamptis morio* (13), *Orchis purpurea* (13), *Platanthera bifolia* (12), *Serapias vomeracea* (12). *Gymnadenia conopsea* (11) e *Limodorum abortivum* (11).

In Tabella 3 sono riportati i risultati dell'analisi corologica, con la ripartizione percentuale dei vari contingenti geografici. Si può osservare come il contingente Mediterraneo sia dominante con 16 taxa. Esso è seguito dai contingenti: Eurasiatico con 14 taxa, Europeo con 8, Nordico con 2 ed Endemico con un solo taxa.

Nel complesso nell'area sono più rappresentati i corotipi mesotermici (Appennino-Balcanico, Eurasiatico, Europeo, Centro-Europeo, Europeo-Caucasico, e Paleotemperato). La presenza contemporanea di taxa appartenenti ai corotipi mesotermici, microtemici (Eurosiberiano e Circumboreale) e macrotermici (contingente Mediterraneo) confermano che l'ambito di studio è caratterizzato da una grande varietà ambientale e climatica che consente l'attecchimento di entità vegetali con esigenze ecologiche molto diversificate.

Tab. 3: Corotipi delle Orchidaceae del Comune di Buzet. Nella tabella i contingenti geografici sono segnati in grassetto (1).
Tab. 3: Horotipi kukavičevk v občini Buzet. V tabeli so geografski kontingenti označeni z mastnim tiskom (1).

Contingenti Geografici[1] e Corotipi	Numero taxa	%
Endemico	**1**	**2,44**
Subendemico	1	
Mediterraneo	**16**	**39,02**
Eurimediterraneo	14	
Stenomediterraneo	1	
Mediterraneo-Orientale	1	
Eurasiatico	**14**	**34,15**
Eurasiatico s.s.	7	
Europeo-Caucasico	3	
Eurosiberiano	2	
Paleotemperato	2	
Nordico	**2**	**4,88**
Circumboreale	2	
Europeo	**8**	**19,51**
Europeo s.s.	4	
Centro-Europeo	2	
Appennino-Balcanico	2	
Totale	**41**	**100**

Conclusioni

I dati riportati dimostrano l'importanza dell'ambito di studio per la ricchezza di orchidacee. Il considerevole numero rilevato è un indicatore della sua buona qualità ambientale poiché le piante di tale famiglia vegetale attecchiscono su terreni che non sono alterati da dissodamenti, concimazioni e largo uso di diserbanti e insetticidi. L'ambito di studio nella situazione attuale è poco popolato e non sembra che le varie entità siano minacciate. È tuttavia possibile che a causa della diffusione delle aree urbane, artigianali, industriali, delle infrastrutture di trasporto, dell'espansione delle aree forestali e dell'abbandono delle pratiche agro-pastorali tradizionali seguano trasformazioni di habitat che potrebbero portare a una diversa ripartizione delle varie specie con alcune in fase espansione e altre in contrazione.

KUKAVIČEVKE BUZETA

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POVZETEK

Buzet (Hrvaška) se nahaja v severozahodni Istri in pokriva približno 167 km² površine. V pričujočem delu, ki temelji na neposrednih popisih, literaturnih virih in neobjavljenih podatkih, avtor podaja ažurirani seznam vseh kukavičevk, potrjenih na obravnavanem območju. Ta vključuje 41 vrst in intraspecifičnih taksonov ter 3 križance. Obenem avtor navaja horološko analizo flore kukavičevk, ki je pokazala prevladovanje sredozemskih elementov, ki so jim sledili evrazijski elementi.

Ključne besede: Buzet, Pinguente, Orchidaceae, popis, horološki spekter

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FAVNA

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CALIGUS MINIMUS (COPEPODA: CALIGIDAE) PARASITIC ON THE GILLS OF A REMORA *ECHENEIS NAUCRATES* ATTACHED TO A SEABASS *DICENTRARCHUS LABRAX* IN KÖYCEĞİZ-DALYAN LAGOON LAKE, AEGEAN SEA, TURKEY

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ABSTRACT

The paper describes a parasitic copepod Caligus minimus *found on the gill rakers of a remora* Echeneis naucrates *attached to a seabass* Dicentrarchus labrax *in the brackish Köyceğiz-Dalyan Lagoon Lake on the shore of the South Aegean Sea, Turkey. Morphological characters of the female copepod are provided and illustrated. The occurrence of this parasitic copepod species on a remora host and the association between this remora species and seabass in a brackish lagoon constitute new records. The present study elevates to four the* Caligus *species found on* E. naucrates *so far. We suggest two mutually non-exclusive scenarios for the occurrence of* E. naucrates *on* D. labrax *in brackish environments.*

Key words: Caligidae, fish parasite, remora-seabass association, Turkey

CALIGUS MINIMUS (COPEPODA: CALIGIDAE) PARASSITA SULLE BRANCHIE DI UNA REMORA *ECHENEIS NAUCRATES* ATTACCATA A UNA SPIGOLA *DICENTRARCHUS LABRAX* NEL LAGO LAGUNARE KÖYCEĞİZ-DALYAN, MAR EGEO, TURCHIA

SINTESI

L'articolo descrive un copepode parassita Caligus minimus *trovato sui rastrelli branchiali di una remora* Echeneis naucrates *attaccata ad una spigola* Dicentrarchus labrax *nel lago salmastro Köyceğiz-Dalyan Lagoon sulla riva dell'Egeo meridionale, in Turchia. I caratteri morfologici del copepode femmina sono forniti e illustrati. L'occorrenza di questa specie di copepode parassita su un ospite remora e l'associazione tra questa remora e la spigola in una laguna salmastra rappresentano dati nuovi. Il presente studio eleva a quattro le specie di* Caligus *trovate finora su* E. naucrates. *Gli autori suggeriscono due scenari reciprocamente non esclusivi per la presenza di* E. naucrates *su* D. labrax *in ambienti salmastri.*

Parole chiave: Caligidae, parassita dei pesci, associazione remora-spigola, Turchia

INTRODUCTION

Research on gill parasites in remoras (Echeneidae) is scarce. A remarkable example of it is the study of the complex relationship between a monogenean (*Dionchus* sp.), a shark (*Carcharhinus limbatus* (Müller & Henle, 1839)), and a remora (*Echeneis naucrates* Linnaeus, 1758) (Figure 3 in Bullard *et al*., 2000). So far there have been very few records of caligid copepods on *E. naucrates* (e.g., Wilson, 1905; Causey, 1953; Cressey, 1991), none of them *Caligus minimus* Otto, 1821. We report herein on a *C. minimus* attached to the gills of the slender sharksucker *Echeneis naucrates* and the association between this remora species and the European seabass *Dicentrarchus labrax* (Linnaeus, 1758) in a brackish lagoon of the South Aegean Sea, Turkey.

Caligus minimus is a widespread oioxenous species, i.e., it has a wide range of hosts (Öktener & Trilles, 2009; Boualleg *et al*., 2011; Tanrıkul & Perçin, 2012; Hafir-Mansouri *et al*., 2017). It is found on gills, mouth, or body surface of the hosts, and is able to live in brackish waters (Fonsêca *et al*., 2000; Tanrıkul & Perçin, 2012; Yalım *et al*., 2014). *Echeneis naucrates* is cosmopolitan and may live free-swimming or attached to a variety of fish hosts, including sharks, rays, bony fishes, sea turtles, dolphins, and whales (Strasburg, 1964; O'Toole, 2002; Brunnschweiller & Sazima, 2008, 2010; Santos & Sazima, 2008), and is able to live in brackish waters (Akyol & Balık, 2007; Santos & Sazima, 2008; Marletta & Lombardo 2020). *Dicentrarchus labrax* inhabits the Eastern Atlantic and the Mediterranean (Freyhof & Kotellat, 2008), is eurythermic (5-28 °C) and euryhaline (3‰ to full strength seawater), which allows it to dwell in coastal inshore waters, estuaries, and in brackish water (Bagni, 2005).

MATERIAL AND METHODS

A specimen of *Echeneis naucrates* attached to a *Dicentrarchus labrax* was caught in a fish trap in the Köyceğiz-Dalyan Lagoon (36.824967 N, 28.632510 E, 0 m a.s.l., 5 m depth) on the shores of the South Aegean Sea during parasitological surveys conducted by the first author in 2019. Parasites were removed from the gill rakers of the sharksucker, fixed in 4% formaldehyde and preserved in 70% ethanol. The copepod specimens were cleared in pure lactic acid for a minimum of 24 h and later dissected under a Wild M5, Leica M140 stereo-microscope. Photos were taken with the aid of a Canon camera (EOS 1100D) connected to the microscope. Measurements were recorded in millimetres. The appendages were measured using a micrometric programme (Proway). Identification and terminology follows Kabata (1979) and Öktener *et al*. (2017).

RESULTS

Subclass Copepoda Milne Edwards, 1840
Order Siphonostomatoida Thorell, 1859
Family Caligidae O.F. Müller, 1785
Caligus minimus Otto, 1821 (Figs. 1-3, Tab. 1)

Female morphology (Fig.1): Body length 3.014 mm; width 1.335mm. Cephalothorax longer than wide. Fourth pediger a little longer than wide. Genital complex longer than wide. First abdominal segment longer than wide. Caudal ramus longer than wide. Exopod of first leg with two middle setae carrying narrow flanges at apices. Antennule (Fig. 2a) two-segmented; distal segment longer than proximal, distal segment bearing 12 setae and 1 subterminal seta on ventral margin, the proximal segment armed with 23 plumose setae. Antenna (Fig. 2b) 3-segmented; first segment features small; second segment nearly quadrangular; third segment long, distally strongly bent curved claw; subchela with a small seta. Postantennal process (Fig. 2b) smaller than antenna. Postantennal process slightly curved, carrying 3 papillae, each with 3 sensillae. Mandible (Fig. 2c) tip with 12 teeth. Maxillule (Fig. 2d) bearing a papilla with 3 unequal setae. Maxilla (Fig. 2e) two-segmented; proximal segment large and unarmed; slender distal segment with hyaline membrane on outer margin and tipped distally with 2 unequal processes. Maxilliped (Figs. 2f, g) proximal segment (corpus) the largest; distal two segments fused to form a claw carrying a small seta at base of claw. Tines of sternal furca (Fig. 2h) slightly curved inward. Caudal rami (Fig. 2i) with 3 long and 3 short setae. Shapes from first leg to fourth leg presented in Figs. 3a-3d, the formula from first leg to fourth leg in Tab. 1.

Fig. 1:** Caligus minimus ♀ **habitus (scale 1 mm) found fastened to gill filaments of** Echeneis naucrates **attached to** Dicentrarchus labrax **host (Photo: A. Öktener).
Sl. 1:** Caligus minimus ♀ **(merilo 1 mm) na škržnih filamentih prilepa** Echeneis naucrates**, pritrjenega na brancina (**Dicentrarchus labrax**) (Foto: A. Öktener).

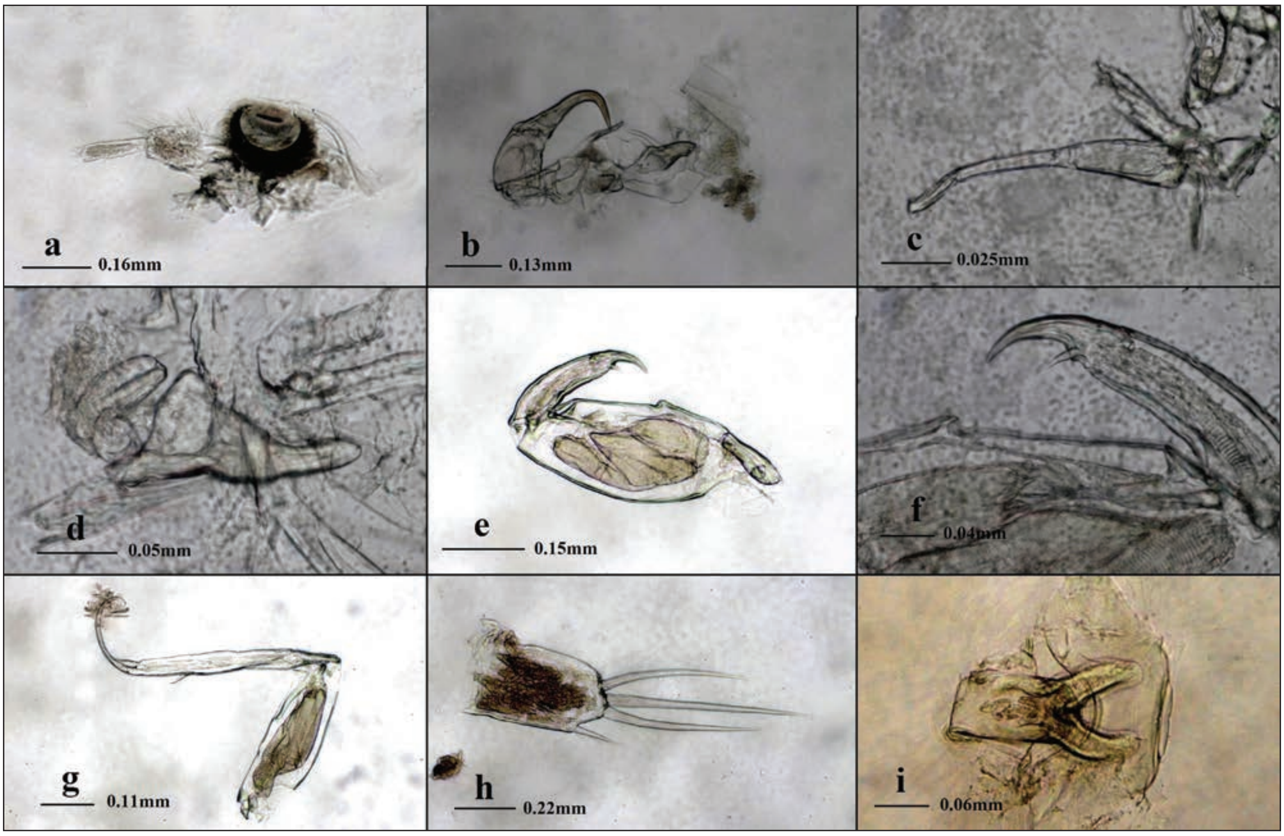

Fig. 2:** Caligus minimus ♀ **a) antennule, b) antenna and postantennal process, c) mandible, d) maxillule, e) maxilla, f) maxilliped, g) distal of maxilliped, h) sternal furca, i) caudal ramus (Photo: A. Öktener).
Sl. 2:** Caligus minimus ♀ **a) antenula, b) antena in postantenski izrastek, c) mandibula, d) maksilula, e) maksila, f) maksiliped, g) distalni del maksilipeda, h) sternalna vilica, i) repni izrastek (Foto: A. Öktener).

The sharksucker *Echeneis naucrates* was about 30 cm total length (TL) with a slim brownish grey body, dark pectoral, pelvic, and caudal fins, and a barely visible darker stripe running from head to tail. The cephalic disk was about 6 cm long (20% of TL). The slim body, the colour, and the relative size of the cephalic disk are diagnostic of this remora species. Its stomach contents revealed no parasites. Its host, a sea bream *Dicentrarchus labrax,* measured about 60 cm TL and was sluggish, with wounds and intense mucus covering its body surface. We were unable to collect the sharksucker and the seabass, and we did not examine the seabass for parasites.

DISCUSSION

Our record of *C. minimus* raises to four the species of siphonostomatoid copepods found parasitising *Echeneis naucrates*. Previously, *Caligus praetextus* Bere, 1936 (Caligidae), *Tuxophorus caligodes* Wilson, 1908 (Tuxophoridae), and *Margolisius* cf. *abditus* (Lernaeopodidae) were reported from this remora species (Wilson, 1908; Cressey, 1991; Justine, 2010). *Margolisius abditus* Benz, Kabata & Bullard, 2000 was reported to have been found on the gill lamellae of another remora species, *Remora remora* (Linnaeus) (Benz *et al*., 2000).

Fifteen species of parasitic copepods, including *C. minimus*, have been recorded for *Dicentrarchus labrax* (WoRMS, 2020). Incidentally, *D. labrax* is a new host for *E. naucrates* (O'Toole, 2002; Brunnschweiller & Sazima, 2008, 2010). This remora species is uncommon in the Mediterranean and may occur in brackish lagoons (Akyol

Tab. 1:** Caligus minimus ♀ **setal and spinal formula from first to fourth leg.
Tab. 1:** Caligus minimus ♀**: formula ščetin in trnov od prve do četrte okončine.

Legs	Endopod	Exopod
First leg (Fig. 3a)	vestigial	I-0; IV-3
Second leg (Fig. 3b)	1-0; 2-0; 6-0	I-1; I-1; III-5
Third leg (Fig. 3c)	1-0; 6-0	I-0; I-1; III-4
Fourth leg (Fig. 3c)	absent	I-0; I, II

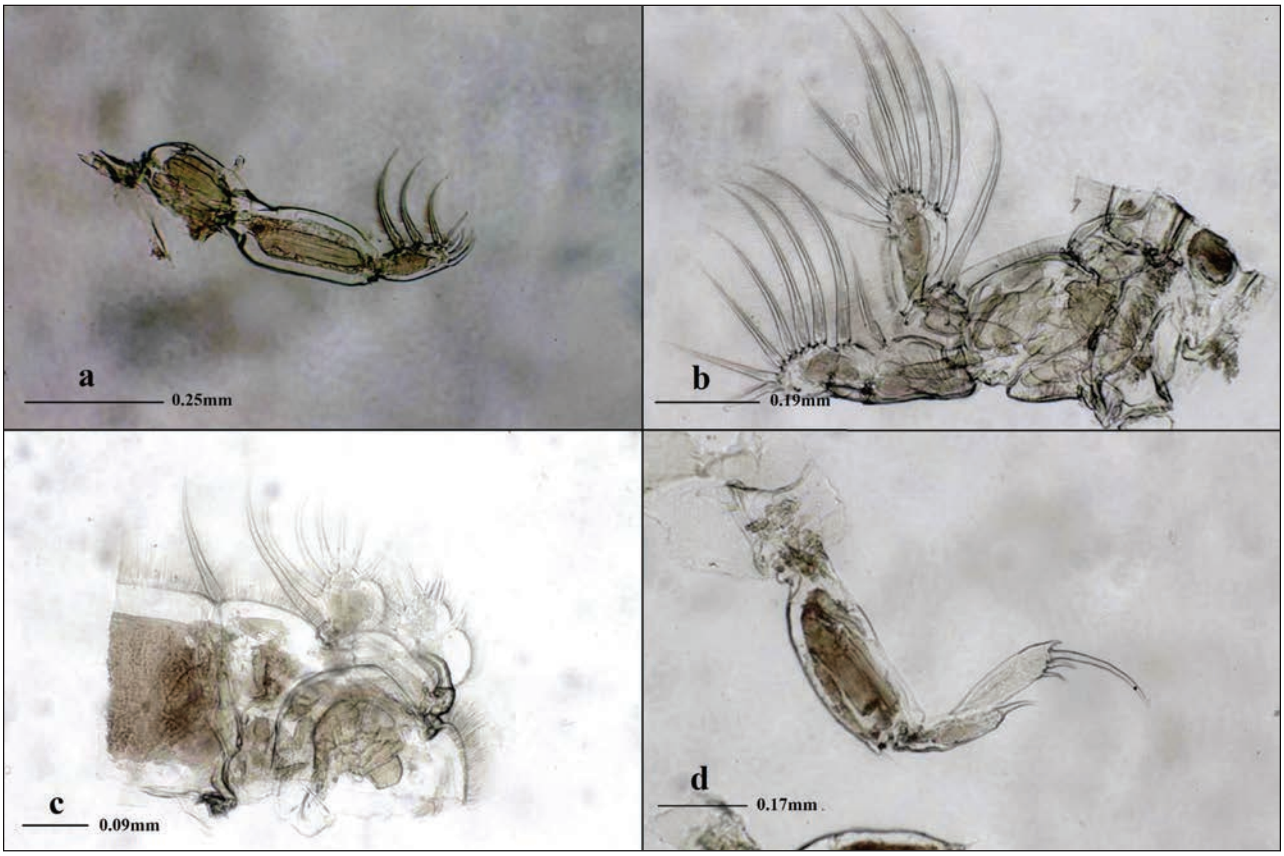

Fig. 3:** Caligus minimus* ♀ ***a) first leg, b) second leg, c) third leg, d) fourth leg (Photo A. Öktener).
Sl. 3:** Caligus minimus* ♀: a) prva okončina, b) druga okončina, c) tretja okončina, d) četrta okončina (Foto: A. Öktener).***

& Balık, 2007; Marletta & Lombardo 2020). Thus, the occurrence of *C. minimus*, *E. naucrates*, and *D. labrax* in the brackish Köyceğiz-Dalyan Lagoon Lake matches the knowledge about salinity tolerance of all three organisms (Bagni, 2005; Akyol & Balık, 2007; Fonsêca *et al*., 2010; Kyne, 2015; Marletta & Lombardo 2020). The wounds observed on the body of *D. labrax* could be due to infestation by *C. minimus* (Noor El-Deen *et al*., 2013) or some other parasite, but we were unable to confirm this hypothesis.

We suggest that the presence of *C. minimus* on *E. naucrates* attached to *D. labrax* can be explained by two scenarios, which are not mutually exclusive: 1) the caligid fastened to the sharksucker when it fed on the parasites and the diseased or dead tissue of the seabass host; 2) the sharksucker swam freely in the lagoon without a host and picked up the caligid when it attached to the seabass. Our scenarios are supported by the biology of *E. naucrates*, as this remora lives free-swimming or attached to a host, from which it picks parasites and dead tissue, changing hosts from time to time (Strasburg, 1964; Cressey & Lachner, 1970; Brunschweiler & Sazima, 2008, 2010). Additionally, remoras may pick up parasites from a host and then transfer them to another host, as postulated by Bullard et al. (2000), which strengthens our suggestions above.

CONCLUSIONS

Our finding of the caligid copepod *C. minimus* on the gills of the slender sharksucker *E. naucrates* raises to four the *Caligus* species recorded on this remora species to date. The association of *E. naucrates* with the seabass *D. labrax* in a brackish lagoon is a new record for the Mediterranean Sea.

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CALIGUS MINIMUS (COPEPODA: CALIGIDAE), ZAJEDAVEC NA ŠKRGAH PRILEPA (*ECHENEIS NAUCRATES*), PRITRJENEGA NA BRANCINA (*DICENTRARCHUS LABRAX*) V LAGUNI KÖYCEĞİZ-DALYAN V EGEJSKEM MORJU, TURČIJA

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POVZETEK

Avtorja poročata o najdbi zajedavskega raka ceponožca vrste Caligus minimus*, najdenega na škržnih ščetinah prilepa* Echeneis naucrates*, ki je bil pritrjen na brancina* Dicentrarchus labrax *iz brakične lagune* Köyceğiz-Dalyan *v južnem Egejskem morju (Turčija). Podajata morfološke znake samice raka ceponožca in slikovno gradivo. Pojavljanje zajedavskega ceponožca na prilepu in zajedanje slednjega na brancinu predstavlja nove podatke o teh odnosih. S pričujočimi podatki se je število zajedavskih vrst iz rodu* Caligus*, ki zajedajo prilepe, povečalo na 4. Nadalje avtorja razpravljata o pojavljanju prilepa na brancinu v brakičnem okolju na podlagi dveh scenarijih, ki se ne izključujeta.*

Ključne besede: Caligidae, ribji zajedavec, združba prilep-brancin, Turčija

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KAZALO K SLIKAM NA OVITKU

SLIKA NA NASLOVNICI: Sinji morski pes (*Prionace glauca*) je široko razširjena oceanska vrsta, ki se pojavlja v tropskih in subtropskih morjih. Včasih je bil eden izmed najpogostejših morskih psov, danes pa je zaradi prelova marsikje ogrožen. (Foto: B. Furlan)

Sl. 1: Sinjega morskega psa (*Prionace glauca*) hitro prepoznamo po dolgem gobcu in dolgih prsnih plavutih, od drugih morskih psov pa ga lahko ločimo tudi po značilni modri barvi. (Foto: B. Furlan)

Sl. 2: Poleg mnogih drugih morskih vretenčarjev zapuščene in odtrgane mreže ogrožajo tudi morske pse in skate. Ta nesrečni primerek velike morske mačke (*Scyliorhinus stellaris*) se je zapletel v ostanke morske mreže v vodah blizu otoka Biševo na južnem Jadranu. (Foto: B. Furlan)

Sl. 3: Tujerodna modra rakovica (*Callinectes sapidus*) že dlje časa naseljuje Sredozemsko morje. Je na seznamu stoterice najnevarnejših invazivnih vrst v Sredozemskem morju in domnevajo, da negativno vpliva na samoniklo biodiverziteto in ribištvu. (Foto: S. Ciriaco)

Sl. 4: Sinji morski pes (*Prionace glauca*) se pojavlja tudi v Jadranskem morju, predvsem v njegovem severnem delu. Po mnenju strokovnjakov se v tem plitvem okolju tudi razmnožuje. (Foto: B. Furlan)

Sl. 5: Vedno znova se v Sredozemskem morju pojavljajo vrste, ki vanj prihajajo iz Indijskega oceana prek Sueškega prekopa. Med njimi je tudi rdečepikasta kirnja (*Epinephelus areolatus*), ki so jo pred kratkim opazili ob obalah Sirije. (Foto: B. Furlan)

Sl. 6: Majhnocvetno čmrljeliko mačje uho (*Ophrys holosericea* subsp. *tetraloniae*) je submediteranska kukavičevka, ki uspeva tudi v slovenski in hrvaški Istri. Kot vse kukavičevke ima tudi ta v Sloveniji status zavarovane rastlinske vrste. (Foto: L. Lipej)

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FRONT COVER: The blue shark (*Prionace glauca*) is a widespread oceanic species occurring in tropical and subtropical seas. While it used to be one of the most common sharks, it is nowadays endangered in many places due to overfishing. (Photo: B. Furlan)

Fig. 1: The blue shark (*Prionace glauca*) is readily recognised by its long muzzle and long pectoral fins. It can also be distinguished from other sharks by its characteristic blue colour. (Photo: B. Furlan)

Fig. 2: Like many other marine vertebrates, sharks and skates are threatened by abandoned fishing nets. This unfortunate specimen of nursehound (*Scyliorhinus stellaris*) became entangled in a ghost net in the waters near the Island of Biševo in the southern Adriatic. (Photo: B. Furlan)

Fig. 3: The alien blue crab (*Callinectes sapidus*) has been colonising the Mediterranean Sea for a long time. It is listed as one of the hundred most dangerous invasive species in the Mediterranean and is thought to have an impact on wildlife biodiversity and fisheries. (Photo: S. Ciriaco).

Fig. 4: The blue shark (*Prionace glauca*) also occurs in the Adriatic Sea, especially in its northern part. According to experts, it also reproduces in this shallow environment. (Photo: B. Furlan)

Fig. 5: Alien fish species have been constantly entering the Mediterranean Sea from the Indian Ocean via the Suez Canal. Among them is the red-spotted grouper (*Epinephelus areolatus*), which was recently spotted off the coast of Syria. (Photo: B. Furlan)

Fig. 6: Bee orchid (*Ophrys holosericea* subsp. *tetraloniae*) is a sub-Mediterranean orchid that thrives in Slovenian and Croatian Istria. Like all wild orchids, this species has the status of protected plant species in Slovenia. (Photo: L. Lipej)

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