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VSEBINA / INDICE GENERALE / CONTENTS 2022(1)

SREDOZEMSKI MORSKI PSI
SQUALI MEDITERRANEI
*MEDITERRANEAN SHARKS***Farid HEMIDA, Christian REYNAUD & Christian CAPAPÉ**

Observations on Thresher Shark, *Alopias vulpinus* (Chondrichthyes: Alopiidae) from the Coast of Algeria (Southwestern Mediterranean Sea) 1
Opazovanja morskih lisic, Alopias vulpinus (Chondrichthyes: Alopiidae) ob alžirski obali (jugozahodno Sredozemsko morje)

Elif ÖZGÜR ÖZBEK & Hakan KABASAKAL

Notes on Smoothback Angel Shark, *Squatina oculata* (Squatiniiformes: Squatinidae) caught in the Gulf of Antalya 9
Zapis o pegastih sklatih, Squatina oculata (Squatiniiformes: Squatinidae), ujetih v Antalijskem zalivu

Alessandro PAGANO & Alessandro DE MADDALENA

Underwater Observations of the Rare Angular Roughshark *Oxynotus centrina* (Chondrichthyes: Squalidae) in the Waters of Santa Tecla (Sicily, Italy) 17
Podvodna opazovanja redkega morskega prašiča, Oxynotus centrina (Chondrichthyes: Squalidae) v vodah Sante Tecele (Sicilija, Italija)

Deniz ERGÜDEN, Deniz AYAS & Hakan KABASAKAL

Morphometric Measurements of Three Young Carcharhinid Species from Northeastern Levant (Mediterranean Sea) 25
Morfometrične meritve mladičev treh vrst morskih psov iz družine Carcharhinidae iz severnovzhodnega Levanta (Sredozemsko morje)

Hakan KABASAKAL

Projections on the Future of Deep-Sea Sharks in the Sea of Marmara, Where Deep Zones Are Threatened by Deoxygenation: a Review 35
Napovedi o prihodnosti globomorskih morskih psov v Marmarskem morju, ogroženem zaradi pomanjkanja kisika: pregled

BIOINVAZIJA
BIOINVASIONE
*BIOINVASION***Alan DEIDUN, Bruno ZAVA & Maria CORSINI-FOKA**

Distribution Extension of *Lutjanus argentimaculatus* (Lutjanidae) and *Psenes pellucidus* (Nomeidae) to the Waters of Malta, Central Mediterranean Sea 49
Širjenje areala vrst Lutjanus argentimaculatus (Lutjanidae) in Psenes pellucidus (Nomeidae) v malteške vode (osrednje Sredozemsko morje)

Sami M. IBRAHIM, Abdulrazziq A. ABDULRAZIQ, Abdulghani ABDULGHANI, Sara A.A. AL MABRUK, David SALVATORI, Bruno ZAVA, Maria CORSINI-FOKA & Alan DEIDUN

First Record of *Enchelycore anatina* (Muraenidae) from Libyan Waters and an Additional Record from Southern Italy (Western Ionian Sea) 59
Prvi zapis o pojavljanju kavljazobe murene Enchelycore anatina (Muraenidae) iz libijskih voda in dodatni zapis za južno Italijo (zahodno Jonsko morje)

Rasha Ali HENEISH & Samir Ibrahim RIZKALLA

Morphometric and Meristic Characteristics of a New Record of Bluespot Mullet *Crenimugil seheli* (Pisces: Mugilidae) in Egyptian Mediterranean waters 67
Novi zapis o pojavljanju vrste Crenimugil seheli (Pisces: Mugilidae) v egiptovskih sredozemskih vodah in njene morfolometrične in meristične značilnosti

Yana SOLIMAN, Adib SAAD, Vienna HAMMOUD & Christian CAPAPÉ

Heavy Metal Concentrations in Tissues of *Siganus rivulatus* (Siganidae) from the Syrian Coast (Eastern Mediterranean Sea) 75
Vsebnost težkih kovin v tkivih marmoriranega morskega kunca Siganus rivulatus (Siganidae) iz sirske obale (vzhodno Sredozemsko morje)

IHTIOLOGIJA
 ITTIOLOGIA
 ICHTHYOLOGY

Jihade ALAHYENE, Brahim CHIAHOU, Hammou EL HABOUZ & Abdelbasset BEN-BANI

Length Based Growth Estimation of the Blue Shark *Prionace glauca* from the Moroccan Central Atlantic Coast 85
Dolžinsko-masni odnos in ocena rasti pri sinjem morskem psu (Prionace glauca) iz osrednje atlantske obale Maroka

Okan AKYOL, Altan LÖK & Funda ERDEM

Occurrence of *Cubiceps gracilis* (Nomeidae) in the Eastern Mediterranean Sea 101
Pojavljanje klateža, Cubiceps gracilis (Nomeidae), v vzhodnem Sredozemskem morju

Farid HEMIDA, Boualem BRAHMI, Christian REYNAUD & Christian CAPAPÉ

Occurrence of the Rare Driftfish *Cubiceps gracilis* (Nomeidae) from the Algerian Coast (Southwestern Mediterranean Sea) 107
Pojavljanje redkega klazeža Cubiceps gracilis (Nomeidae) z alžirske obale (jugozahodno Sredozemsko morje)

Deniz ERGÜDEN & Cemal TURAN

A Rare Occurrence of *Carapus acus* (Carapidae) in the Eastern Mediterranean, Turkey 113
Redko pojavljanje strmorinca Carapus acus (Carapidae) v vzhodnem Sredozemskem morju (Turčija)

Laith JAWAD, Murat ŞIRIN, Miloslav PETRTÝL, Ahmet ÖKTENER, Murat ÇELİK & Audai QASIM

Skeletal Abnormalities in Four Fish Species Collected from the Sea of Marmara, Turkey 119
Skeletne anomalije pri štirih vrstah rib iz Marmarskega morja (Turčija)

RAZMNOŽEVALNA EKOLOGIJA
 ECOLOGIA RIPRODUTTIVA
 REPRODUCTIVE ECOLOGY

Amaria Latefa BOUZIANI, Khaled RAHMANI, Samira AIT DARNA, Alae Eddine BELMAHI, Sihem ABID KACHOUR & Mohamed BOUDERBALA

Gonadal Histology in *Diplodus vulgaris* from the West Algerian Coast 137
Histologija gonad pri navadnem šparu (Diplodus vulgaris) iz zahodne alžirske obale

Cheikhna Yero GANDEGA, Nassima EL OMRANI, Rezan O. RASHEED, Mohammed RAMDANI & Roger FLOWER

The Growth and Reproduction of Two Sparidae, *Pagrus caeruleostictus* and *Pagellus bellottii* in Northern Mauritanian Waters (Eastern Tropical Atlantic) 143
Rast in razmnoževanje dveh vrst pagrov, Pagrus caeruleostictus in Pagellus bellottii v severnih mavretanskih vodah (vzhodni tropski Atlantik)

Nassima EL OMRANI, Hammou EL HABOUZ, Abdellah BOUHAIMI, Jaouad ABOU OUALID, Abdellatif MOUKRIM, Jamila GOUZOU, Mohammed RAMDANI, Roger FLOWER & Abdelbasset BEN-BANI

The Reproductive Biology of the Pouting *Trisopterus luscus* from the Atlantic Coast of Morocco 155
Reproduktivna biologija francoskega moliča (Trisopterus luscus) iz atlantske obale Maroka

Mourad CHÉRIF, Rimel BENMESSAOUD & Christian CAPAPÉ

Growth Patterns and Age Structure of *Mullus surmuletus* (Mullidae) from the Northern Coast of Tunisia (Central Mediterranean Sea) 173
Rastni parametri in starostna struktura progastih bradačev Mullus surmuletus (Mullidae) iz severne tunizijske obale (osrednje Sredozemsko morje)

FLORA

FLORA

FLORA

Martina ORLANDO-BONACA, Erik LIPEJ, Romina BONACA & Leon Lojze ZAMUDA

Improvement of the Ecological Status of the *Cymodocea nodosa* Meadow near the Port of Koper 185
Izboljšanje ekološkega stanja morskega travnika kolenčaste cimodoceje (Cymodocea nodosa) v bližini kopskega pristanišča

FAVNA

FAVNA

FAVNA

Manja ROGELJA, Martin VODOPIVEC & Alenka MALEJ

Cestum veneris Lesueur, 1813 (Ctenophora) – a Rare Guest in the Northern Adriatic Sea 197
Cestum veneris Lesueur, 1813 (Ctenophora) – redek gost v severnem Jadranu

Adla KAHRIĆ, Dalila DELIĆ & Dejan KULIJER

Notospermus annulatus (Nemertea: Lineidae), a New Record for Bosnia and Herzegovina 205
Notospermus annulatus (Nemertea: Lineidae), prvi zapis o pojavljanju za Bosno in Hercegovino

Andrea LOMBARDO & Giuliana MARLETTA

Report of an Interesting *Trapania* (Gastropoda: Nudibranchia: Goniodorididae) Specimen from Central Eastern Sicily 211
Zapis o zanimivem primerku iz rodu Trapania (Gastropoda: Nudibranchia: Goniodorididae) iz osrednje vzhodne Sicilije

Abdelkarim DERBALI & Othman JARBOUI

Stock Assessment, Cartography and Sexuality of the Wedge Clam *Donax trunculus* in the Gulf of Gabes (Tunisia) 217
Ocena staleža, kartografija in spolnost klinaste školjke Donax trunculus v gabeškem zalivu (Tunizija)

Abdelkarim DERBALI, Aymen HADJ TAIEB & Othman JARBOUI

Length-Weight Relationships and Density of Bivalve Species in the Shellfish Production Area of Zarzis (Tunisia, Central Mediterranean Sea) 229
Dolžinsko-masni odnos in gostota školjk na gojišču školjk v predelu Zarsisa (Tunizija, osrednje Sredozemsko morje)

Toni KOREN

The Diversity of Moths (Lepidoptera: Heterocera) of Significant Landscape Donji Kamenjak and Medulin Archipelago, Istria, Croatia 237
Raznolikost nočnih metuljev (Lepidoptera: Heterocera) Pomembne pokrajine Donji Kamenjak in Medulinski arhipelag, Istra, Hrvaška

OCENE IN POROČILA

RECENSIONI E RELAZIONI

REVIEWS AND REPORTS

Ines Mandić Mulec & Nives Ogrinc

Recenzija knjige: Mikrobn biogeokemija vod 263

Kazalo k slikam na ovitku 265

Index to images on the cover 265

FIRST RECORD OF *ENCHELYCORE ANATINA* (MURAENIDAE) FROM LIBYAN WATERS AND AN ADDITIONAL RECORD FROM SOUTHERN ITALY (WESTERN IONIAN SEA)

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ABSTRACT

In the Bomba Gulf, Tobruk, eastern Libya, a specimen of the fangtooth moray, Enchelycore anatina (Lowe, 1839), was caught in gill nets at approximately 20 m of depth. An additional observation of the species from southern Calabria, Italy, is also reported. The findings of this range-expanding species of Atlantic origin document the first record from Libyan waters and from the southern shores of the Mediterranean Sea as well as the expansion of the species' distribution in western Ionian waters.

Key words: Non-Indigenous Species (NIS), Atlantic range-expanding species, neonative species, *Enchelycore anatina*, Libya, Italy, Mediterranean Sea

PRIMO RITROVAMENTO DI *ENCHELYCORE ANATINA* (LOWE, 1839) (MURAENIDAE) IN ACQUE LIBICHE E ULTERIORE SEGNALAZIONE IN ITALIA MERIDIONALE (MAR IONIO OCCIDENTALE)

SINTESI

Un esemplare di Enchelycore anatina (Lowe, 1839) è stato pescato con tramaglio nel Golfo di Bomba, Tobruk, in Libia orientale, a circa 20 m di profondità. La specie è stata inoltre osservata nelle acque della Calabria meridionale, in Italia. Le segnalazioni di questa specie di origine atlantica, il cui areale di distribuzione è in espansione nel Mediterraneo, documentano per la prima volta la sua presenza in acque libiche e lungo le coste del bacino meridionale nonché l'estensione della sua distribuzione nel Mar Ionio occidentale.

Parole chiave: Specie non indigene (NIS), specie di origine atlantica in espansione, specie neonative, *Enchelycore anatina*, Libia, Italia, Mar Mediterraneo

INTRODUCTION

At a global scale, the Mediterranean Sea is considered a hotspot of non-indigenous species introductions (NIS), both in terms of the number of species introduced and introduction rates (Tempesti et al., 2020). The deliberate or inadvertent introduction of NIS represents an essential stressor for ecosystems marine biological communities (Grosholz, 2002; Bax et al., 2003). NIS can exert significant ecological impacts, such as an escalation of changes in the patterns of distribution, abundance and diversity of native species (Claudet & Fraschetti, 2010) as well as modification of food web structure and energy flow (Libralato et al., 2002).

Concurrent with the entry of thermophilic NIS, mostly native to the Indo-Pacific region, the so-called “Lessepsian migration,” the arrival of natural range-expanding thermophilic Atlantic species into the Mediterranean Basin has been well-documented in recent years (Evans et al., 2020). Marchini et al. (2015) define eastern Atlantic species as “having most likely entered the Mediterranean Sea through the Strait of Gibraltar, lacking evidence of human transport,” whilst Essl et al. (2019) have recently proposed the term “neonatives” as an alternative designation for this class of newcomers. The distribution of these Atlantic range-expanding species is not restricted to the western half of the Mediterranean, but is increasingly spreading eastwards within the basin. Deidun et al. (2021a), for instance, recently documented the occurrence of nine Atlantic range-expanding species within the Malta–Sicily Channel in the central Mediterranean.

Despite a recent surge in the research effort to document the increase of NIS and neonative species within the Mediterranean, considerable knowledge gaps are still evident in a number of areas, most notably the Libyan coastal waters (Al Mabruk et al., 2021).

The fangtooth moray, *Enchelycore anatina* (Lowe, 1839), belongs to the family Muraenidae, which is represented in the Mediterranean by three other species, the two natives, the Mediterranean moray *Muraena helena* (Linnaeus, 1758) and the brown moray *Gymnothorax unicolor* (Delaroche, 1809), as well as a NIS of Indo-Pacific origin, the moray eel *Gymnothorax reticularis* Bloch, 1795 (Bauchot, 1986; Stern & Goren, 2013; Froese & Pauly, 2021). Another moray eel species, *Anarchias euryurus* (Lea, 1913), native to the eastern Atlantic Ocean, has been recorded from the Mediterranean, but through a single record off Nice, France, in non-recent times (Bauchot, 1986; Froese & Pauly, 2021).

The fangtooth moray *E. anatina* is a demersal inshore species living on rocky vegetated habitats, up to depths of 50 m; it reaches a maximum length

of 120 cm, feeds prevalently on fishes and large invertebrates and its larvae are pelagic (Golani et al., 2021). This subtropical species is widely distributed in the eastern Atlantic, occupying a broad swathe extending from the Azores to the island of St. Helena (Golani et al., 2021). Although it is considered an Atlantic range-expanding fish species in the Mediterranean (Zenetos et al., 2012), it shows an atypical distribution within the basin. In fact, after being first recorded in the Mediterranean from Israeli waters in 1979 (Ben-Tuvia & Golani, 1984), the species progressively spread into the Levantine Sea (Katsanevakis et al., 2009; Ergüden et al., 2013; Iglésias & Frotté, 2015; Bariche & Fricke, 2020), the Aegean (Kalogirou, 2010 and references therein; Şenbahar & Özaydın, 2020) and the Adriatic (Lipej et al., 2011), and the Ionian seas as far west as the island of Malta (Guidetti et al., 2012; Pirkenseer, 2013; Katsanevakis et al., 2014; Deidun et al., 2015; Marletta & Lombardo, 2020). The distribution of records of *E. anatina* in the Mediterranean has been recently reviewed in detail by Marletta & Lombardo (2020). Of late, the species has also been recorded along the southern coasts of the Mediterranean, off Alexandria, Egypt (Ragheb & Rizkalla, 2020); however, this record is a dubious one as it might be a misidentification of a *M. helena* specimen. The fangtooth moray is thus unknown to date from the western basin as well as from its southern shores.

This study describes the first finding of *E. anatina* from Libyan waters, confirming that the species is spreading along the North African coasts. A further documentation of *E. anatina* along the southwestern coast of the Italian region of Calabria is also hereby reported, corroborating the species' establishment in the western Ionian waters of Italy.

MATERIAL AND METHODS

On 26 December 2020, one individual of *E. anatina* was caught by a local fisherman in Bomba Bay, west of Tobruk, eastern Libya (32.392593°N, 23.135857°E) (Fig. 1) with gillnets at approximately 20 m of depth, over a rocky seabed. The freshly-caught sample was photographed, measured and weighed in the lab, and preserved in the private collection of one of the authors (AA). In order to count the number of vertebrae, the sample was subjected to X-ray analysis.

Furthermore, a specimen of *E. anatina* was photographed during SCUBA diving on 17 July 2020 at 10 m of depth along the southwestern tip of Italy, at Saline Joniche (Reggio Calabria), Ionian Sea (37.934326°N, 15.712948°E) (Fig. 1). The seabed of the area was sandy and rocky, with *Posidonia oceanica* meadows and coralligenous assemblages.

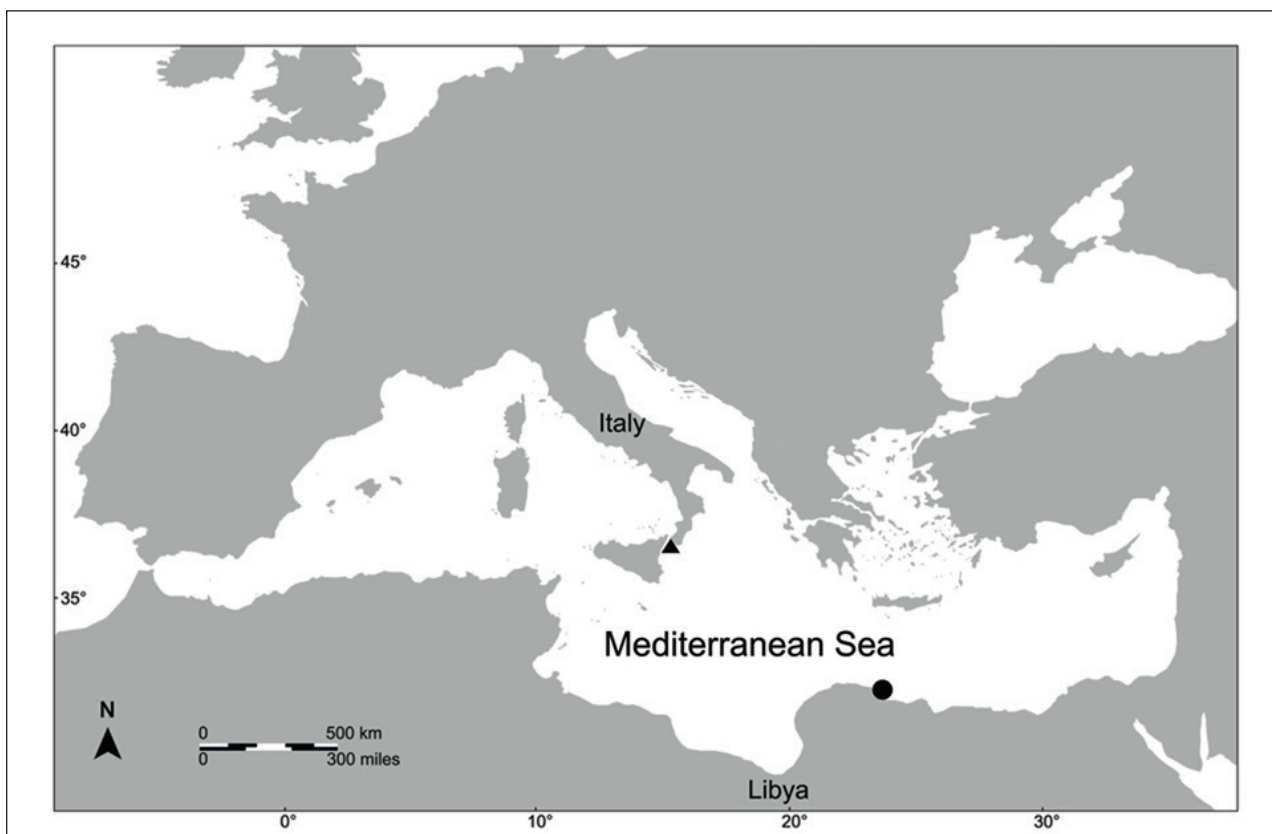


Fig. 1: Map of the Mediterranean Sea showing the locations of Bomba Bay, Libya (●) and Saline Joniche (Italy) (▲), where the *Enchelycore anatina* species was recorded.

Sl. 1: Zemljevid Sredozemskega morja z označenima lokalitetama zaliva Bomba, Libija (●) in Saline Joniche (Italija) (▲), kjer je bila zabeležena vrsta *Enchelycore anatina*.



Fig. 2: The specimen of *Enchelycore anatina* captured in eastern Libya [Black bar= 100 mm] (A) and its upper (B) and lower (C) jaws (Photos by A. Abdulghani).

Sl. 2: Primerek vrste *Enchelycore anatina*, ujet v vzhodni Libiji [Črna črta = 100 mm] (A) in njena zgornja (B) in spodnja (C) čeljust (Foto: A. Abdulghani).



**Fig. 3: The specimen of *Enchelycore anatina* observed in Saline Joniche, Calabria, Italy (Photo by D. Salvatori).
Sl. 3: Primerek vrste *Enchelycore anatina*, opažen v Saline Joniche, Kalabrija, Italija (Foto: D. Salvatori).**

At a depth between 10 and 15 m, vertical walls rich with ravines and cavities created a series of corridors and along one of these corridors the specimen in question was observed.

The specimens from Libya and Italy were identified as *E. anatina* (Figs. 2, 3) according to Ben-Tuvia & Golani (1984), Bauchot (1986), Böhlke & Smith (2002), Smith & Brito (2016) and Golani et al. (2021).

RESULTS

The captured specimen, 640 mm in length and 185 g in weight, presented a compressed and elongated body with no scales, a very long dorsal fin, its origin slightly in advance of gill openings, and an anal fin confluent with the caudal fin. Pectoral and pelvic fins absent. Head pointed with elevated occipital region (Figs. 2, 3). Anterior nostril tubular, posterior nostril oval and opening above anterior margin of eye, mouth large, its cleft extending be-

hind eye, jaws arched, a series of fang-like teeth visible even when the mouth is closed (Figs. 2, 3). Fang-like teeth arranged in an irregular series on both side of the upper jaw and in two series on both sides of the lower jaw, smaller in the outer rows, larger in the inner ones (Fig. 2A, 2B). A total of 151 vertebrae were counted. Body colour brown with yellowish blotches, for the most part irregularly rounded, and dots, running longitudinally along the length of the fish and on fins; snout and cheeks light brown with small yellow spots; jaw pores not noticeably white (Figs. 2, 3).

The proportions of selected measurements were: body depth 5.6, head length 12.5, trunk length 43.8, tail length 56.3, snout length 2.4, eye diameter 1.0, interorbital width 1.1, and mouth cleft 6.3, all expressed as % of total length (Tab. 1).

DISCUSSION

The description of our specimens, the findings concerning the body proportions, the number of vertebrae as well as the habitat type agreed with those reported in the literature for *E. anatina* (cf. Ben-Tuvia & Golani, 1984; Smith & Brito, 2016).

A number of diagnostic characteristics distinguish the fangtooth moray from the other Muraenidae species reported in the Mediterranean. In the genus *Gymnothorax*, the jaws are not arched; the body is uniformly coloured in the native *G. unicolor* while striped with 18 dark brown bars on pale yellowish background in the Red Sea/Indo-Pacific *G. reticularis* (Bauchot, 1986; Stern & Goren, 2013). In *M. helena*, the jaws are not arched, both posterior and anterior nostrils are tubular and the body is brown with large, pale yellow spots, each of which contains smaller brown spots (Smith & Brito, 2016).

Compared to other Atlantic NIS fishes that follow a natural range expansion into the Mediterranean through the Strait of Gibraltar and further eastwards within the basin (see Evans et al., 2020; Golani et al., 2021), the current Mediterranean distribution of *E. anatina* appears anomalous, since, to date, it has only been recorded within the eastern and central swathes of the basin while, concurrently, its occurrence has not been reported in the western ones. The recent findings of *Ablennes hians* (Valenciennes, 1846) in the eastern and central Mediterranean (Deidun et al., 2021b) are similarly reminiscent of the equally anomalous *E. anatina* distribution, but it is far too early to draw any parallels between the two species. A similar spreading pattern, on the other hand, has been observed for the heterobranch seaslug *Aplysia dactylomela* Rang, 1828, of confirmed Atlantic origin (Valdés et al., 2013). In the Mediterranean, this sea hare was first recorded from the Strait of Sicily (Trainito, 2003), subsequently greatly expanding its

Tab. 1: Measurements (mm) and body proportions (as percentages of total length) of the *Enchelycore anatina* specimen from Libya.

Tab. 1: Meritve (mm) in deleži telesa (v odstotkih celotne dolžine) osebk vrste *Enchelycore anatina* iz Libije.

Measurements	Size (mm)	%
Total length (TL)	640.0	
Body depth	35.8	5.6
Head length	80.1	12.5
Trunk length	280.0	43.8
Tail length	360.0	56.3
Snout length	15.2	2.4
Eye diameter	6.7	1.0
Interorbital width	7.0	1.1
Mouth cleft	40.0	6.3

distribution within the Adriatic, and the central and eastern Mediterranean (Crocetta & Galil, 2012). The blue crab *Callinectes sapidus* Rathbun, 1896, a western Atlantic species, was first recorded in the Mediterranean in the late 1940s from the north Adriatic (Kampouris et al., 2020), rather than from Atlantic-contiguous areas of the basin, subsequently spreading to extensive swathes of the Mediterranean, including the coasts of the eastern and central basins (Corsini-Foka et al., 2021).

A number of hypotheses have been put forward to tentatively explain the unusual Mediterranean distribution of this restricted cohort of Atlantic range-expanding species. Marletta & Lombardo (2020) proposed two most feasible mechanisms which could be conveying species of eastern Atlantic origin, including *E. anatina*, directly to the eastern Mediterranean. The first involves the weakening of the Almeria–Oran front as a result of climate change and the strong Algerian

Current, which flows along the North African coast in a west-east direction. The second mechanism, equally if not more feasible, involves a ballast water-mediated transport of larval stages of the same species through shipping. In fact, the prolonged pelagic stage in *E. anatina* (Guidetti et al., 2012) would allow for long-distance transport of its larval forms, and the species' higher abundance in the eastern sectors of the Mediterranean basin appears to support to a greater degree this hypothesis of the shipping introduction pathway. The latter has already been postulated to explain the introduction of species of Atlantic origin to Mediterranean areas far from the western basin, as is the case with the northern brown shrimp *Penaeus aztecus* Ives, 1891 (Scannella et al., 2017) and *C. sapidus* (Kampouris et al., 2020).

The first catch of *Enchelycore anatina* in Libyan waters represents the first substantiated record of the species along the North African coast. The additional record of the species from the southern tip of the Italian mainland further confirms the expansion of *E. anatina* within the western Ionian Sea, to the north of previous published records of the species from the same region, described by Guidetti et al. (2012) and Marletta & Lombardo (2020).

The fangtooth moray is an active predator that could heavily affect native communities directly (via predator-prey interactions) and indirectly (via food web or habitat alterations) (Sala et al., 2011). As a result, continuous monitoring at strategic outposts in the Mediterranean (e.g., the Strait of Sicily, Azzurro et al., 2014) and *in situ* observations are fundamental in understanding how NIS and neonatives can modify ecosystem functioning and change native fish community structure (Katsanevakis et al., 2014).

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PRVI ZAPIS O POJAVLJANJU KAVLJEZOBE MURENE *ENCHELYCORE ANATINA*
(MURAENIDAE) IZ LIBIJSKIH VODA IN DODATNI ZAPIS ZA JUŽNO ITALIJO
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POVZETEK

V zalivu Bomba, Tobruk, vzhodna Libija, je bil v zabodne mreže na približno 20 m globine ujet primerek kavljezobe murene *Enchelycore anatina* (Lowe, 1839). Avtorji poročajo tudi o novi najdbi primerka te vrste iz južne Kalabrije v Italiji. Najdbe te vrste atlantskega izvora, ki se širi, potrjujejo prvi zapisi iz libijskih voda in z južnih obal Sredozemskega morja ter širitev areala vrste v zahodno Jonsko morje.

Ključne besede: tujerodne vrste, ekspanzivne vrste atlantskega izvora, neonativne vrste, *Enchelycore anatina*, Libija, Italija, Sredozemsko morje

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