ANNALES

Anali za istrske in mediteranske študije
Annali di Studi istriani e mediterranei
Annals for Istrian and Mediterranean Studies
Series Historia Naturalis, 34, 2024, 1

UDK 5 Annales, Ser. hist. nat., 34, 2024, 1, pp. 1-172, Koper 2024 ISSN1408-533X

UDK 5

ISSN 1408-533X
e-ISSN 2591-1783

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Series Historia Naturalis, 34, 2024, 1

KOPER 2024

Anali za istrske in mediteranske študije - Annali di Studi istriani e mediterranei - Annals for Istrian and Mediterranean Studies

ISSN 1408-533X UDK 5 Letnik 34, leto 2024, številka 1
e-ISSN 2591-1783

Tisk/*Stampa/Print:* Založništvo PADRE d.o.o.

Izdajatelja/*Editori/Published by:* Zgodovinsko društvo za južno Primorsko - Koper / *Società storica del Litorale - Capodistria*©
Inštitut IRRIS za raziskave, razvoj in strategije družbe, kulture in okolja / *Institute IRRIS for Research, Development and Strategies of Society, Culture and Environment / Istituto IRRIS di ricerca, sviluppo e strategie della società, cultura e ambiente*©

Sedež uredništva/*Sede della redazione/ Address of Editorial Board:* Nacionalni inštitut za biologijo, Morska biološka postaja Piran / *Istituto nazionale di biologia, Stazione di biologia marina di Pirano / National Institute of Biology, Marine Biology Station Piran*
SI-6330 Piran /*Pirano*, Fornače/*Fornace* 41, tel.: +386 5 671 2900, fax +386 5 671 2901;
e-mail: annales@mbss.org, *internet:* www.zdjp.si

Redakcija te številke je bila zaključena 23. 06. 2024.

Sofinancirajo/*Supporto finanziario/ Financially supported by:* Javna agencija za znanstveno-raziskovalno in inovacijsko dejavnost Republike Slovenije (ARIS)

Annales - Series Historia Naturalis izhaja dvakrat letno.

Naklada/*Tiratura/Circulation:* 300 izvodov/copie/copies

Revija Annales, Series Historia Naturalis je vključena v naslednje podatkovne baze / *La rivista Annales, series Historia Naturalis è inserita nei seguenti data base / Articles appearing in this journal are abstracted and indexed in:* BIOSIS-Zoological Record (UK); Aquatic Sciences and Fisheries Abstracts (ASFA); Elsevier B.V.: SCOPUS (NL); Directory of Open Access Journals (DOAJ).

Navodila avtorjem in vse znanstvene revije in članki so brezplačno dostopni na spletni strani https://zdjp.si/en/p/annalesshn/
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ANNALES · Ser. hist. nat. · 34 · 2024 · 1

Anali za istrske in mediteranske študije - Annali di Studi istriani e mediterranei - Annals for Istrian and Mediterranean Studies

UDK 5 Letnik 34, Koper 2024, številka 1 ISSN 1408-53 3X
e-ISSN 2591-1783

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received: 2024-01-02 DOI 10.19233/ASHN.2024.01

A REVIEW OF OCCURRENCES OF HAMMERHEAD SHARK (CARCHARHINIFORMES: SPHYRNIDAE) IN TURKISH SEAS OVER THE PAST FIVE DECADES

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ABSTRACT

The screening of data sources has revealed five evidence-based records of the smooth hammerhead shark Sphyrna zygaena *captured or sighted in Turkish Aegean and Mediterranean waters between 1977 and 2015. Three individuals were recorded in the Aegean Sea and two in the north Levantine Sea. Despite previous reports on the occurrence of* S. lewini *and* S. tudes *in Turkish waters, these two species of hammerhead shark are apparently absent from the region and may not have ever inhabited the Turkish coast at all. The occurrence data of smooth hammerhead shark for the period from 1977 to 2015 (n=5; 0.13 individuals per year) shows that* S. zygaena *is a very rare shark in Turkish waters.*

Key words: Sphyrnidae, eastern Mediterranean, historical occurrence, evidence based record

RASSEGNA DELLE PRESENZE DI PESCE MARTELLO (CARCHARHINIFORMES: SPHYRNIDAE) NEI MARI TURCHI NEGLI ULTIMI CINQUE DECENNI

SINTESI

Lo screening delle fonti di dati ha rivelato cinque segnalazioni basate su prove del pesce martello Sphyrna zygaena *catturato o avvistato nelle acque turche del Mar Egeo e del Mediterraneo tra il 1977 e il 2015. Tre individui sono stati trovati nel Mar Egeo e due nel Mar Levantino settentrionale. Nonostante le precedenti segnalazioni sulla presenza di* S. lewini e S. tudes *nelle acque turche, queste due specie di squalo martello sono apparentemente assenti dalla regione e potrebbero non aver mai abitato la costa turca. I dati di presenza dello squalo martello per il periodo dal 1977 al 2015 (n=5; 0,13 individui per anno) mostrano che* S. zygaena *è uno squalo molto raro nelle acque turche.*

Parole chiave: Sphyrnidae, Mediterraneo orientale, presenza storica, dati basati sull'evidenza

INTRODUCTION

During the 440 million years of evolutionary history, numerous species of sharks have existed, varying in life history traits, ecological preferences, behavior, size, and shape (Fowler *et al.*, 2005; Ebert *et al.*, 2021). Today, hammerheads (Carcharhiniformes: Sphyrnidae) are one of the most charismatic taxa among the 536 extant shark species (Ebert *et al.*, 2021) due to the characteristic shape of their heads, which makes them easily identifiable compared to other shark families (Gilbert, 1967; Nakaya, 1995; Ebert *et al.*, 2021). Hammerhead sharks are globally represented by two genera, *Eusphyra* and *Sphyrna,* and 11 valid species. They are found in tropical and warm seas, inhabiting shelf waters and submarine mounts from surface down to a depth of 1,043 m (Ebert *et al.*, 2021; Froese & Pauly, 2023). The Mediterranean Sea currently hosts four hammerhead sharks: *S. zygaena* (Linnaeus, 1758), *S. lewini* (Griffith & Smith, 1834), *S. mokarran* (Rüppell, 1837), and *S. tudes* (Valenciennes, 1822) (Kovacic *et al.*, 2021). However, the latter two species are probably vagrant, and further confirmation of their presence is required (Otero *et al.*, 2019; Serena *et al.*, 2020).

The occurrence of hammerhead sharks in the Mediterranean Sea is mentioned both in general ichthyological inventories (e.g., Bellon, 1553; Risso, 1810; Fischer *et al.*, 1987; Papakonstantinou, 1988; Golani *et al.*, 2006; Bariche, 2012), and shark-specific studies (e.g., Tortonese, 1956; Capapé, 1989; Lipej *et al.*, 2004; Celona & De Maddalena, 2005; Damalas & Megalofonou, 2012; Sperone *et al.*, 2012; Kabasakal, 2020; Barone *et al.*, 2022). Although the presence of the hammerhead shark along the Turkish coastline is historically known (see Belon, 1553), no relevant information about the species was provided in the pioneering ichthyological inventories published in the early decades of the 20th century (Ninni, 1923; Deveciyan, 1926). *S. zygaena* was first mentioned by Nalbandoğlu (1952), who sought to compile the common names of marine fish inhabiting Turkish seas; the second revised version of his study added *S. tudes* to the list (Nalbandoğlu, 1954). While the first ever published identification key to Turkish marine fish (Akşıray, 1954) already included these two species and their drawings, a third hammerhead species, *S. lewini,* was added in the publication's updated version (Akşıray, 1987). Unfortunately, none of these studies were supported by any solid proof of the species' presence that would include photographs, morphological examination of a captured individual, data on sampling locality and date, or, most conclusively, preserved specimens in local collections or museums. Current local ichthyological checklists only tend to keep *S. zygaena* as part of Turkish fauna (e.g., Mater & Meriç, 1996; Bilecenoğlu *et al.*, 2014; Kabasakal, 2020), and disregard previous records of its congenerics. In the present article, authors review the current status of hammerhead sharks in the seas of Turkey following an evidence-based approach and present a previously unpublished record of *S. zygaena* captured in Adrasan, Antalya Bay.

MATERIAL AND METHODS

The presented data on historical, previous, and contemporary records of *Sphyrna* spp. in Turkish waters were collected from: (a) ichthyological inventories of Turkish marine fishes; (b) peer-reviewed scientific articles and books on sharks in Turkish waters; and (c) news reports on the captures of hammerhead sharks published in printed, digital, and social media. In the case of news reports (data source c), the main source was verified through interviews with the owners of the respective social media post or news report via direct messaging in order to avoid duplication of records. Whenever possible the following basic data were gathered for each record: total length (TL), total weight (TW), sex, date and locality of capture, and type of fishing gear. Due to the fishery-dependent nature of opportunistic research (Jessup, 2003), the data on TL and TW of some specimens were necessarily based on information provided by the fishermen or extracted through data mining in the fishing logs or on social media. Species identification of the specimens captured in photographs was performed in accordance with guidelines by Ebert and Stehmann, (2013), Ebert *et al.* (2021), and Barone *et al.* (2022). Confirmed records of *S. zygaena* in Turkish waters follow evidence-based criteria provided by Kovačić *et al.* (2020).

RESULTS AND DISCUSSION

Sphyrna zygaena (Linnaeus, 1758)

Description of the specimens depicted in the photographs: anterior margin of head arched without median indentation in any stage of life (Fig. 1a–c); mouth broadly arched, anterior teeth oblique and blade-like with slightly serrated edges (Fig. 1a); posterior margin of first dorsal fin moderately falcate, free rear tip of first dorsal fin well anterior of origin of pelvic fin base; posterior margin of pelvic fin straight and non-falcate; posterior margin of anal fin deeply notched (Fig. 1b,c). Since the photograph of specimen no. 5 was taken in blue water as the shark was maneuvering, the smaller second dorsal fin bent to the side of the body and was briefly obscured by the shade of dorsal coloration (Fig. 1c). The hammerhead sharks depicted in the photographs are in agreement with descriptions of *S. zygaena* by Ebert and Stehmann (2013), Ebert *et al.* (2021), and Barone *et al.* (2022).

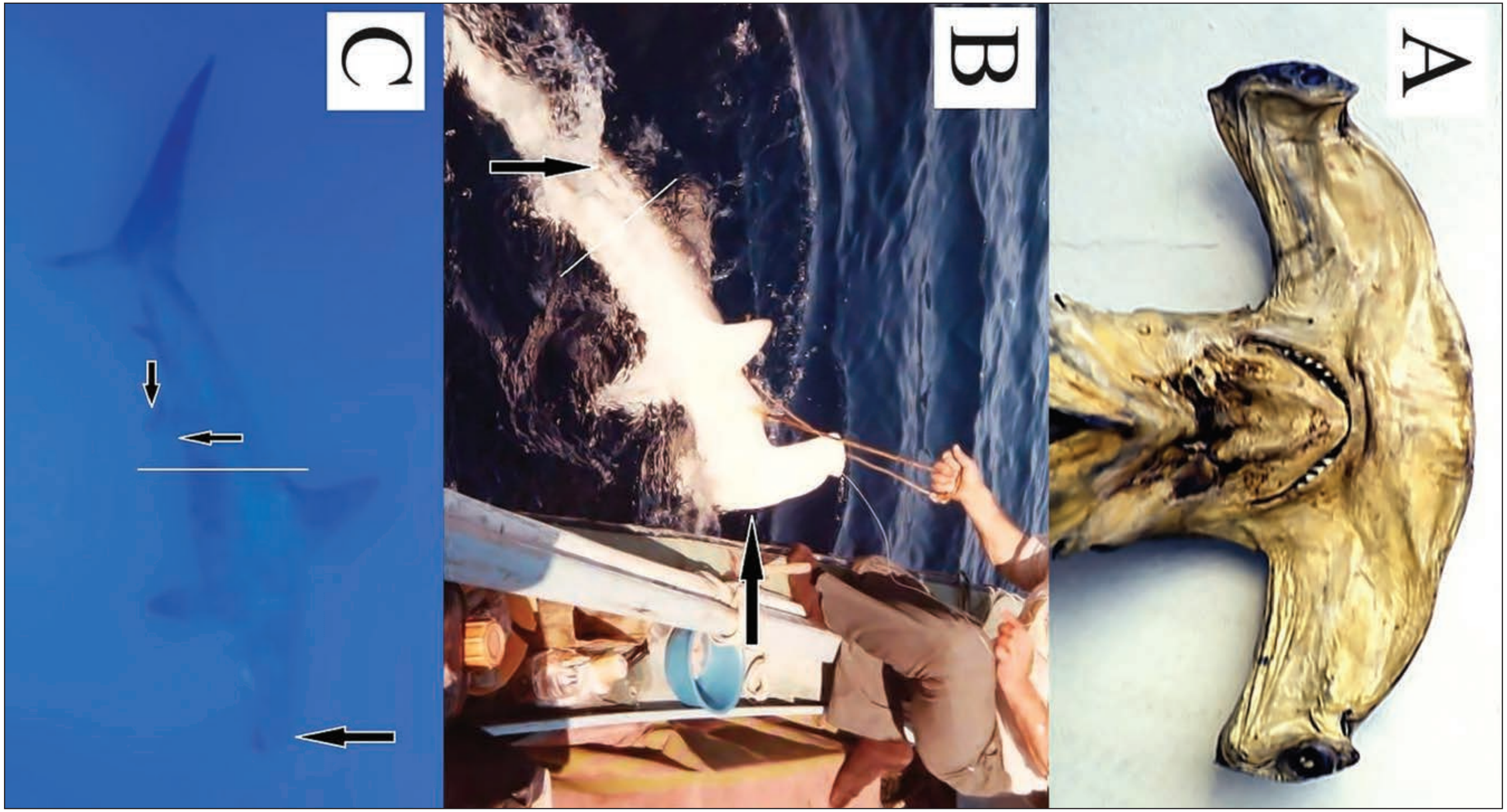

Fig. 1: Specimens of** Sphyrna zygaena **captured in Turkish waters. (A) a smooth hammerhead shark (sp. 1) captured off the northern coast of Gökçeada Island in 1977 (photo: Hakan Kabasakal); (B) a smooth hammerhead shark (sp. 2) captured off Adrasan in 1985, with ↑ pointing at the origin of the pelvic fin base, / demarcating the free rear tip from the first dorsal fin, and ← indicating the smooth margin of the cephalofoil at midpoint (photo: Oben Orhan); and (C) a smooth hammerhead shark (sp. 5) sighted off Kaş in 2015, with / designating the non-falcate posterior margin of the pelvic fin, ↓ pointing at the origin of the pelvic fin, / demarcating the free rear tip from the first dorsal fin, and the larger ↓ indicating the smooth margin of the cephalofoil at midpoint (photo: personal archive of Hakan Kabasakal).

Sl. 1: Primerki navadne kladvenice, ujeti v turških vodah. (A) kladvenica (primerek 1), ujeta ob severni obali otoka Gökçeada leta 1977 (Foto: Hakan Kabasakal); (B) kladvenica (primerek 2) ujeta pri Adrasanu leta 1985, ↑ označuje sprednji rob trebušne plavuti, bela črta / označuje prosto konico prve hrbtne plavuti, in ← kaže gladki rob bočnih razširitev glave (cefalopfoil) na sredini (foto: Oben Orhan); in (C) kladvenica (primerek 5), opažena pri Kaşu leta 2015, kjer / označuje nesrpasti zadnji rob trebušne plavuti, ↓ kaže na bazo trebušne plavuti, / označuje prosto konico prve hrbtne plavuti, in večja ↓ kaže gladek rob cefalofoila na sredinski točki (foto: osebni arhiv Hakana Kabasakala).

Tab. 1: Summary of evidence-based occurrences of* Sphyrna zygaena *(Linnaeus, 1758) along the Turkish coast in chronological order. N/A: Not available. The specimen numbers correspond to those in Figure 2.
Tab. 1: Povzetek na dokazih temelječih primerov pojavljanja vrste* Sphyrna zygaena *(Linnaeus, 1758) vzdolž turške obale v kronološkem zaporedju. N/A: ni podatka. Številke primerkov ustrezajo tistim na Sliki 2.

No	Year	Location	Size (cm)	Sex	Depth	Evidence type [Kovačić *et al.* (2020)]	Remarks	Reference
1	1977	Gökçeada, Northern Aegean Sea	240	F	N/A	Collection: verified presence (Fig. 1A)	Captured by means of trammel net deployed in coastal water. Body parts of the specimen are preserved in Gökçeada Marine Museum of İstanbul University (catalogue no. PSC20170513-27)	Ulutürk (1987); Gönülal & Güreşen (2017)
2	1985	Adrasan, northern Levantine Sea	ca. 200 cm	N/A	N/A	Publication: evidence from photo (Fig. 1B)	Captured by means of pelagic long-line. Visual evidence of this record, which was uploaded to facebook page by Mr. Oben Orhan, is available at the following link: https://www.facebook.com/groups/sharksinTurkey/permalink/1058239638125238/?mibextid=Nif5oz	Unpublished record
3	1995	Marmaris, southeastern Aegean Sea	N/A	N/A	N/A	Publication: expert providing individual collecting data	Captured by means of unknown type of set-net	Kabasakal (2002)
4	1998	Gökçeada, North Aegean Sea	221	F	70	Publication: expert providing individual collecting data	Captured by means of trammel net	Kabasakal & Kabasakal (2004)
5	2015	Kaş, western sector of eastern Mediterranean Sea	ca. 250	N/A	N/A	Publication: evidence from photo (Fig. 1C)	Sighted during scuba diving. Photographic evidence is available.	Kabasakal *et al.* (2017)

The screening of available references and non-conventional data sources revealed five records of *S. zygaena* captured or sighted in Turkish Aegean and Mediterranean waters between 1977 and 2015 (Tab. 1). Three of the smooth hammerhead sharks were recorded in the Aegean Sea and two in the northern Levantine Sea (Fig. 2). In 1977, a female smooth hammerhead shark measuring 240 cm TL was captured in the trammel net fishery off Gökçeada Island (northern Aegean Sea). Its taxidermied head, anterior torso, and pectoral fins are currently on display (catalogue no. PSC20170513-27) at the Gökçeada Marine Museum of Istanbul University (Fig. 1a), representing the single specimen ever captured in Turkey. Furtherly, in 1985, a smooth hammerhead shark measuring 200 cm TL was incidentally captured in pelagic longlining off Adrasan coast (Antalya Bay, northern Levantine Sea), but the occurrence was not recorded at the time. The photograph of this specimen has recently been made available online, on Facebook (Köpekbalıkları Türkiye / Sharks and Rays in Turkey; link provided in Table 1, sp. 2; Fig. 1b). In 1995, a smooth hammerhead shark was captured in the entangling-net fishery off the coast of Marmaris (southeastern Aegean Sea) and followed by an incidental capture of a female specimen of 221 cm TL in a trammel net fishery off the southwestern coast of Gökçeada Island in 1998 (sp. 3 and 4, respectively; Table 1). Finally, in 2015, a smooth hammerhead shark with an estimated 250 cm TL (Fig. 1c) was sighted and photographed during scuba diving in the waters around Kaş (Antalya Bay, northern Levantine Sea).

Despite the contemporary rarity of *S. zygaena* in the Mediterranean Sea, several historical anecdotes suggest that it might have once been common throughout the region. One of the earliest anecdotal records of the Mediterranean hammerhead shark can be found in the ancient epic titled *Halieutica* (2nd century AD), in which the poet Oppianus the Cilician writes of the fear of sharks shared among Mediterranean mariners and divers in a story that portrays *S. zygaena* (referred to as *Zygaena malleus*, Valenciennes 1822) as a large and fearsome shark patrolling the Strait of Messina (Oppianus, 1928; p. 463). In another historical account by the 16th century naturalist Pierre Bellon, which constitutes the earliest mention of the hammerhead shark in Turkish waters, *S. zygaena* is mentioned as a dangerous species with a distribution range in the

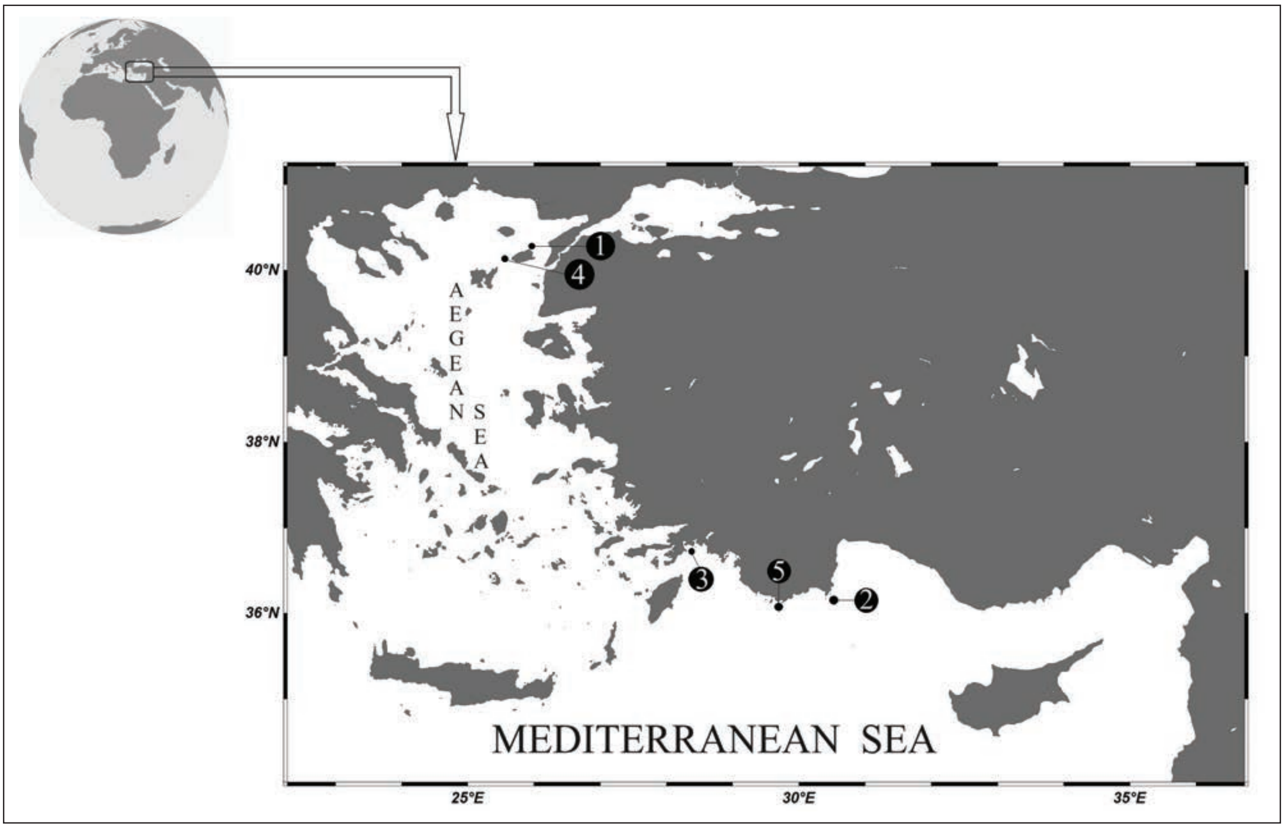

Fig. 2: Locations of capture (sp. 1–4) or sighting (sp. 5) of** Spyhrna zygaena **in Turkish waters. The specimen numbers correspond to those in Table 1.

Sl. 2: Lokalitete ulova (primerki 1–4) ali opazovanj (primerek 5) vrste** Spyhrna zygaena **v turških vodah. Številke primerkov ustrezajo tistim v Tabeli 1.

Mediterranean Sea extending as far as Smyrna (now Izmir, eastern Aegean Sea) (Belon, 1553; p.61). The existing occurrence records of the hammerhead shark were compiled by Carus (1893). They include almost 30 locations for *S. zygaena*, ranging from the Balearic Islands in the west to Naxos Island (southern Aegean Sea) in the east, and 8 locations for *S. tudes*, extending from the Gibraltar Strait to the Adriatic Sea. Until the early 20th century, information from the eastern Levant was scarce, with the most detailed account provided by Gruvel (1931), who indicated that *S. zygaena* is still quite common in the region, can be found in nearly all fish markets, and is generally consumed by the poor.

Interviews conducted by the authors with local fishermen over the last three decades have revealed that in the period from the 1970s to the 1990s, the captured smooth hammerhead sharks were either discarded or sold immediately, without the opportunity to take photographs or perform further examination of them. This is not uncommon, but lack of concrete evidence prevents us from including these observations in the literature as valid. Examples are available from Bodrum, southern Aegean Sea, where a hammerhead shark was captured and immediately released during the early 1980s, with a few people witnessing the incident (Aşkın Cambazoğlu, pers. comm., 1998), and from Alanya (Antalya Bay, northern Levant), where the species is reported to have made rare appearances in longline fishery during the 1970s and 1980s (Mehmet Mısırlıoğlu, pers. comm., 1993).

Inventories compiled in shark-specific studies that were carried out in the Mediterranean Sea over the past two decades demonstrate that *S. zygaena* still exists in the region (Kabasakal, 2002; Lipej *et al.*, 2004; Celona & De Maddalena, 2005; Golani *et al.*, 2006; Storai *et al.*, 2006; Bariche, 2012; Damalas & Megalofonou, 2012; Sperone *et al.*, 2012; Kabasakal *et al.*, 2017; Mancusi *et al.*, 2020; Giovos *et al.*, 2021; Barone *et al.*, 2022). To date, *S. zygaena* has not been reported in the Sea of Marmara (Eryılmaz & Meriç, 2005; Kabasakal, 2020, 2022), while the single record of the smooth hammerhead shark from the Romanian coast of the Black Sea dating from the 19th century (Vasil'eva, 2007; Kvach & Kutsokon, 2017) is questionable and would require confirmation (Serena *et al.*, 2020).

Historical changes in the abundance of large predatory sharks have been investigated along the northwestern Mediterranean coasts, where the hammerhead shark has recorded the most significant decline, by almost 100 percent compared to its former abundance (Ferretti *et al.*, 2008). This is in agreement with results obtained from the central Mediterranean Sea, particularly the Sicilian waters, where populations of *S. zygaena* have declined by 96 to 98 percent (Celona & De Maddalena, 2005). During an extensive survey investigating the occurrences of large elasmobranch species in pelagic longline fishery in southeastern Mediterranean Sea between 1998 and 2005, no specimen of *S. zygaena* was captured or observed (Damalas & Magalofonou, 2012), which supports the statements of Bariche (2012) and Kabasakal *et al.* (2017) that the species is either occasional or very rare in the area. In the Mediterranean Large Elasmobranchs Monitoring (MEDLEM) database, which contains more than 3,000 records of over 4,000 specimens, gathered from 1666 to 2017, *S. zygaena* is evaluated as rare (Mancusi *et al.*, 2020). In a second MEDLEM evaluation, no additional record of *S. zygaena* was reported for the period between 2017 and 2022 (Gallo *et al.*, 2022). Despite a remarkable case of population recovery for this shark on the Ionian side of Calabria (Sperone *et al.*, 2012), the smooth hammerhead shark population has severely declined during the last century, thus becoming a critically endangered species in the Mediterranean Sea (Otero *et al.*, 2019).

Sphyrna lewini (Griffith & Smith, 1834) and *S. tudes* (Valenciennes, 1822)

The presence of *S. lewini* in the Mediterranean Sea was first mentioned by Tortonese (1956), based on a single specimen captured in an unknown locality and preserved in the British Museum, but the topic of its occurrence has long been a matter of dispute. According to Compagno (1984) and Ebert *et al.* (2021), *S. lewini* is a questionable species in the Mediterranean shark fauna; Quero (1984) and Fischer *et al.* (1987), on the other hand, still mention the distribution of the scalloped hammerhead shark in the western basin. While Barone *et al.* (2022) consider *S. lewini* to be a rare shark in the Mediterranean Sea, the recent MEDLEM report (Gallo *et al.*, 2022) does not mention it at all. The species is not included in the inventory of fish fauna of the eastern Mediterranean by Golani (1996) and Golani *et al.* (2006), but there are two recent studies (Bariche, 2012; Serena *et al.*, 2020) that list the species as occurring in the region, although without providing any references or evidence. The most recent observation of *S. lewini* was made in June 2009 along the southern Italian coast (Leonetti *et al.*, 2020), which stands to be the easternmost record of the species.

In the Mediterranean Sea, *S. tudes* was first recorded off the coast of Nice, in the western basin (Risso, 1810), and subsequently in the Patraikos Gulf, in the Ionian Sea (Hoffman & Jordan, 1892). According to Carus (1893), the smalleye hammerhead shark is an extremely rare shark only occurring in the western and central Mediterranean Sea; its rarity in the region was later also emphasized by Tortonese (1956), Quero (1984), and Fischer *et al.* (1987). However, contrary to the above references, Compagno (1984) and Ebert *et al.* (2021) stated that *S. tudes* is not present in the Mediterranean Sea and that its distribution is confined to the western Atlantic, from the coast of Venezuela southward to the Brazilian coast. According to Serena *et al.* (2020) *S. tudes* is a vagrant species only occurring in the western Mediterranean Sea, but its contemporary occurrence in the region requires confirmation (Barone *et al.,* 2022). During the second MEDLEM evaluation covering the 2017–2022 period, no specimens of *S. tudes* were recorded in the Mediterranean Sea (Gallo *et al.*, 2022). Collareta and Farina (2023) have recently argued that the occurrence of *S. tudes* in the region is supported by two historical specimens captured in Nice (southeastern France) and Leghorn (northern Tyrrhenian coast of central-northern Italy), and further suggested that a population of smalleye hammerheads inhabited the Mediterranean at least as recently as the early 19th century. However, according to Serena (2005), who also confirmed the validity of Tortonese's specimen (observed in 1951), it had been purchased at the fish market. For this reason, it is not possible to establish with absolute certainty that the individual was captured in Mediterranean waters, much less that there was an entire population present in the region in the past. Therefore, contrary to Collareta and Farina's (2023) conclusion, *S. tudes* remains a doubtful inhabitant of the Mediterranean and further investigations are required to confirm its presence.

Since the earliest records of *S. tudes* (Nalbandoğlu, 1954; Akşıray, 1954; Akyüz, 1957; Akşıray, 1987) and *S. lewini* (Akşıray, 1987) from Turkish waters were presented without essential taxonomic data and specimens available for inspection, there is currently not enough evidence to support their occurrence in the region. Only the presence of *S. zygaena* can be confirmed, as it is corroborated by data from general ichthyological and shark-specific checklists published since the 1990s (Mater & Meriç, 1996; Kabasakal, 2002, 2020; Bilecenoğlu *et al.*, 2014). Applying the evidence-based record criteria established by Kovačić *et al.* (2020), it can be confirmed that five smooth hammerhead sharks were captured in Turkish Aegean and Levantine waters between 1977 and 2015, with the frequency of occurrence of 0.13 individuals/year indicating that *S. zygaena* is a very rare shark species in Turkish waters. *S. zygaena* is a critically endangered and thus protected shark species in the Mediterranean Sea (List of endangered or threatened species – Annex II to the SPA/BD Protocol of the Barcelona Convention, Recommendations GFCM/42/2018/2 and GFCM/44/2021/16) (Barone *et al.*, 2022). Since the smooth hammerhead shark is considered a species requiring regular monitoring and data collection following the relevant annexes to the SPA/BD Protocol (Barone *et al.*, 2022), it is necessary to monitor its occurrence as bycatch in commercial fisheries or its possible landings in order to regularly update the contemporary status of this species in the seas of Turkey. A comprehensive study based on local ecological and/or fishers' knowledge could provide additional information on hammerhead shark occurrences in the region.

ACKNOWLEDGMENTS

Authors thank to commercial fisherman Mr. Oben Orhan from Fethiye (southwestern Türkiye, Aegean seaboard), for generously sharing the photograph and relevant information of the smooth hammerhead shark (specimen no 2 in Table 1; Fig. 1b), and his voluntary and protective actions supporting our efforts for the conservation of rare and endangered chondrichthyans in the seas of Türkiye. Special thanks go to two anonymous reviewers for their valuable comments, which improved the content and quality of the article.

PREGLED POJAVLJANJA KLADVENIC (CARCHARHINIFORMES: SPHYRNIDAE) V TURŠKIH MORJIH V ZADNJIH PETIH DESETLETJIH

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POVZETEK

Na podlagi preverjanja podatkovnih virov sta avtorja razkrila pet primerov pojavljanja navadne kladvenice Sphyrna zygaena*, ujetih ali opaženih v turških vodah Egejskega morja in Sredozemskega morja med leti 1977 in 2015. Tri primerki so bili zabeleženi v Egejskem morju in dva v severnem Levantskem morju. Kljub predhodnim zapisom o pojavljanju vrst* S. lewini *in* S. tudes *v turških vodah, omenjeni vrsti očitno nista prisotni na tem območju in verjetno tudi nista nikoli naseljevali turška morja. Podatki o pojavljanju navadne kladvenice v obdobju od 1977 do 2015 (n=5; 0,13 osebkov na leto) kažejo, da je* S. zygaena *zelo redek morski pes v turških vodah.*

Ključne besede: Sphyrnidae, vzhodno Sredozemsko morje, zgodovinsko pojavljanje, na dokazih temelječi zapisi

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received: 2024-04-19 DOI 10.19233/ASHN.2024.02

ADDITIONAL HISTORICAL RECORDS OF THE GREAT WHITE SHARK, *CARCHARODON CARCHARIAS* (LAMNIFORMES: LAMNIDAE) IN THE EASTERN ADRIATIC: UPDATING REGIONAL OCCURRENCE OF A CRITICALLY ENDANGERED SHARK

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ABSTRACT

This paper presents additional historical records of Carcharodon carcharias *in the eastern Adriatic and provides an updated list of the species' occurrence in this area from 1868 onwards. Since the publication of the last list in 2002, 10 new records have been added based on newly available information. Out of these, 8 records date back to the 19th and 20th centuries, while the remaining 2 are from the 21st century.*

Key words: *Carcharodon carcharias*, great white shark, occurrence, Adriatic Sea

ULTERIORI SEGNALAZIONI STORICHE DEL GRANDE SQUALO BIANCO, *CARCHARODON CARCHARIAS* (LAMNIFORMES: LAMNIDAE) NELL'ADRIATICO ORIENTALE: AGGIORNAMENTO DELLA PRESENZA REGIONALE DI UNO SQUALO A RISCHIO CRITICO DI ESTINZIONE

SINTESI

Il presente lavoro fornisce ulteriori dati storici di Carcharodon carcharias *nell'Adriatico orientale e un elenco aggiornato della presenza della specie in quest'area dal 1868 in poi. Dalla pubblicazione dell'ultimo elenco nel 2002 sono state aggiunte 10 nuove segnalazioni basate su nuove informazioni disponibili. Di queste, 8 risalgono al XIX e XX secolo, mentre le restanti due sono del XXI secolo.*

Parole chiave: *Carcharodon carcharias*, grande squalo bianco, presenza, Adriatico

INTRODUCTION

The great white shark, *Carcharodon carcharias* (Linnaeus, 1758), is a cosmopolitan species that inhabits various marine environments, ranging from shallow coastal waters, including bays and estuaries, to far offshore areas, including remote oceanic islands. It is found at depths of up to 1,300 m (Compagno, 2001; Ebert & Dando, 2021). *C. carcharias* is one of the fish species with the widest habitat and geographic ranges, tolerating temperatures from 5 to 25°C and able to undertake long-distance seasonal migrations across oceans (Compagno, 2001; Ebert & Dando, 2021). It has a long historical track record in the Adriatic Sea, particularly in its eastern part. This is not surprising, considering that the white shark, as the world's largest carnivorous fish with a nearly global distribution and dramatic interactions with humans, has always appeared as a charismatic species, attracting significant public attention (Huveneers *et al*., 2018). But despite its high media presence, this apex predator is still considered elusive in the Mediterranean, and in the Adriatic, due to its low population density and absence of conventional aggregation sites. Such a situation is highly challenging for any comprehensive study. Although electronic tagging is commonly used in monitoring studies in other parts of the world, it has not been successful in the Mediterranean Sea, despite attempts being made (Soldo & Peirce, 2005). Most of the knowledge about the species is therefore derived from occurrence records published for the various regions of the Mediterranean Sea (e.g., Bradai & Saidi, 2004; Storai *et al*., 2005; Kabasakal *et al*., 2022). The problem with these records is that they provide limited information, which allows for various opinions on different patterns related to the biology and ecology of the species. Furthermore, the origin, and therefore credibility, of many records is questionable. Numerous regional records are opportunistic, being collected and reported without using a consistent field method, as well as without specific knowledge of the situation and various factors potentially impacting the validity of the data in a particular region. For example, Soldo & Jardas (2002a, 2002b) reported a total of 61 records of the white shark in the eastern Adriatic from 1868 to 2000, but did not include Fergusson's records (1996) related to several alleged sightings of a white shark in 1993 near Šibenik and the Lošinj area. In fact, Soldo & Jardas (2002a, 2002b) thoroughly investigated these records and, after tracing the original information, discovered that they were based on fake news. As a result, they excluded them from their list. However, since those records had already been published, some authors (De Maddalena & Heim, 2012; Boldrocchi *et al*., 2017; Moro *et al*., 2020) ignored Soldo & Jardas's findings (2002a, 2002b) and continued to cite Fergusson (1996), thus perpetuating the error and inevitably compromising the validity of their conclusions, as they were based on inaccurate data.

Soldo & Jardas (2002a, 2002b) were the first in the Mediterranean region to associate the presence of the great white shark in the coastal waters of the eastern Adriatic Sea with a high abundance of Atlantic bluefin tuna *Thunnus thynnus* (Linnaeus, 1758), which was suggested as the shark's major prey. With the introduction of intensive tuna fishing in the open waters of the Adriatic Sea, and especially during the 1970s, the tuna disappeared from the coastal waters of the eastern Adriatic and, as a result, the great white shark was no longer recorded in the last decades of the 20th century. Soldo & Jardas (2002a, 2002b) then predicted that future records of the great white shark in the Adriatic Sea would be linked to new migratory routes and areas with high tuna populations. This was later supported by a record of a 5.70 m long female shark caught in a tuna purse-seine 15 Nm southwest of the island of Jabuka (Soldo & Dulčić, 2005).

Great white sharks recorded in the Adriatic are considered to be part of the Mediterranean population, which is classified as critically endangered on the IUCN Red List of Threatened Species (Soldo *et al*., 2016). A recent assessment has found the species to be critically endangered in the Adriatic Sea as well, prompting the introduction of several protective regulations, the most important being the designation of the strictly protected species status in Croatia (Soldo & Lipej, 2022).

Taking into account the critically endangered status of the species, it is important to understand the changes in its abundance and distribution and prioritize the conservation efforts accordingly. Any information on the occurrence of this species in the Adriatic is valuable. This paper aims to present additional historical records of *C. carcharias* in the eastern Adriatic and thus update the list of its occurrences in this area since 1868.

MATERIAL AND METHODS

The new database of occurrences of the great white shark in the eastern Adriatic is based on the most comprehensive list published by Soldo & Jardas (2002a, 2002b), which includes records from 1868 until the end of the 20th century. Further investigation involved extensive bibliographic research of other currently available "grey literature", such as historical editions of various newspapers and personal reports written in different languages, e.g., Croatian, German (Austrian), Hungarian, Italian, and Albanian. For each observation, we followed Soldo & Jardas (2002a, 2002b) and recorded: date and location; total length; weight; sex; and type of record (capture, sighting, stomach content, fishing gear used).

The identification of the specimens was based on the most distinctive characteristics of the great white shark, which clearly set *C. carcharias* apart from other sharks and facilitate accurate species determination. One of the basic traits we focused on was the length

Tab. 1: The records of the great white shark, *Carcharodon carcharias**, **in the Eastern Adriatic since 1868.***
Tab. 1: Zapisi o pojavljanju belega morskega volka (*Carcharodon carcharias****) v vzhodnem Jadranu od leta 1868.***

NO.	DATE	LOCATION	TL (cm)	WEIGHT (kg)	SEX	REMARKS
1	01.09.1868	Trieste	-	-	-	attack with fatal injury
2	14.09.1868	Jablanac	-	-	-	-
3	16.12.1868	Sv. Juraj	460	-	-	-
4	16.04.1872	Rijeka	490	-	-	man's head and leg and dolphin in stomach
5	19.04.1872	Trieste	300	-	-	-
6	12.05.1872	Opuzen	95	-	-	-
7	12.05.1872	Mljet	237	-	-	-
8	08.06.1872	Rijeka	131	-	-	-
9	16.06.1872	Dugi Otok	146	-	-	-
10	25.07.1872	Cavtat	260	-	-	-
11	08.08.1872	Rab	130	-	-	-
12	05.05.1877	Cres	460	-	-	-
13	08.05.1877	Cres	413	-	-	-
14	17.06.1878	Osor-Cres	371	-	-	-
15	09.08.1878	Poreč	-	-	-	-
16	21.05.1879	Osor	382	-	-	-
17	23.07.1879	Split	402	-	-	-
18	21.09.1879	Cres	530	-	-	-
19	05.10.1879	Gradac	250	-	-	-
20	22.04.1881	Rab	380	-	-	-
21	16.10.1881	Rab	405	-	-	-
22	13.04.1882	Cres	529	-	-	-
23	13.06.1883	Vrboska-Krk	300	-	-	-
24	26.09.1883	Rab	396	-	-	-
25	14.09.1885	Trieste	400	-	-	-
26	03.03.1886	Korčula	560	-	-	-
27	02.09.1887	Krk	470	-	-	-
28	July 1888	Sv. Juraj	470	-	-	woman's body and lamb in stomach
29	23.10. 1888	Sušak	500	3500	female	caught during tuna fishing, in stomach 7 unborn sharks and human remains
30	26.08. 1890	Senj	4,40 m	-	-	-
31	15.09.1890	Bakarac	3,84			
32	26.04.1891	Pag	-	-	-	preserved at Nat. Hist. Mus. Zagreb
33	September 1892	Bakarac	450	-	-	-
34	19.02.1893	Zlarin	165	-	male	-
35	29.08.1894	Bakar	-	-	-	preserved at Nat. Hist. Mus. Rijeka
36	15.07.1901	Dubrovnik	520	-	-	-
37	1901	Eastern Adriatic	500	-	-	-
38	1902	Trieste	375	-	male	-
39	30.09.1903	Povile	450	-	-	-
40	29.06.1906	Bakarac	522	-	female	-
41	June 1908	Trieste	-	1400	-	-
42	October 1909	Kraljevica	550	-	-	-
43	02.02.1920	Dugi Otok-Kornati	525	1300	-	dolphin in stomach
44	March 1926	Ugljan	500	700	-	noticed and the second shark
45	June 1926	Herceg Novi	300	-	-	woman's shoes, laundry in the stomach
46	August 1926	Lumbarda	400	500	-	human remains in the stomach
47	Summer 1926	Kraljevica	600	1000	-	several inedible objects in the stomach
48	October 1926	Lumbarda	600	1800	-	caught in gillnet
49	1931	Rogoznica	150	-	female	-
50	1934	Kraljevica	775	1100	-	caught in tuna gillnet
51	21.08.1934	Kraljevica	-	-	-	fatal attack
52	September 1934	Mošćenička Draga	600	1000	-	caught
53	20.07.1935	Lukovo	600	2500	-	caught in tuna gillnet
54	Summer of 1946	Bakarac	-	-	-	a pig of 10 kg in the stomach
55	May 1947	Eastern Adriatic	300	300	-	-
56	August 1950	Primošten	700-800	-	-	encounter during the eating of a dead calf
57	02.10.1954	Pag	550	1500	-	attack on boat
58	August 1955	Budva	-	-	-	fatal attack
59	1956	Krk	400	-	-	-
60	24.09. 1961	Opatija	-	-	-	fatal attack
61	22.10. 1963	Izola	600	1100	-	dolphin of 200 kg in the stomach
62	15.04.1964	Qeparo-Borsh, Himare,	445	>550	female	Caught in trammel net, the stomach empty
63	1968	Rava	-	-	-	-
64	1969	Central Adriatic	-	-	-	-
65	1971	Opatija	-	-	-	fatal attack
66	17.08.1972	Kornati	600	-	-	-
67	26.07.1973	Luka Šipanska	-	-	-	-
68	10.08.1974	Lokva Rogoznica	-	-	-	fatal attack
69	17.6.1976	Vrsi near Nin	-	-	-	killed by locals
70	25.06.2003	15 SI of island of Jabuka	570	2000-2500	female	caught during tuna purse seining
71	06.10.2008	Smokova Bay, island of Vis	cca. 450	-	-	non-fatal attack on speardiver

Fig. 1: Distribution of great white shark records in the eastern Adriatic. Red circles indicate previously published records, red triangles indicate new historical records dating from the 19th and 20th centuries, and red stars mark the locations of 21st century records.
Sl. 1: Razširjenost belega morskega volka na podlagi zapisov o pojavljanju v vzhodnem Jadranu. Rdeči krogci označujejo predhodno objavljene zapise o pojavljanju, rdeči trikotniki označujejo nove historične zapise o pojavljanju iz 19. in 20. stoletja, in rdeče zvezdice označujejo lokalitete, ki se nanašajo na zapise in 21. stoletja.

of the captured specimen, reported and/or visible from the available photo. Other indicative characteristics included the visible heavy spindle-shaped body and moderately long conical snout, as well as the broadly triangular and serrated teeth, an unmistakable feature of this species (Compagno, 2001; Ebert & Dando, 2021).

Only records in which these characteristics were reported and/or unquestionably visible were considered valid; reports in which the species of the specimen was not immediately determinable and could not be irrefutably verified were not listed, as the potential issues arising from reporting uncertain data were deemed more significant than any value gained from their inclusion.

RESULTS AND DISCUSSION

Since 1868, a total of 71 records of the great white shark have been reported for the eastern Adriatic (Tab. 1). The new list presented herein contains 10 additional records (Fig. 1) compared to the one previously published by Soldo & Jardas (2002a, 2002b), along with some newly available information that rectifies previous presumed data. This information, related to records no. 47 and 51 also cited by Soldo and Jardas (2002a, 200b), changes the previously reported date of catch from 1927 to 1926 in record no. 47, and further specifies the location of record no. 51, from 'nearby Sušak' to 'Kraljevica'. The correction to record no. 47 is based on an article published on 2 September 1926 in Austrian newspapers (Fig. 2), which described an event so similar to the one reported for 1927 that it was inferred to be the same, thereby suggesting that the catch likely occurred during the summer of 1926.

The first additional record (no. 29) is based on a newspaper article published on 23 October 1888, announcing the display of a 5-meter-long carcass weighing

Fig. 2: Photo of record no. 47.
Sl. 2: Fotografija v zvezi z zapisom št. 47.

3.5 tons, along with the price of the ticket. The article mentions that the shark was caught near Rijeka during tuna fishing and was killed by fishermen after getting entangled in a purse-seine. Further on, three rows of large triangular and serrated teeth are mentioned, along with other distinguishing and described characteristics (although the weight is probably overestimated). These point to the great white shark, one that was likely caught just a few days before the publishing date.

There are also 33 historical records dating to the last decades of the 19th and the beginning of the 20th century, more specifically to the period from 1872 to 1909, which have been reported by Klinger (2011). Some of these were previously cited by Soldo & Jardas (2002a, 2002b), and many are associated with tuna fishery, reporting sharks that were either caught during fishing or found entangled in tuna seines. It should be noted that Klinger himself (2011) questioned the homogeneity of the data and concluded that many of the records are likely unreliable, as a large number of them were essentially based on reports by Professor Giovanni (János) Matisz and not verified against any other source. Hence, the authors of this paper, reluctant to indiscriminately include all additional unsubstantiated records, decided to only include those which, along with the reported length, contained other information that could be attributed to the great white shark, such as the description of large triangular teeth (records no. 30, 31, and 39). Also, the records were reported for the larger area of Kvarner Bay, which has already been identified as a historical hotspot for the great white shark in the last decades of the 19th century and for the greater part of the 20th century. As explained, this was associated with intensive tuna fishing conducted in coastal areas at the time (Soldo & Jardas, 2002a, 2002b). There are several other available photos showing landed great white sharks, presumably from the wider area of Kvarner Bay and allegedly dating from the first half of the 20th century, but since they lack other corroborating information, these records were not included in the list either.

The record with most information is no. 62, which pertains to the great white shark caught on 15 April 1964, close to the coast of Qeparo-Borsh in Albania. It is based on morphological and biometric measurements performed by a researcher, Panajot Jorgji, who published that information in his personal report in the Albanian language. According to his data, the shark got entangled in a trammel net with a mesh size of 28 mm, at a depth of 5–6 m. At that time, this species of shark was highly uncommon on the Albanian coast and even more conspicuous for its dimensions. Panajot Jorgji measured its total length at 4.45 m and estimated a weight exceeding 550 kg. He also included a description of the shark, noting that its body was relatively slim along the main axes. The mouth was large, located on the underside of the head, 45 cm long and with a perimeter of 65 cm (bottom jaw). The snout length was 1.4 times larger than the mouth and 2.3 times larger than the mouth perimeter. The dorsal fin was triangular, measuring 0.5 m in height and 0.44 m in width at the base, which means that the base width was 1.1 times smaller than the height. Furthermore, Jorgji reported that the pectoral fins, located in the first third of the shark's body, were triangular in shape, with their base dimension 2.5 times smaller than the height of the triangle. The pelvic fins were located in the middle of the body, triangularly shaped and with the height 1.3 times larger than the triangle

Tab. 2: Measurement of the great white shark caught on 15th April 1964, close to the coast of Qeparo-Borsh near Himare on the Albanian coastline (translated from the Albanian language).
Tab. 2: Meritve belega morskega volka, ujetega 15. aprila 1964 blizu obale Qeparo-Borsh pri Himari na albanski obali (prevedeno iz albanskega jezika).

Total length	445 cm
Standard length	430 cm
Head length (Ceph.)	134 cm
Biggest height of the body (H)	50 cm
Smaller height of the body (h)	30 cm
Antedorsal (Antd)	180 cm
Anteventral (Antv)	265 cm
Anteanale (Anta)	330 cm
Snout length	28 cm
Base length of dorsal fin	44 cm
Height of the dorsal fin	50 cm
Base length of the pectoral fin	35 cm
Height of the pectoral fin	88 cm
Base length of the pelvic fin	43 cm
Height of the pelvic fin	58 cm
Base length of the anal fin	8 cm
Height of the anal fin	13 cm
Maximal width of the body (in the part where the pectoral fin begins)	85 cm
Minimal width of the body	12 cm

base. The triangular anal fins were relatively small, located close to the end part of the body, their height 2 times larger than the base. The caudal fin was composed of two parts, with the bottom part measuring about 2/3 of the upper part. The eye diameter equalled 1/7 of the snout length. Additional morphologic and biometric measurements were reported in Table 2.

The teeth of the upper jaw were described as being arranged in two rows attached to the base, with 14 teeth in each row. The teeth of the lower jaw were positioned in the same way and their number was also the same. The teeth were triangular in shape, with a 30 mm wide base and 38 mm long sides. Each tooth was serrated, resembling the edge of a saw. The distance between two teeth (at their highest points) in a row was 50 mm, while the distance between the rows measured up to 70 mm. The shark's body was dark on the dorsal and white on the ventral side. The skin was rough and thick. Underneath

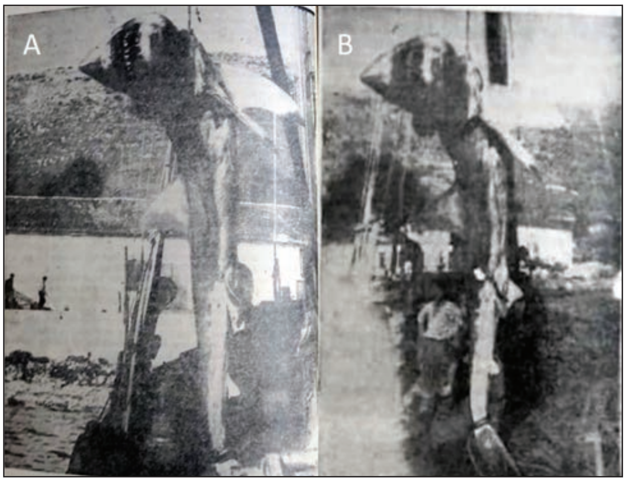

Fig. 3: Photos of record no. 62.
Sl. 3: Fotografija v zvezi z zapisom št. 62.

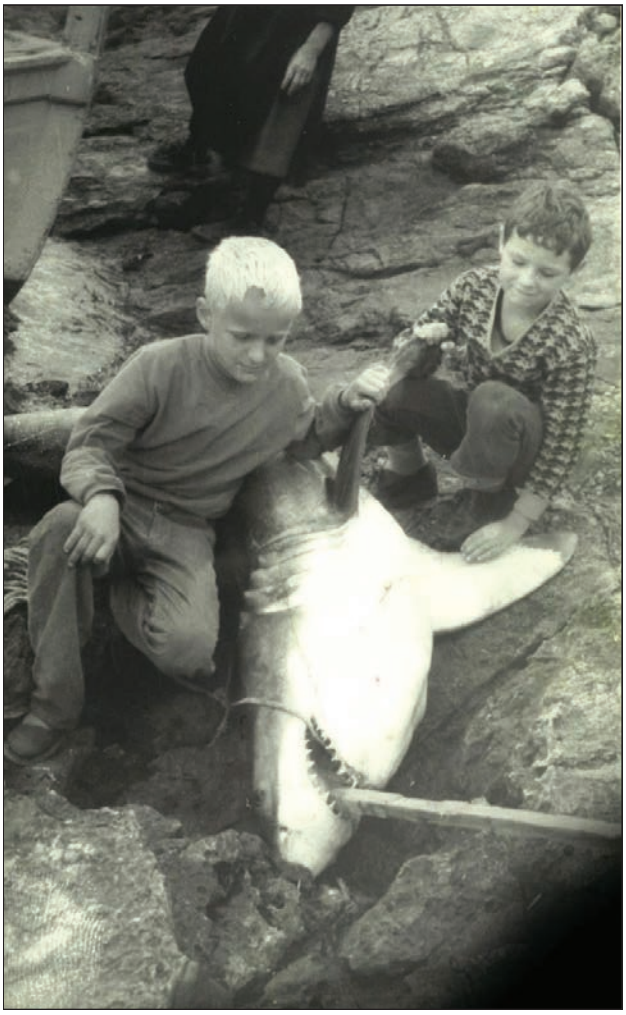

Fig. 4: Photo of record no. 63.
Sl. 4: Fotografija v zvezi z zapisom št. 63.

Fig. 5: Photo of record no. 67.
Sl. 5: Fotografija v zvezi z zapisom št. 67.

the skin, there was a stratum similar to a fatty layer, with a thickness of up to 2 cm.

The shark's stomach was empty, with no presence of any organisms observed inside. The specimen was identified as female. Based on the provided morphometric data, the researcher concluded that the shark belonged to the genus *Carcharhinus*. Indeed, although some of the characters were not measured or described according to contemporary standards, the description and the available photos (Fig. 3) undoubtedly correspond to those of the great white shark. It should be noted that this is the most recent documented record of the great white shark from the Albanian coast.

The additional record no. 63 is from 1968, but the exact date is not known. The available information refers to the catch of a great white shark on the NE coast of the island Rava (Fig. 4).

Another new record, no. 67, is related to the capture of a 4-meter-long great white shark near Luka Šipanska on the island of Šipan on 26 July 1973. Not many details are provided, apart from several photos and the information that many locals kept its large teeth as souvenirs (Fig. 5).

Record no. 69 refers to a male great white shark measuring 4.5 m in length, which was caught on 17 June 1976 in Vrsi near Nin. There are several accounts of this event, two differing in the date of the catch, one placing the record in 1978, the other one in 1975. Since the former was provided by persons involved in catching the shark themselves, it is considered more accurate. As all the accounts are similar, it can be presumed that they are all related to this single event. The great white shark entered a very shallow area where it was spotted by the locals. These eventually killed it and landed it on the

Fig. 6: Photo of record no. 69.
Sl. 6: Fotografija v zvezi z zapisom št. 69.

coast with the use of a tractor (Fig. 6). The shark's belly was cut open but, according to the available information, the stomach did not contain anything worth mentioning.

Subsequent to the latest list of records published by Soldo & Jardas (2002a, 2002b), two additional records were reported. The first (no. 70), reported and published by Soldo & Dulčić (2005), referred to a large female measuring 570 cm in length and weighing 2–2.5 tons, which was caught during tuna purse-seining on 24 June 2003. The second (no. 71) reported an attack by a great white shark on a spear diver that occurred on 6 October 2008 on the island of Vis. It seems that the great white shark was attracted to the fish caught by the spear diver, whom it then bit on the leg. Luckily, the spear diver was quickly transported to the hospital, where he recovered after a long treatment. Teeth particles extracted from the bitten leg were examined (Fig. 7) by one of the authors of this paper (A. Soldo), who confirmed that the attack was carried out by a great white shark.

Apart from these new verified records, others have been reported over the past two decades and all of them were again related to tunas, either of sharks seen feeding on tuna or following or swimming in the vicinity of a school of tunas. However, since these reports were not substantiated with additional evidence (reliable photo or video) or the available evidence was inconclusive (photos not allowing proper identification), they were

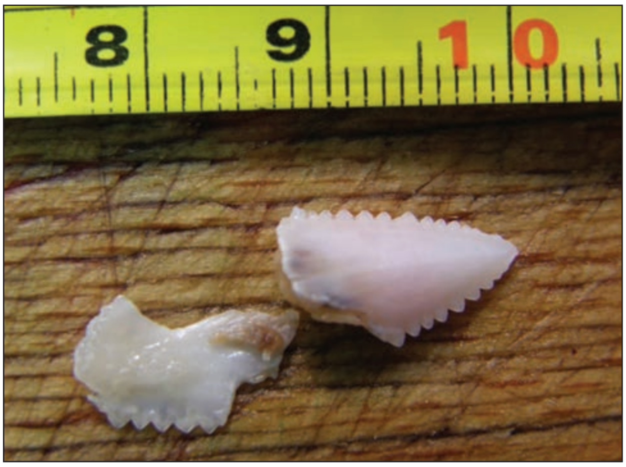

Fig. 7: Photo of teeth particles related to record no. 71.
Sl. 7: Fotografija zobnih partiklov, ki se nanašajo na zapis št. 71.

not included in the list. Interestingly, despite advancements in information technologies, the records reported in recent times are not always more accurate and validated, as would be expected. In fact, the same errors are frequently made, with plain misidentification being particularly common (Casey & Pratt, 1985). Typically, the mistake consists in confusing the great white shark with its close relatives, the shortfin mako *Isurus oxyrinchus*, Rafinesque, 1810, or the porbeagle *Lamna nasus* (Bonnaterre, 1788), and erroneously reporting them as juvenile great white sharks. Such misidentifications are not only suspected in historical records, which cannot be verified anymore without any additional data, but are even discovered in contemporary records. For example, in the recently reported case of a porbeagle caught near Šibenik on 14 September 2023. Porbeagles are rarely but typically caught in that area, and a careful examination of the available photos confirmed it was indeed another case of a porbeagle. However, in many media the specimen was reported as a juvenile great white shark, which would have been the first record of a juvenile in the Adriatic Sea ever. In the beginning of the 20th century, a sudden increase in the records of basking shark *Cetorhinus maximus* (Gunnerus, 1765) was observed in the northern Adriatic, and probably due to its size, the species was mistakenly reported as the great white shark at the time (Soldo *et al.*, 2008). Nowadays, the general public is better educated about the basking shark, so mistakes in identification are much fewer. As for historical records, given the absence of any confirmable data, we will never know for sure how many reports of the great white shark were actually of the basking shark or some other species. Considering that even nowadays, numerous new records of different shark species are being published without verification, Soldo and Lipej (2024) encourage authors to refrain from making tentative identifications of species and publishing arbitrary observations in the absence of verified evidence. This would avoid adding to the confusion surrounding the status of sharks in the Mediterranean, which is particularly important for species such as the great white shark, where such records are usually the only source of data used to interpret their population patterns.

Soldo & Jardas (2002a, 2002b) assumed that as tuna fishing activities gradually declined near the Adriatic coast in the late 20th century and shifted more towards open sea areas, new discoveries of great white sharks would occur in the open sea, where tuna now mainly live, while previously known areas of high abundance of the great white shark, such as Kvarner Bay, would lose their importance. Reports in the 21st century, both verified and unverified, seem to confirm that assumption. Interestingly, since the beginning of the 21th century, the tuna farming industry has developed in the eastern Adriatic, but there have been no reports yet of white shark sightings around the tuna cages. The reason may be the fact that their location is near the coast; however, based on the same set of data, some authors suggest that this is rather the result of a significant decline in the great white shark population in the eastern Adriatic. They estimate a 3- to 20-fold decline (median estimate = 8) in population abundance from 1868 to 1970 and an 84% decrease over three generations (McPherson & Myers, 2009). However, McPherson & Myers (2009) also argue that interpretations of high declines do not take into account an important predator-prey interaction between the great white shark and tunas. This raises a new question: are the reported population declines real, or have they been influenced, fully or in part, by a relocation of the great white shark populations due to changes in tuna distribution? The answer to this question is obviously very important, not only for the Adriatic Sea, but for the Mediterranean as a whole. Therefore, further studies are needed to address this issue and find an accurate answer that would explain the true conservation status of this charismatic species in the Mediterranean.

ACKNOWLEDGEMENTS

The authors thank to the researcher of the Laboratory of Aquaculture and Fisheries in Durres (Agricultural University of Tirana) Mrs. Jerina Kolitari, for sharing the printed document which included information about the landed great white shark from the Albanian coast, to Prof. Robert Lončarić from the University of Zadar for providing a photo of the record No. 63 and Ivo Batričević for a photo of the record No. 67.

DODATNI HISTORIČNI ZAPISI O POJAVLJANJU BELEGA MORSKEGA VOLKA, *CARCHARODON CARCHARIAS* (LAMNIFORMES: LAMNIDAE) V VZHODNEM JADRANSKEM MORJU: AKTUALNO REGIONALNO POJAVLJANJE KRITIČNO OGROŽENE VRSTE

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POVZETEK

Avtorja predstavljata dodatne historične zapise o pojavljanju belega morskega volka v vzhodnem Jadranu in ponujata posodobljen seznam pojavljanja vrste na tem območju od leta 1868 naprej. Od objave zadnjega seznama iz leta 2002 je bilo na podlagi razpoložljivih podatkov dodanih 10 novih zapisov o pojavljanju. Od teh jih 8 sega v 19. in 20. stoletje, druga dva pa sta iz 21. stoletja.

Ključne besede: *Carcharodon carcharias*, beli morski volk, pojavljanje, Jadransko morje

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received: 2024-03-21 DOI 10.19233/ASHN.2024.03

FIRST RECORDS OF SAWBACK ANGELSHARKS *SQUATINA ACULEATA* (SQUATINIDAE) FROM THE ALGERIAN COAST (SOUTHWESTERN MEDITERRANEAN SEA)

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ABSTRACT

The present paper reports the captures of two specimens of sawback angelshark Squatina aculeata *Risso, 1810 in the eastern region of the Algerian coast (GSA 04). Both specimens were sub-adult females, with a total length (TL) of 1200 mm and 1300 mm, and an estimated total body weight of 10 kg and 18 kg, respectively. These findings provide the first substantiated records of* S. aculeata *in the Algerian ichthyofauna and address the gap in knowledge for the Maghreb coast. The origin of these specimens remains speculative. However, if the possibility of a viable population in the Mediterranean Sea cannot be completely ruled out, a management plan is needed for* S. aculeata *to prevent the extinction of this squatinid and its two congeneric species.*

Key words: Squatinidae, Angel shark, *Squatina aculeata*, Mediterranean Sea, origin, management

PRIME SEGNALAZIONI DI SQUADROLINO *SQUATINA ACULEATA* (SQUATINIDAE) LUNGO LA COSTA ALGERINA (MARE MEDITERRANEO SUD-OCCIDENTALE)

SINTESI

Il presente lavoro riporta la cattura di due esemplari di squadrolino Squatina aculeata *Risso, 1810 nella regione orientale della costa algerina (GSA 04). Entrambi gli esemplari erano femmine subadulte, con una lunghezza totale (TL) di 1200 mm e 1300 mm, e un peso corporeo totale stimato a 10 kg e 18 kg, rispettivamente. Questi risultati forniscono la prima documentazione di* S. aculeata *per l'ittiofauna algerina e colmano la lacuna di conoscenze per la costa del Maghreb. L'origine di questi esemplari rimane speculativa. Tuttavia, sebbene non si possa completamente escludere la possibilità di una popolazione vitale nel Mediterraneo, è necessario un piano di gestione per* S. aculeata *per prevenire l'estinzione di questa specie e delle due specie congeneriche.*

Parole chiave: Squatinidae, squadrolino, *Squatina aculeata*, Mediterraneo, origine, gestione

INTRODUCTION

The sawback angelshark, *Squatina aculeata* Risso, 1810, is distributed from the eastern Atlantic south to the Strait of Gibraltar, off Morocco (Llorid & Rucabado, 1998) and Mauritania (Maurin & Bonnet, 1970). It is caught in relative abundance in the coast of Senegal and landed in craft fishing sites (Capapé *et al*., 2005). The species is locally used for human consumption, and the oil extracted from its liver protects dried flesh from insects and acarians (Gueye-Ndiaye *et al*., 1996). Further south, *S. aculeata* has been recorded in Guinea-Bissau (Sanchès, 1991), in the Gulf of Guinea (Blache *et al*., 1970), and, apparently, along the coast of Angola and Namibia (Compagno, 1984; Roux, 1984).

S. aculeata is found in the Mediterranean Sea with its two other congeneric species: the smoothback angelshark *S. oculata* Bonaparte, 1840 and the common angelshark *S. squatina* (Linnaeus, 1758) following Roux (1984). At present, *S. aculeata* is caught sporadically and is classified as critically endangered (CR) on the IUCN Red List of threatened species, reflecting a drastic decline of captures (Zava *et al*., 2020, 2022). The species has been progressively disappearing from fishery landings and is presently absent from some northern Mediterranean areas, such as the Languedocian coast (Capapé *et al*., 2000). Moreno (1995) and Barrull & Mate (2002) considered its presence doubtful off the coast of Spain. Massuti & Moranta (2003) reported no captures of squatinid species from the bottom trawl surveys that were carried out in depths between 46 and 1800 m in the waters surrounding the Balearic Islands.

Tortonese (1956) reported the occurrence of *S. aculeata* in Italian marine waters, based on specimens deposited in ichthyological collections, but Zava *et al*. (2022) now deem such occurrence doubtful. While Soljan (1975) still reported the presence of *S. aculeata* in the Adriatic Sea, the species, according to Soldo & Lipej (2023), no longer exists in the area.

Eastwards, *S. aculeata* has been reported throughout the Aegean Sea (Filiz *et al*., 2005; Zava *et al*., 2020) and Basusta (2016) stated that the finding of a juvenile specimen in the Bay of Iskenderun suggested the existence of a nursery ground in Turkish marine waters. Additionally, during the second phase of MEDITS surveys from bottom trawling in the Mediterranean Sea (period 2012–2015), *S. aculeata* was only reported from the Aegean Sea (GSA 22), with a 3.3% frequency of occurrence in the total chondrichthyan captures in the depth range of 200–800 m (Follesa *et al*., 2019).

The species has also been reported from the Levant Basin, where rare specimens were generally observed and/or captured off the Israeli coast (Golani, 2005), the Syrian coast (Ali, 2018), and the Lebanese coast (Bariche & Fricke, 2020). *S. aculeata* is also sporadically caught in Libyan (Shakman *et al*., 2023) and Egyptian marine waters (El Sayed *et al*., 2017).

With special regard to the Algerian coast, only two squatinid species have been recorded to date: *S. squatina*, reported by Dieuzeide *et al.* (1953) and, more recently, *S. oculata*, by Capapé *et al.* (2023). *S. aculeata* was previously unknown in the area (Dieuzeide *et al*., 1953), but scientific investigations regularly carried out in the same area have allowed us to collect two specimens of *S. aculeata*, which are herein described and provided with comments on the distribution of the species.

MATERIAL AND METHODS

The specimens of *S. aculeata* were observed at the main fish market in Algiers, where fish caught from various areas along the Algerian coast, between the Moroccan and Tunisian borders, are landed. During the sampling period, which extended from 2010 to

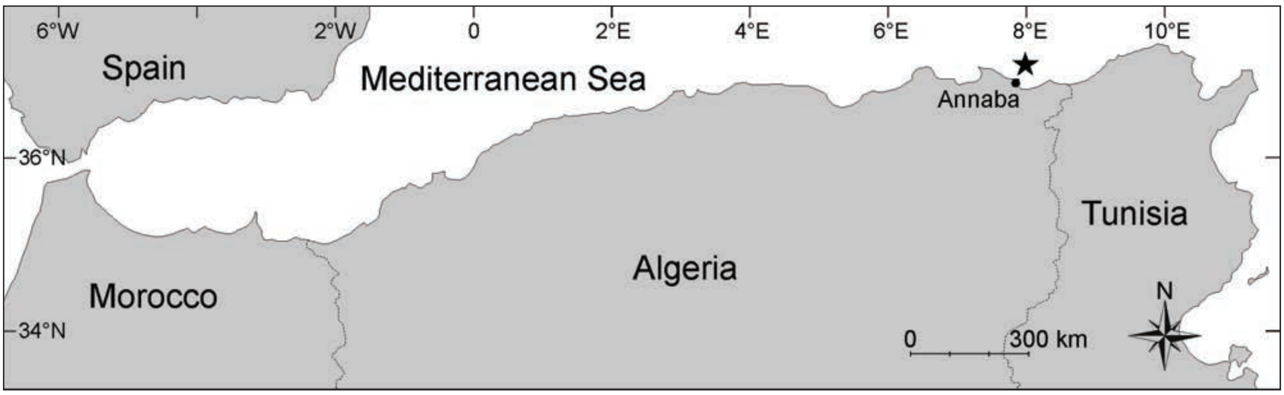

Fig. 1: Map of the Algerian coast with the black star indicating the capture site of the specimens of *Squatina aculeata* ***(redrawn from Capapé*** *et al.****, 2023).***
Sl. 1: Zemljevid alžirske obale z označeno zvezdico, ki ponazarja lokaliteto ulova primerkov vrste *Squatina aculeata* ***(prirejeno po Capapé in sod., 2023).***

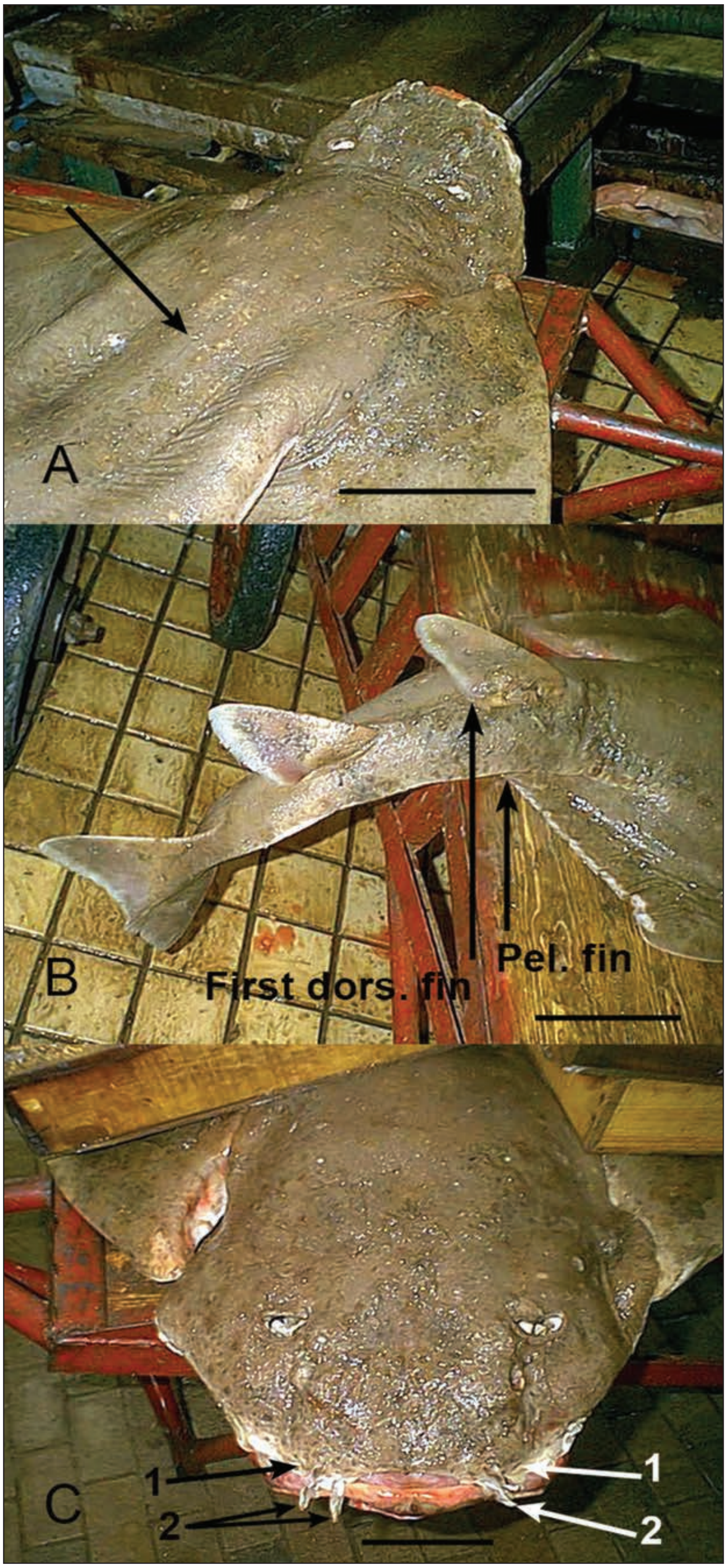

Fig. 2: Specimen of** Squatina aculeata **caught on 26 December 2016. A. Dorsal surface with arrow indicating median line of spines. B. Lateral and posterior view showing hind tips of pelvic fins (Pel Fin) reaching level of first dorsal fin origin (First Dors Fin). C. Anterior view of head with arrows indicating dermal folds on sides, slightly undulate (1), external nasal flap heavily fringed with prominent fringes (2). Photos by F. Hemida, scale bar = 200 mm.

Sl. 2: Primerek vrste** Squatina aculeata **ujet 26. decembra 2016. A. Hrbtna površina s puščico, ki označuje sredinski niz trnov. B. Pogled na bočni in zadnji del telesa kaže zadnji konici trebušnih plavuti (Pel Fin), ki dosegata koren prve hrbtne plavuti (First Dors Fin). C. Sprednji pogled glave s puščicami, ki kažejo: kožni gubi na straneh, rahlo valoviti (1), in zunanje nosne krpe, izrazito resaste (2). Fotografije: F. Hemida, merilo = 200 mm.

2020, only these two specimens were recorded. Both specimens were captured by a commercial trawl at a depth of 100 m over sandy-muddy bottoms, off Annaba, in the east, at 35°42′′35″ N and 1°22′17″ W (Fig. 1). The geographical region where the presented specimens of *S. aculeata* were captured coincided with the borders of the GFCM geographical subarea (GSA) 04 (GFCM, 2018). The specimens were carefully examined and identified using field guides in ichthyological fauna. One specimen was photographed, and both were measured for total length (TL) to the nearest millimetre. Their total body weights (TBW) to the nearest kilogram was provided by fishermen and/or sellers. It should be noted that it is generally difficult to get morphometric measurements at the market, as the fish here, intended for local consumption, are sold rapidly and mainly in bulk.

RESULTS AND DISCUSSION

The first specimen, captured on 27 March 2010, was a female measuring 1200 mm TL and with an estimated total body weight of 10 kg (Fig. 2). The second specimen, also a female, was caught on 26 December 2016. It measured 1300 m TL and weighed about 18 kg. Based on Capapé *et al.* (2005), who noted that the size at first sexual maturity for female *S. aculeata* is typically about 1370 mm TL, the studied specimens were determined to be sub-adults, nearing adulthood.

Both specimens were identified as *S. aculeata* through a combination of main morphological characters: dorsal surface rough with a median line of spines (Fig. 2-A), pectoral fins very high and broad with rounded rear tips; hind tips of pelvic fins reaching level of first dorsal fin origin (Fig. 2-B), dermal folds on sides of head slightly undulate (Fig. 2-C1); external nasal flap heavily fringed with prominent fringes (Fig.2-C2); teeth pointed, slightly curved at the distal end and with triangular base; colour greyish-brown with some white spots, belly beige. The morphology and colour of both specimens were consistent with previous descriptions of the species (Roux, 1984; Capapé & Roux, 1980; Compagno, 1984; Ebert & Stehman, 2013; Zava *et al.*, 2020, 2022; Barone *et al.*, 2022). Therefore, *S. aculeata* can be considered as present in Algerian marine waters and included in the local ichthyofauna.

The main morphological difference between *S. acuelata* and *S. oculata* is that in *S. oculata*, the hind tips of pelvic fins do not reach the level of first dorsal fin origin. While in both *S. aculeata* and *S. squatina* the hind tips of pelvic fins reach the level of first dorsal fin origin, *S. aculeata* can be distinguished from *S. squatina* by the spinules on the dorsal surface and by the heavily fringed external nasal flap.

Zava *et al.* (2022) reported the capture of one specimen of *S. aculeata* off the Sardinian coast, and one in the central Mediterranean Sea in the marine waters surrounding the Islands of Malta, Lampedusa, and Linosa. Capapé *et al.* (2005) reported that 27 specimens, 15 males and 12 females, of different sizes, including small specimens, were caught throughout the Tunisian coast, also located in the central Mediterranean Sea, which could constitute a nursery ground for *S. aculeata*.

The finding of the two specimens herein presented fills the gap in the knowledge of the species concerning the area between the Tunisian coast (Capapé *et al.*, 2005) and the Moroccan coast (Lloris & Rucabado, 1998). The origin of both specimens remains speculative. A potential nursery ground in the central Mediterranean Sea could indicate an easterly origin of these specimens. On the other hand, *S. aculeata* is caught in relative abundance along the eastern tropical Atlantic coast (Capapé, 2005), and therefore a westerly migration of the species through the Strait of Gibraltar into the Mediterranean Sea cannot be totally ruled out. At the moment, both hypotheses regarding the origin remain equally plausible.

Between 2005 and 2022, a total of 18 specimens of *S. aculeata* were detected in the Mediterranean Sea according to Zava *et al.* (2022); the present report brings the count to 20. The species appears to be very rare and could potentially be considered as critically endangered due to fishing pressure and its *k*-selected characteristics (Zava *et al.*, 2020). However, according to Zava *et al.* (2020), the species' rarity could also be attributed to the prohibition of captures and trades since 2012, as recommended by GFCM/36/2012/3. Nevertheless, local fishermen have observed a substantial decline in captures of squatinid species throughout the Algerian coast.

PRVI ZAPISI O POJAVLJANJU TRNASTEGA SKLATA *SQUATINA ACULEATA* (SQUATINIDAE) IZ ALŽIRSKIH VODA (JUGOZAHODNO SREDOZEMSKO MORJE)

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POVZETEK

Avtorji poročajo o ulovu dveh primerkov trnastega sklata Squatina aculeata *Risso, 1810 v vzhodni regiji alžirske obale (GSA 04). Bili sta skoraj odrasli samici, ki sta merili 1200 mm in 1300 mm telesne dolžine in tehtali 10 kg oziroma 18 kg. Ti najdbi predstavljata prva utemeljena zapisa o pojavljanju vrste* S. aculeata *v alžirski ihtiofavni in odpravljata vrzel v poznavanju te vrste na obali Magreba. Izvor teh primerkov ostaja nejasen. Ni možno povsem izključiti možnost pojavljanja viabilne populacije v Sredozemskem morju, zato je smiselna priprava načrta upravljanja, da bi s tem preprečili izumrtje vrste* S. aculeata *in njegovih najbližjih sorodnikov iz istega rodu.*

Ključne besede: Squatinidae, sklat, *Squatina aculeata*, Sredozemsko morje, izvor, načrt upravljanja

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received: 2024-04-04 DOI 10.19233/ASHN.2024.04

PHYLOGENETIC RELATIONSHIPS AND CONSERVATION IMPLICATIONS OF SHARK SPECIES FROM TURKISH WATERS

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ABSTRACT

*Phylogenetic relationships of seven shark species (*Squalus blainville, Carcharhinus plumbeus, Galeus melastomus, Scyliorhinus canicula, Isurus oxyrinchus, Mustelus mustelus *and* Oxynotus centrina*) sampled from Turkish marine waters were examined using the mtDNA cytochrome b region. There were 293 variable and 74 conservative nucleotides, 279 of which were parsimony informative over 367 bp sequences of the mtDNA Cyt b region. Overall mean genetic diversity was 0.433, with the smallest genetic distance (0.2384) observed between* M. mustelus *and* S. canicula*, and the largest (1.3040) between* G. melastomus *and* I. oxyrinchus. *All species were clearly separated in NJ and MP trees, exhibiting high bootstrap values, and the observed genetic divergence clearly discriminated among all the shark species examined. Additionally, the study identified low genetic diversity and the presence of regional haplotypes, which suggests the need for immediate conservation strategies that are tailored specifically to these ecologically important predatory shark species.*

Key words: shark species, mtDNA Cyt b, phylogeny, DNA barcoding, Turkey, Mediterranean Sea

RELAZIONI FILOGENETICHE E IMPLICAZIONI PER LA CONSERVAZIONE DELLE SPECIE DI SQUALI DELLE ACQUE TURCHE

SINTESI

*Le relazioni filogenetiche di sette specie di squali (*Squalus blainville, Carcharhinus plumbeus, Galeus melastomus, Scyliorhinus canicula, Isurus oxyrinchus, Mustelus mustelus *e* Oxynotus centrina*) provenienti dalle acque marine turche sono state esaminate utilizzando la regione del citocromo b del mtDNA. C'erano 293 nucleotidi variabili e 74 conservativi, 279 dei quali erano informativi per parsimonia su 367 bp di sequenze della regione del citocromo b del mtDNA. La diversità genetica media complessiva è stata di 0,433, con la distanza genetica più piccola (0,2384) osservata tra* M. mustelus *e* S. canicula*, e la più grande (1,3040) tra* G. melastomus *e* I. oxyrinchus. *Tutte le specie sono state chiaramente separate negli alberi NJ e MP, mostrando alti valori di bootstrap, e la divergenza genetica osservata discriminava chiaramente tra tutte le specie di squali esaminate. Inoltre, lo studio ha identificato una bassa diversità genetica e la presenza di aplotipi regionali, il che suggerisce la necessità di strategie di conservazione immediate, specificamente adattate a queste specie di squali predatori ecologicamente importanti.*

Parole chiave: specie di squalo, mtDNA Cyt b, filogenesi, DNA barcoding, Turchia, Mediterraneo

INTRODUCTION

Chondrichthyans, particularly the group of sharks, are an extraordinarily diverse group of large predatory animals inhabiting the world's seas. As primary predators of many species they play a significant role in oceanic ecosystems (Soldo, 2003; Vélez-Zuazo & Agnarsson, 2011; Kabasakal, 2021a). However, due to their life history characteristics, such as long generation times and low intrinsic population growth rates, these species are especially susceptible to over-exploitation. In many seas around the world, sharks are commercially captured for their meat, fins, gill plates, and liver oil, resulting in documented serious declines (Davidson *et al*., 2016). The first global assessment by the IUCN (International Union for Conservation of Nature), which is widely recognized as the most comprehensive and scientifically-based source of information on the global status of plant and animal species, estimated that one quarter of sharks were in danger of extinction, making sharks the most threatened vertebrate lineage after amphibians (Dulvy *et al*., 2014). For the Mediterranean region, the IUCN reported vulnerability of chondrichthyans and a general lack of data. Over half of the species assessed, specifically 39 out of 73, were found to be regionally threatened (critically endangered, endangered, or vulnerable), while 13 species were data deficient (Dulvy *et al*., 2016). This makes the Mediterranean the world region with the highest level of threat to chondrichthyans. Furthermore, in some areas of the Mediterranean, the situation is even more serious; a recent assessment of the conservation status of chondrichthyan species in the Adriatic Sea, for example, has revealed that 70% are regionally threatened and three species are regionally extinct (Soldo & Lipej, 2022).

As members of chondrichthyans, sharks comprise over 500 documented species distributed among nine orders: Hexanchiformes, Heterodontiformes, Orectolobiformes, Lamniformes, Carcharhiniformes, Squaliformes, Echinorhiniformes, Pristiophoriformes, and Squatiniformes (Van der Laan *et al*., 2024). Diversity patterns across these shark lineages are highly uneven. Over 75% of extant shark diversity is found within two lineages, the Carcharhiniformes and the Squaliformes. The Squatiniformes, Lamniformes, and Orectolobiformes exhibit moderate species diversity: ~4%, ~3%, and ~12%, respectively. The Echinorhiniformes, Heterodontiformes, and Pristiophoriformes are species poor, accounting for ~3% of the total described shark species diversity combined (Sorenson *et al*., 2014).

Scientific data for chondrichthyans related to life parameters, particularly for the Mediterranean area, are available only for a few common species (Fowler *et al*., 2005). In Turkey, limited research has been conducted on sharks, with a significant portion focusing on distribution and bycatch data only (Yaglıoglu *et al*., 2015; Başusta, 2016; Kabasakal, 2021a; 2021b; Gül *et al.,* 2022; Kabasakal *et al*., 2023). Overall, 37 species of sharks have been reported so far in Turkish marine waters (Kabasakal, 2021a).

Genetic markers are a valuable tool for describing species and monitoring genetic diversity levels in an exploited species (Turan, 2008). Molecular genetic studies utilizing mtDNA have proven advantageous in investigating the phylogeography and phylogeny of marine fish species (Turan *et al*., 2009; Avise, 2012; Doğdu & Turan, 2021; Yağlıoğlu *et al*., 2023; Uyan *et al*., 2024). Sequence analysis of mtDNA regions is a common tool used for elucidating phylogenetic relationships of marine species (Avise *et al*., 1994; Carvalho & Hauser, 1994; Turan *et al*., 2017). The cytochrome b gene (Cyt b), whose phylogenetic performance is comparable to that of COI, has been widely used for fish species identification and enhancing our understanding of phylogenetic relationships (Farias *et al*., 2001; Dettai & Lecointre, 2005; Sevilla *et al*., 2007; Doğdu & Turan, 2016; Karan *et al*., 2019).

In this study, we aimed to analyze the phylogenetic relationship of seven shark species (*Squalus blainville* (Risso, 1827), *Carcharhinus plumbeus* (Nardo, 1827), *Galeus melastomus* Rafinesque, 1810, *Scyliorhinus canicula* (Linnaeus, 1758), *Isurus oxyrinchus* Rafinesque, 1810, *Mustelus mustelus* (Linnaeus, 1758), and *Oxynotus centrina* (Linnaeus, 1758)) from Turkish waters by sequencing the Cyt b region.

MATERIAL AND METHODS

Seven shark species, comprising *Squalus blainville* (5 specimens), *Carcharhinus plumbeus* (2 specimens), *Scyliorhinus canicula* (5 specimens), *Galeus melastomus* (3 specimens), *Isurus oxyrinchus* (2 specimens), *Mustelus mustelus* (5 specimens), and *Oxynotus centrina* (3 specimens), were collected from Iskenderun Bay, in the northeastern Mediterranean. Tissue samples were collected in Eppendorf tubes from the specimens caught by fishermen and transported to the laboratory in bags with crushed ice. All tissue samples were then stored in 98% ethanol at –20 °C until analysis.

Total genomic DNA was extracted from muscle samples using a slightly modified phenol-chloroform procedure (Sambrook *et al*., 1989). The total DNA was visualized by agarose gel electrophoresis (1.5%) and quantified by spectrophotometric assay. Polymerase chain reaction (PCR) amplification was performed with the following universal mtDNA Cyt b primers (Kocher *et al*., 1989):

Cyt b- Forward 5′- AAA CTG CAG CCC CTC AGA ATG ATA TTT GTC CTC -3'
Cyt b- Reserved 5′- CGA ACG TTG ATA TGA AAA ACC ATC GTT- 3'

Tab. 1: The number of haplotype and its distribution among the species.
Tab. 1: Oznaka in prisotnost haplotipa in njegova razširjenost med vrstami.

Haplotype	***S. blainville***	***C. plumbeus***	***S. canicula***	***I. oxyrinchus***	***M. mustelus***	***G. melastomus***	***O. centrina***
Hap_1	**1**	-	-	-	-	-	-
Hap_2	**1**	-	-	-	-	-	-
Hap_3	**1**	-	-	-	-	-	-
Hap_4	**1**	-	-	-	-	-	-
Hap_5	**1**	-	-	-	-	-	-
Hap_6	-	**1**	-	-	-	-	-
Hap_7	-	**1**	-	-	-	-	-
Hap_8	-	-	**1**	-	-	-	-
Hap_9	-	-	**1**	-	-	-	-
Hap_10	-	-	**1**	-	-	-	-
Hap_11	-	-	**1**	-	-	-	-
Hap_12	-	-	**1**	-	-	-	-
Hap_13	-	-	-	**1**	-	-	-
Hap_14	-	-	-	**1**	-	-	-
Hap_15	-	-	-	-	**1**	-	-
Hap_16	-	-	-	-	**1**	-	-
Hap_17	-	-	-	-	**1**	-	-
Hap_18	-	-	-	-	**1**	-	-
Hap_19	-	-	-	-	**1**	-	-
Hap_20	-	-	-	-	-	**1**	-
Hap_21	-	-	-	-	-	**1**	-
Hap_22	-	-	-	-	-	**1**	-
Hap_23	-	-	-	-	-	-	**1**
Hap_24	-	-	-	-	-	-	**1**
Hap_25	-	-	-	-	-	-	**1**
Total	**5**	**2**	**5**	**2**	**5**	**3**	**3**

The PCRs were conducted in a total volume of 50 µl with 0.4 uM of each primer, 0.2 mM of dNTP, and 1.25 U of Taq DNA polymerase in a PCR buffer containing 20 mM of Tris–HCl (pH 8.0), 1.5 mM of MgCl2, 15 mM of KCl, and 1–2 µl of template DNA. The pre-denaturation step at 95°C for 1 min was followed by 5 cycles of denaturation at 94°C for 30 s, 50 °C for 30 s, and 72 °C for 45 s. This was repeated for 30 cycles, with a final extension step at 72 °C for 7 min. The PCR products were visualized using electrophoresis on a 1.5% agarose gel. The DNA sequencing was performed to determine the order of the nucleotides in the mtDNA Cyt b region. The chain termination method by Sanger *et al*. (1977) was applied with Bigdye Cycle Sequencing Kit V3.1 and ABI 3130 XL genetic analyzer. The initial alignments of partial Cyt b sequences were carried out using the Mega X program (Kumar *et al*., 2018), and the final alignment was completed manually with BioEdit (Hall, 1999). Haplotype diversity, genetic diversity (Nei, 1987), and mean number of pairwise differences (Tajima, 1983) were calculated using the Arlequin program (Schneider *et al*., 2000).

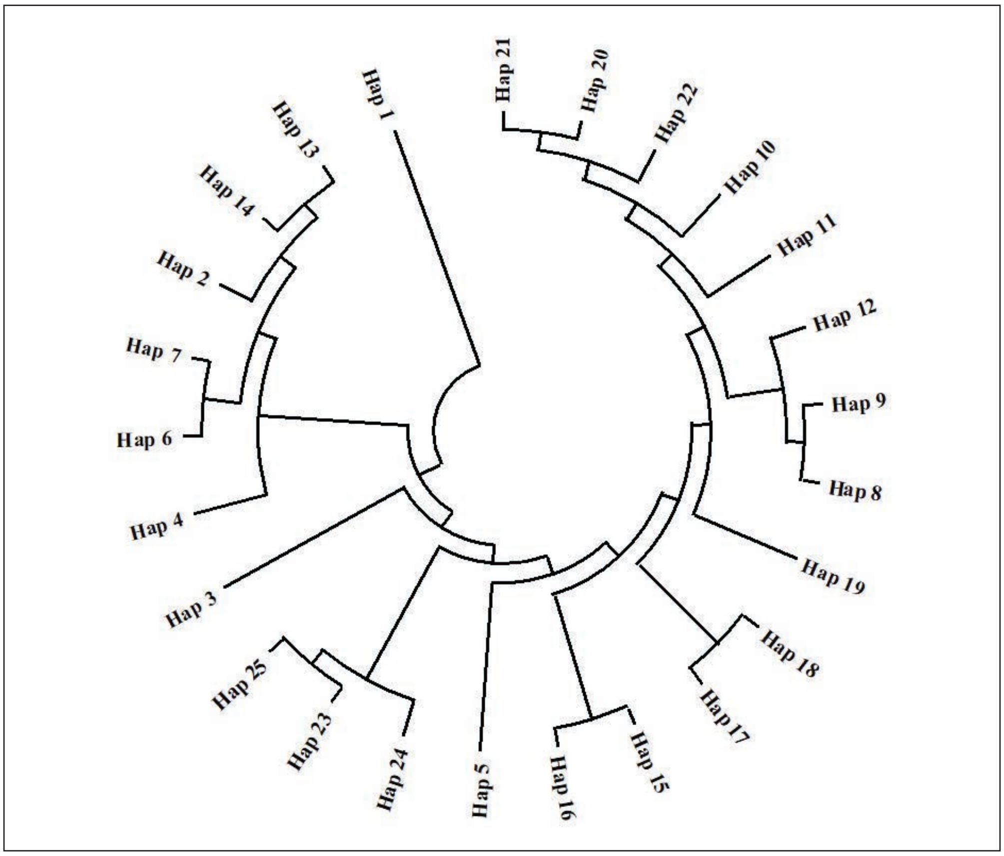

Fig. 1: A minimum spanning tree illustrating the relationships among the haplotypes.
Sl. 1: Minimalno vpeto drevo, ki kaže na odnose med haplotipi.

We also created a haplotype network for shark species. Haplotypes were obtained with the DnaSP 6 program (Rozas, 2017). The minimum spanning tree (Excoffier & Smouse, 1996) of haplotypes was produced with the FigTree (v1.4.3) program.

The molecular phylogenetic tree was constructed using Mega X (Kumar *et al*. 2018), employing neighbor joining (NJ) (Nei & Kumar, 2000) as the distance-based method and cladistics as the maximum parsimony (MP) criterion. The reliability of the inferred phylogenies was evaluated using the bootstrap method (Felsenstein, 1985) with 1000 replicates.

RESULTS

There were 293 variable and 74 conservative nucleotides, 279 of which were parsimony informative over 367 bp sequences of the mtDNA Cyt b gene region. The average nucleotide composition was 28.1% A, 31.3% T, 24.9% G, and 15.7% C. Twenty-five haplotypes were found, all of them unique, resulting in a haplotype diversity of 1.00 (Tab. 1). The minimum spanning tree revealed the relationships among the haplotypes (Fig. 1), with ancestral haplotypes 1, 2, and 4 only found *in S. blainville*.

The Tamura 3-parameter method was selected as the best method for analyzing intra- and interspecific variations (BIC score: 6923.7398). The mean genetic diversity across all species was found to be 0.43367. The matrix of pairwise genetic distances within species is presented in Table 2. The smallest genetic distance was observed between *M. mustelus* and *S. canicula* (0.2384), the largest between *G. melastomus* and *I. oxyrinchus* (1.3040). The lowest genetic diversity within species (0.024) was detected in *O. centrin*a.

In the neighbor-joining phylogenetic tree, two main phylogenetic nodes were detected, with *I. oxyrinchus* separately branched as one main node. In the second main node, four sub-branches were identified, with each sub-branch comprising one species with a high bootstrap value (Fig. 2).

The maximum parsimony tree showed a different topology, with two main phylogenetic nodes detected. In the first node, *G. melastomus* was branched separately, whereas in the second node, four sub-branches were generated: *O. centrina* was closely grouped with *S. blainville*, while *C. plumbeus* was closely grouped with *I. oxyrinchus* (Fig. 3).

Tab. 2: Pairwise genetic distances between species and diversity within species (transversal diagonal) given in bold.
Tab. 2: Parne genetske razdalje med vrstami in genetska variabilnost med vrstami (transverzalna diagonala) je podana v krepkem tisku.

Species	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Squalus blainville (1)	**0.0324**						
Carcharhinus plumbeus (2)	0.3683	**0.0278**					
Scyliorhinus canicula (3)	0.3290	0.4343	**0.0357**				
Isurus oxyrinchus (4)	1.1958	1.2574	1.3715	**0.0686**			
Mustelus mustelus (5)	0.3003	0.3854	0.2384	1.1601	**0.0555**		
Galeus melastomus (6)	0.3255	0.4020	0.3077	1.3040	0.3294	**0.0871**	
Oxynotus centrina (7)	0.2569	0.4530	0.3530	1.2713	0.3269	0.3854	**0.024**

DISCUSSION

The study investigated the phylogenetic relationships of the seven shark species distributed in Turkish marine waters. All the species resulted separated in the NJ and MP trees with high bootstrap values. No shared haplotypes were detected between species, with the identified haplotypes distinct for each examined shark species.

The number of examined species was low due to the endangerement of shark species in the studied area. However, despite the small number, the results show a clear discrimination of each species. *O. centrina* had the lowest genetic diversity (0.024), which may call into question its conservation status (VU) as assessed by the IUCN. The genetic diversity of *G. melastomus* (0.0871) was the highest among the examined species. Castilho *et al*. (2007) studied the morphological and mitochondrial DNA divergence of *G. melastomus* and *Galeus atlanticus* (Vaillant, 1888) in the Iberian Peninsula, Portugal, using the mtDNA ND2 gene. Haplotype diversity and genetic diversity of *G. melastomus* were found to be 0.911 and 0.1, respectively, and seven haplotypes were observed. Their results for this species were similar to the findings presented herein. The genetic diversity of *M. mustelus* was also found to be low. Pereyra *et al*. (2010) studied the population genetic structure of *Mustelus Schmitt* Springer, 1939, in Río de la Plata, southwest Atlantic Ocean, using mitochondrial cytochrome b gene region. The genetic and haplotype diversity resulted to be 0.226 and 0.0015, respectively. Much lower genetic diversity was observed on the Atlantic coast, which may suggest a more conserved status of the species in the Mediterranean. Kousteni *et al*. (2015) studied the population genetic structure of the small-spotted catshark, *S. canicula*, in the Mediterranean using the mtDNA COI gene region. The investigation revealed high haplotype diversity (0.808) and low genetic diversity (0.0032). The detected genetic diversity of *S. canicula* in the present study was found to be low (0.0357), but still much higher than that established by Kousteni *et al.* (2015). Coastal and demersal chondrichthyans, such as *S. canicula*, are expected to exhibit genetic differentiation in complex geomorphology like the Mediterranean Basin due to their limited dispersal ability (Kousteni *et al*., 2015). Furthermore, Kousteni *et al*. (2015) suggested that strong genetic subdivision in both mitochondrial and nuclear microsatellite DNA data between the western and eastern Mediterranean is indicative of the geographic isolation of the two basins, with the deep sea acting as a significant barrier to dispersal. Kousteni *et al*. (2015) sampled from the Aegean and Egyptian coasts, while the present study is the first to sample from the northeastern Mediterranean for this species and has indicated that more conserved populations may exist in this area.

The genetic diversity of *C. plumbeus* in the present study was observed to be low (0.0278). Geraghty *et al*. (2014) investigated the genetic structure of the dusky shark, *Carcharhinus obscurus* (Lesueur, 1818), and the sandbar shark, *C. plumbeus*, in the Indo-Australian region using the mtDNA ND4 region. They found haplotype diversity and genetic diversity to be 0.2814 and 0.0009, respectively. The genetic diversity detected herein was relatively higher than that established by Geraghty *et al*. (2014), which may indicate a more conserved status for sandbar sharks in the Mediterranean Sea.

The level of genetic and haplotype diversity of other shark species from the Atlantic and Pacific Oceans was also low compared to that observed in the Mediterranean Sea. Murray *et al.* (2008) studied the relationships of sleeper sharks *Somniosus microcephalus* (Bloch & Schneider, 1801), *Somniosus pacificus* Bigelow & Schroeder, 1944, and *Somniosus antarcticus* Whitley,

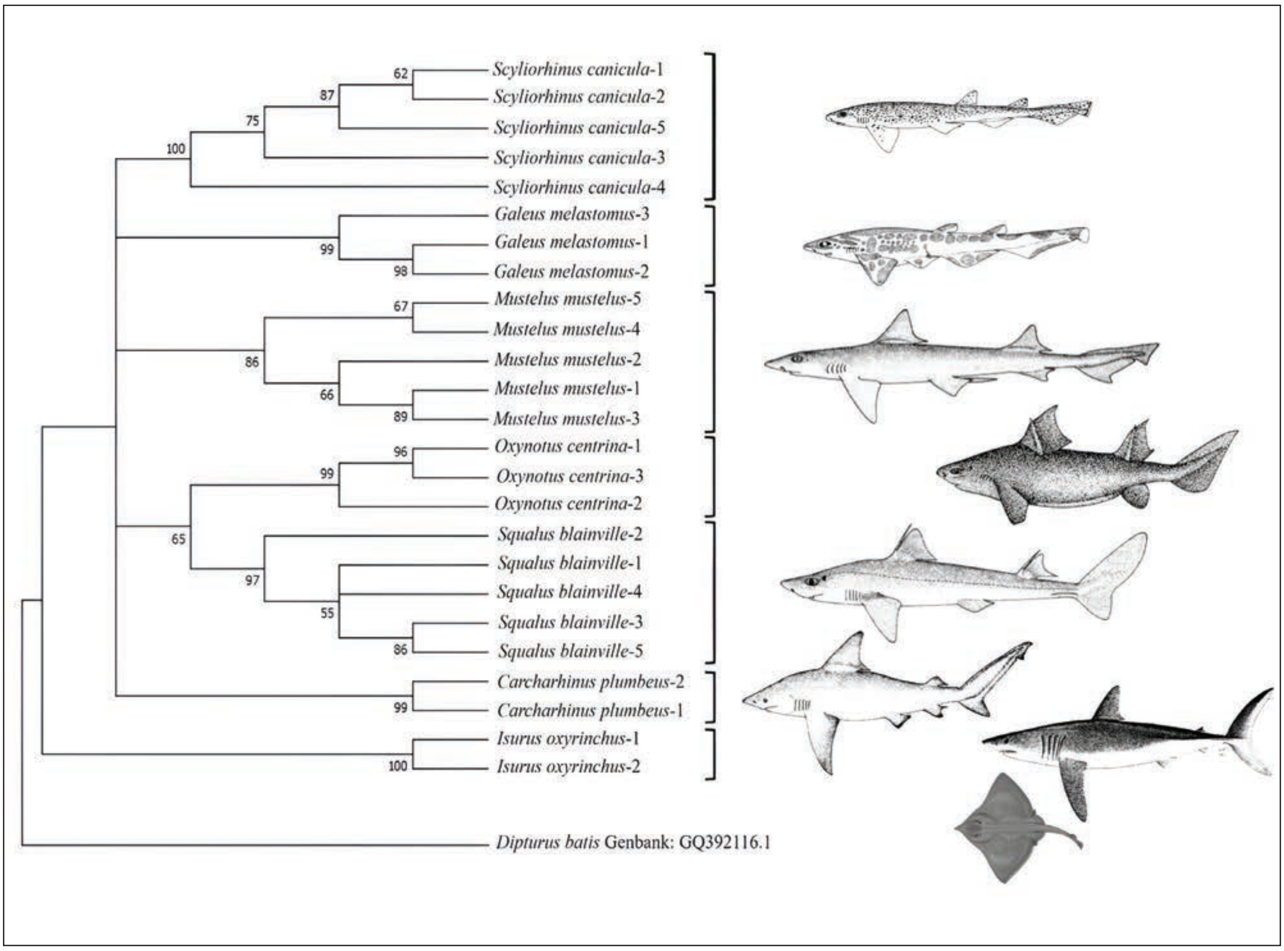

Fig. 2: A neighbor-joining phylogenetic tree based on Cyt b sequences. *Dipturus batis* ***(Linnaeus, 1758) was used as an outgroup. Bootstrap values are indicated on the nodes. Fish illustrations from Froese & Pauly (2023).***
Sl. 2: Filogenetsko drevo združevanja sosedov, ki temelji na sekvencah Cyt b. Kot stranska skupina je bila uporabljena vrsta *Dipturus batis* ***(Linnaeus, 1758). Vrednosti bootstrap so navedene na vozliščih. Ilustracije rib so povzete po Froese in Pauly (2023).***

1939, using the mtDNA Cyt b region. They observed a haplotype diversity of 0.7937 for *S. pacificus*, 0.6667 for *S. antarcticus*, and 0.7750 for *S. microcephalus*. Li *et al*. (2017) studied the genetic differentiation of *Prionace glauca (Linnaeus, 1758)* in the central Pacific Ocean, and found the haplotype diversity and genetic diversity to be 0.768 and 0.0011, respectively.

Although *S. blainville* had ancestral haplotypes, the highest genetic differentiation in this study was observed in *I. oxyrinchus*. This may be related to the species' low genetic diversity, which could be caused by anthropogenic factors such as fishing pressure and distraction of fishing grounds since limited spawning grounds of this species are known (Costa *et al*. 2002).

In phylogenetic analysis, all the species of the seven genera resulted aggregated into clusters in the NJ and MP trees, with high bootstrap values. The discrimination success of the present study can be associated with the detected low levels of sequence differentiation within species and higher levels between species, as also reported by studies by Holmes *et al*. (2009) and Barbuto *et al*. (2010). The discrimination performance of the Cyt b gene is reasonable and applicable in future barcoding studies, especially in comparison to the performance of the COI gene, which has been widely used for identifying fish species and resolving fish phylogenies (Chen *et al*., 2003; Dettai & Lecointre 2005; Sevilla *et al*., 2007; Seyhan & Turan, 2016).

This study indicates that *O. centrina*, *C. plumbeus*, *S. blainville*, and *S. canicula*, which have low genetic diversity, are under threat. These results are only partially in accordance with the status of the mentioned species in the Mediterranean, as *O. centrina* is indeed assessed as critically endangered, and *C. plumbeus* as endangered. On the other hand, *S. canicula* is categorized as least concern and *S. blainville* as data deficient (Dulvy *et al*.,

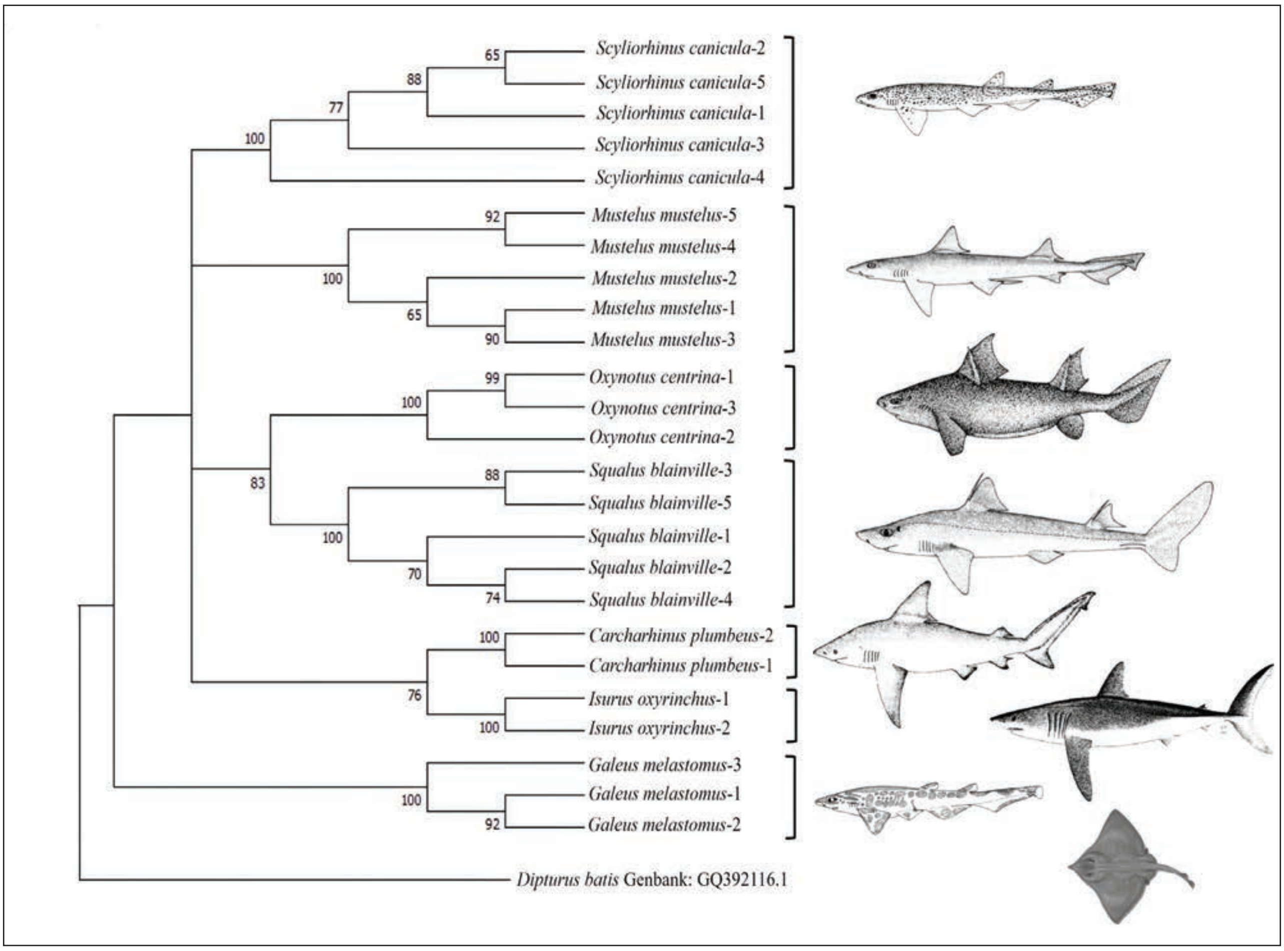

Fig. 3. A maximum parsimony phylogenetic tree based on Cyt b sequences. *Dipturus batis* ***was used as an outgroup. Bootstrap values are indicated on the nodes. Fish illustrations from Froese & Pauly (2023).***
Sl. 3: Filogenetsko drevo z največjo parsimonijo (varčnost), ki temelji na sekvencah Cyt b. Za stransko skupino so uporabili vrsto *Dipturus batis****. Vrednosti bootstrap so navedene na vozliščih. Ilustracije rib so povzete po Froese in Pauly (2023).***

2016). These two species belong to a group of demersal chondrichthyans that are highly impacted by various fishing gears, especially bottom trawls (Soldo & Lipej, 2022). Soldo & Lipej (2022) warned that even if these species are protected by various legislation, this does not prevent them from being caught. This is especially true for those inhabiting inshore areas where fishing effort is highest and a broad range of various unselective bottom fishing gear is used in both small-scale and large-scale fisheries. Soldo & Lipej (2022) therefore proposed that the ultimate conservation priority should be to identify and map the critical habitats of these species and, subsequently, implement in these relatively small areas such management measures that will only allow the use of highly selective bottom fishing gear. This approach is aimed at avoiding strong conflicts with the interests of fisheries, which can prevent any conservation measure.

An overview of IUCN extinction risk assessments shows that most of the Mediterranean populations of elasmobranches are at a higher risk of extinction than their counterparts elsewhere (Dulvy *et al.*, 2016; Vella & Vella, 2023). Due to the infrequency of shark encounters in the Mediterranean Sea, conducting detailed studies on these species poses a challenge. Consequently, there are still knowledge gaps that need to be addressed in order to better understand and safeguard these species. There is an increasing need to improve the data on sharks to more accurately assess their status in the region. This study has identified low genetic diversity and the presence of regional haplotypes, highlighting the importance of developing immediate conservation strategies that are specifically tailored to these ecologically significant predatory species.

FILOGENETSKI ODNOSI IN POSLEDICE OHRANJANJA VRST MORSKIH PSOV V TURŠKIH VODAH

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POVZETEK

*Avtorji so raziskovali filogenetske odnose pri sedmih vrstah morskih psov (*Squalus blainville*,* Carcharhinus plumbeus*,* Galeus melastomus*,* Scyliorhinus canicula*,* Isurus oxyrinchus*,* Mustelus mustelus *in* Oxynotus centrina*) iz turških voda z uporabo mtDNA citohrom b regija. Bilo je 293 variabilnih in 74 konzervativnih nukleotidov, od katerih jih je bilo 279 varčnih informativnih v 367 bp sekvencah regije mtDNA cyt b. Skupna genetska diverziteta je bila 0,433, z najmanjšo ugotovljeno genetsko razdaljo (0,2384) med vrstama* M. mustelus *in* S. canicula*, in največjo (1,3040) md vrstama* G. melastomus *in* I. oxyrinchus. *Vse vrste so se dobro razlikovale na nivoju NJ in MP dreves, ki so pokazale visoke zagonske vrednosti, opažena genetska divergence pa je jasno razlikovala med vsemi raziskanimi vrstami morskih psov. Poleg tega je raziskava odkrila nizko genetsko variabilnost in prisotnost regionalnih haplotipov, kar kaže na potrebo po takojšnjih strategijah ohranjanja, ki so posebej prilagojene tem ekološko pomembnim plenilcem.*

Ključne besede: vrste morskih psov, mtDNA Cyt b, filogenija, DNA barcoding, Turčija, Sredozemsko morje

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received: 2024-01-10 DOI 10.19233/ASHN.2024.05

ON THE OCCURRENCE OF UNDULATE RAY, *RAJA UNDULATA* (RAJIDAE), FROM THE ALGERIAN COAST (SOUTHWESTERN MEDITERRANEAN SEA)

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ABSTRACT

The authors report past captures of undulate ray Raja undulata *Lacépède, 1802 from the coast of Algeria. One specimen was an adult male, caught off Annaba in the eastern region of the Algerian coast, measuring 501 mm in disc width (DW) and 792 mm in total length (TL), with an estimated total body weight (TBW) of 3200 g. Other specimens were off caught off Tipasa in the central region of the Algerian coast. The paper describes the specimens, discussing and commenting the occurrence of the species in the local area and in the broader Mediterranean Sea.*

Key words: Rajidae, *Raja undulata*, distribution, Algerian coast, migration, eastern Atlantic, Mediterraenan Sea

PRESENZA DI RAZZA ONDULATA, *RAJA UNDULATA* (RAJIDAE), LUNGO LA COSTA ALGERINA (MEDITERRANEO SUDOCCIDENTALE)

SINTESI

Gli autori riportano le catture della razza ondulata Raja undulata *Lacépède, 1802 lungo le coste dell'Algeria. Uno degli esemplari era un maschio adulto, catturato al largo di Annaba, nella regione orientale della costa algerina, e misurava 501 mm di larghezza del disco (DW) e 792 mm di lunghezza totale (TL), con un peso corporeo totale (TBW) stimato a 3200 g. Altri esemplari sono stati catturati al largo di Tipasa, nella regione centrale della costa algerina. L'articolo descrive gli esemplari, discutendo e commentando la presenza della specie nell'area locale e nel più ampio mare Mediterraneo.*

Parole chiave: Rajidae, *Raja undulata*, distribuzione, costa algerina, migrazione, Atlantico orientale, Mediterraneo

INTRODUCTION

The undulate ray *Raja undulata* Lacépède, 1802 occurs in the north-eastern Atlantic, ranging from the British Isles, southern Ireland, the English Channel, and Bay of Biscay (Ellis *et al*., 2012; Conant, 2015), to the Portuguese and Spanish coasts, and further down, south of the Strait of Gibraltar, to the coasts of Morocco (Aloncle, 1966) and Senegal (Almeida & Biscoito, 2019). In Portugal, the fish is especially captured in the south-western region, in shallow coastal waters less than 50 m deep, over sandy bottoms (Coelho *et al*., 2005), while in the northern coasts of Spain it occurs at depths between 20 and 90 m (Bañon *et al*., 2008).

In the Mediterranean, *R. undulata* is mainly distributed in the western areas of the basin (Stehmann & Bürkel, 1984; Conant, 2015). The species was once fairly abundant in the Gulf of Lion, but currently, captures have been declining (Capapé *et al*., 2017). In the northern region of the western Mediterranean basin, off the Balearic Islands, there has been a report of a single specimen (Massutí & Moranta, 2003), followed by a report of two additional specimens (Massutí & Reñones, 2005). Psomadakis *et al*. (2006) noted that only 10 records have been reported from the Italian seas, confirming that *R. undulata* is a rare occurrence there.

Further to the east, in the Adriatic Sea, *R. undulata* is a rare species only found in the deep waters of the southern Adriatic region (Soldo & Lipej, 2022), with still unknown population limits. While the species is sporadically caught off Turkey (Bilecenoglu *et al*., 2014), it has never been recorded on the coasts of Syria (Ali, 2018) or Lebanon (Bariche & Fricke, 2020). Golani (*in letteris*, 2024) has noted that the information on the presence of *R. undulata* in Israeli marine waters was based on old records in Ben-Tuvia's publications. Additionally, Golani (*pers. com.*, 2024) assumes that he never collected or saw this species in the area where at present it probably no longer exists.

Similarly, this ray is not present on the coasts of Egypt (El Sayed *et al*., 2017) or Libya (Shakman *et al*., 2023). With regard to the latter area, Fitori *et al*. (2023) recently reported the capture of a specimen of *R. undulata*, but it was, apparently, a misidentified specimen of rough skate *R. radula* Delaroche, 1809.

In the central Mediterranean, *R. undulata* has been reported from the waters surrounding the islands of Malta (Borg *et al*., 2023), but no specimens have been found for confirmation. On the other hand, the species has not been recorded in Tunisian marine waters despite extensive research carried out in the area (Capapé, 1989; Rafrafi-Nouira *et al*., 2015; Enajjar *et al*., 2023).

In the south-western Mediterranean, two specimens were caught off Melilla, Morocco (Dieuzeide *et al*., 1953), both reaching a total length of 780 mm, while the species was considered very rare off the Algerian coast. These trends are also consistent with more recent observations by Hemida (2005), which suggest that the species is not currently observed in the region. Nevertheless, investigations carried out along the Algerian coast with the help of local fishermen familiar with the fishing grounds, resulted in the capture of a few specimens described herein. The document also provides a few insights into the distribution of the species in the area and throughout the Mediterranean Sea.

MATERIAL AND METHODS

On 6 January 2000, a specimen of *R. undulata* was caught with a trammel net off Annaba, a town located in the eastern region of the Algerian coast at 37°06′10″ N and 7°51′02″ E (Fig. 1). The catch was made at a

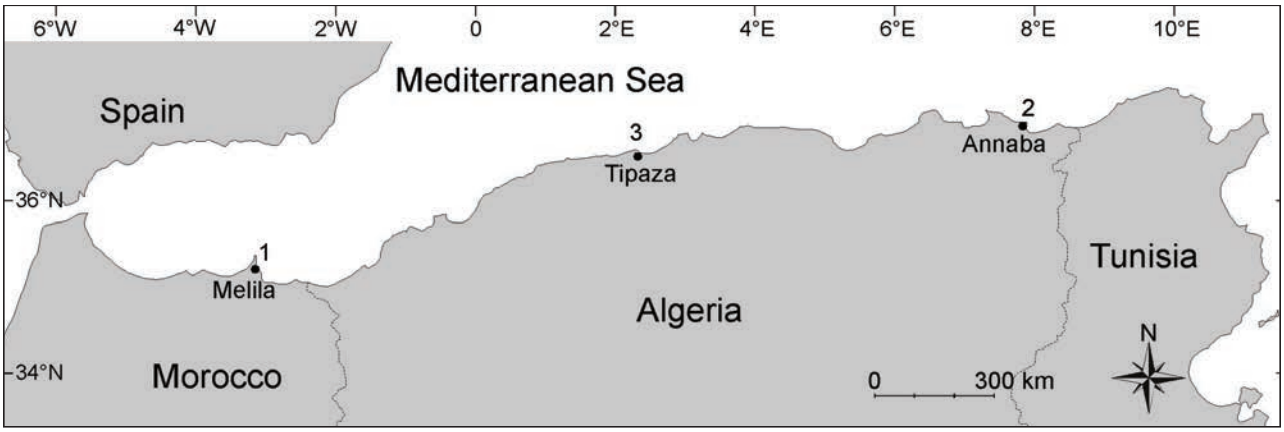

Fig. 1: Capture sites of *Raja undulata* ***located along the Maghreb shore. 1. Off Melilla (Dieuzeide*** *et al.*, ***1953). 2. Off Tipasa, this study (2000). 3. Off Annaba, this study (2019).***
Sl. 1: Lokalitete ulova vrste *Raja undulata* ***vzdolž magrebske obale. 1. Melilla (Dieuzeide in sod., 1953). 2. Tipasa, ta raziskava (2000). 3. Annaba, ta raziskava (2019).***

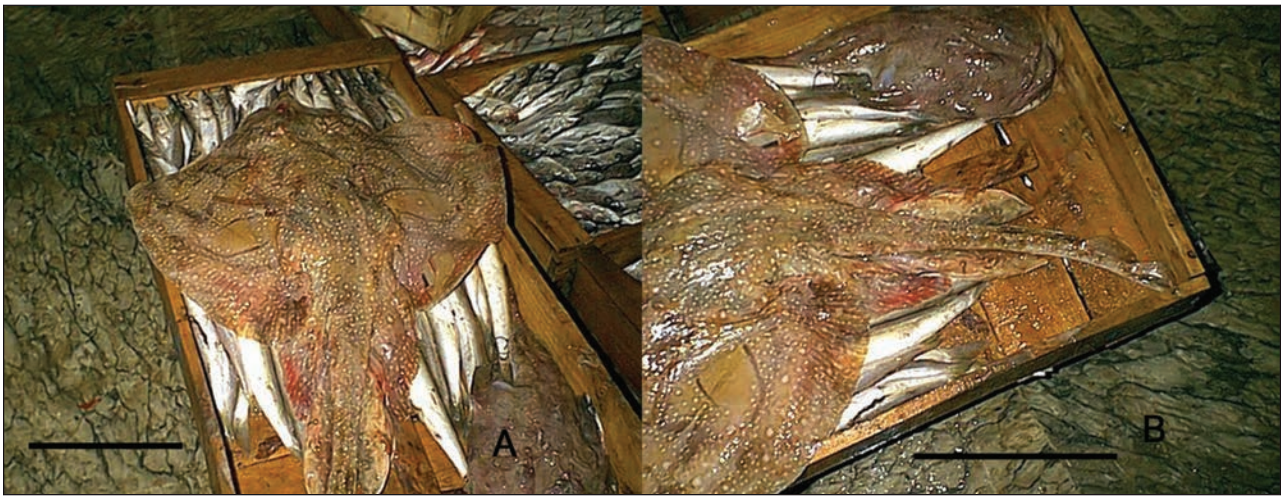

Fig. 2. Specimen of* Raja undulata *captured off Tipasa (2000). A. Anterior view, scale bar = 200 mm. B. Posterior view, scale bar = 200 mm (photos: Farid Hemida).
Sl. 2: Primerek vrste* Raja undulata*, ujet v vodah okoli Tipase (2000). A. Pogled na prednji del, merilo = 200 mm. B. Zadnji del, merilo = 200 mm (fotografije: Farid Hemida).

depth of 114 m on soft bottom, and included specimens of monkfish *Lophius piscatorius* Linnaeus, 1758 and hake *Merluccius merluccius* (Linnaeus, 1758). On 16 March 2019, new specimens, at least four, were caught off Tipasa, a town located in the central region of the Algerian coast at 36°41′18″ N and 2°27′14″ E (Fig. 1). The catches were made at a depth of 110 m on a sandy-rocky seabed partly covered with seaweed and algae, together with a slender rockfish *Scorpaena elongata* Cadenat, 1943, and a comber *Serranus cabrilla* (Linnaeus, 1758).

The *R. undulata* specimens were carefully examined and identified with the help of field guides in ichthyological fauna. They were photographed and, where possible, measured. It was generally difficult to obtain morphometric measurements, because the specimens were sliced and quickly sold by fishmongers for local consumption.

RESULTS AND DISCUSSION

The *R. undulata* specimen caught off Annaba was a large adult male with well-developed, rigid, and calcified claspers; it measured 501 mm disc width (DW), 792 mm total length (TL), and its total body weight (TBW) was estimated by the fish trader at 3200 g (Fig. 2). The specimens caught off Tipasa appeared to be females of similar size, of which a single specimen with 350 mm DW and 540 mm TL could be measured, but their TBW was estimated by the fishermen to be over 4000 g. It was assumed they were juveniles, based on Ellis *et al.* (2012) who found that females mature at a TL of 84 cm in Portuguese waters. However, it has been known since Leloup & Olivereau (1951) that there are latitudinal differences between Mediterranean and Atlantic elasmobranchs, with the former maturing at smaller sizes and reaching a smaller maximum length than the latter. These latitudinal differences have been confirmed by Mellinger (1989), Capapé *et al.* (2004), and Moreira *et al.* (2021). Nevertheless, currently, there are no studies on the reproductive biology of *R. undulata* in the Mediterranean Sea to compare sizes at first sexual maturity and maximum sizes between specimens from this sea and those from the Atlantic Ocean.

All the specimens examined were identified as *R. undulata* according to the following combination of morphological characters: disc broadly rounded, especially posterior margins, anterior margins very slightly concave opposite the spiracles and at the level of the eyes; snout short and blunt, tip prominent and rounded; mouth arched; dorsal surface covered with spines, except on the posterior part of the disc and pelvic fins, where rather smooth, snout and tail covered with dense spines; ventral surface smooth except on snout, disc margins, and tail; a discontinuous median series of spines spanning from end of body to first dorsal fin, three rows of spines on tail; dorsal surface ochre to greyish brown, with white spots and long wavy dark brown bands edged with light spots resembling pearl strings; ventral surface white except for the greyish brown end of tail.

The morphology and colouration are fully consistent with previous descriptions of *R. undulata* by Garman (1913), Clark (1926), Capapé & Desoutter (1979), Stehmann & Bürkel (1984), and Capapé *et al.* (2017). Therefore, the presence of the species from the Algerian coast can be considered confirmed, however, further

Fig. 3. Specimen of* Raja undulata *captured off Annaba (2019), scale bar = 50 mm (photo: Farid Hemida).
Sl. 3: Primerek vrste* Raja undulata*, ujet v vodah okoli Annabe (2019), merilo = 50 mm (foto: Farid Hemida).

records are needed before asserting that a viable population is successfully established in the area. Doumet (1860), Moreau (1881), and Quignard (1965) noted that *R. undulata* was quite common in the Mediterranean coast of France. Nevertheless, it appears that the species is only sporadically caught in the area, with merely a few specimens observed across several decades: two captured in 1992 (Capapé *et al.*, 2006), one captured in 2015 (Capapé *et al.*, 2017), and one photographed in the wild by Louisy (2002). Like other skates and rays, *R. undulata* develops *K*-selected biological characteristics (*sensu* McAuley *et al.*, 2007) and its vulnerability to fishing pressure contributes to the decline and rarity of its catches. It is very important to improve the sustainable efforts for preserving the species in this region, following Aldebert's recommendations (1997), and also in other Mediterranean regions.

R. undulata can easily be mistaken for its closely related species. Ellis *et al.* (2012) note that early accounts of British fishes did not include *R. undulata* because it was likely confused with the small-eyed ray *R. microocellata* Montagu 1818. Juveniles of rough ray *R. radula* Delaroche, 1807 display wavy dark bands on the dorsal surface similar to those of *R. undulata*, which has led to misidentification and erroneous reports of the latter species off Jalta, an island in northern Tunisia (Le Danois, 1925), as well as from the Gulf of Hammamet in central Tunisia (FAO, 1970) and, more recently, off the Libyan coast (Fitori *et al.*, 2023). An adult *R. radula* can easily be distinguished from a *R. undulata* by the presence of a circular eyespot with a dark centre surrounded by a yellowish inner ring and a brown outer ring (see Fig. 4).

In the Mediterranean, *R. undulata* appears to be captured more frequently in the western basin than in the eastern basin, where records for confirmation are sometimes unavailable (Capapé *et al.*, 2017). *R. undulata* is not a Mediterranean species *sensu stricto* and the occurrence of specimens is likely due to migrations from the eastern Atlantic through the Strait of

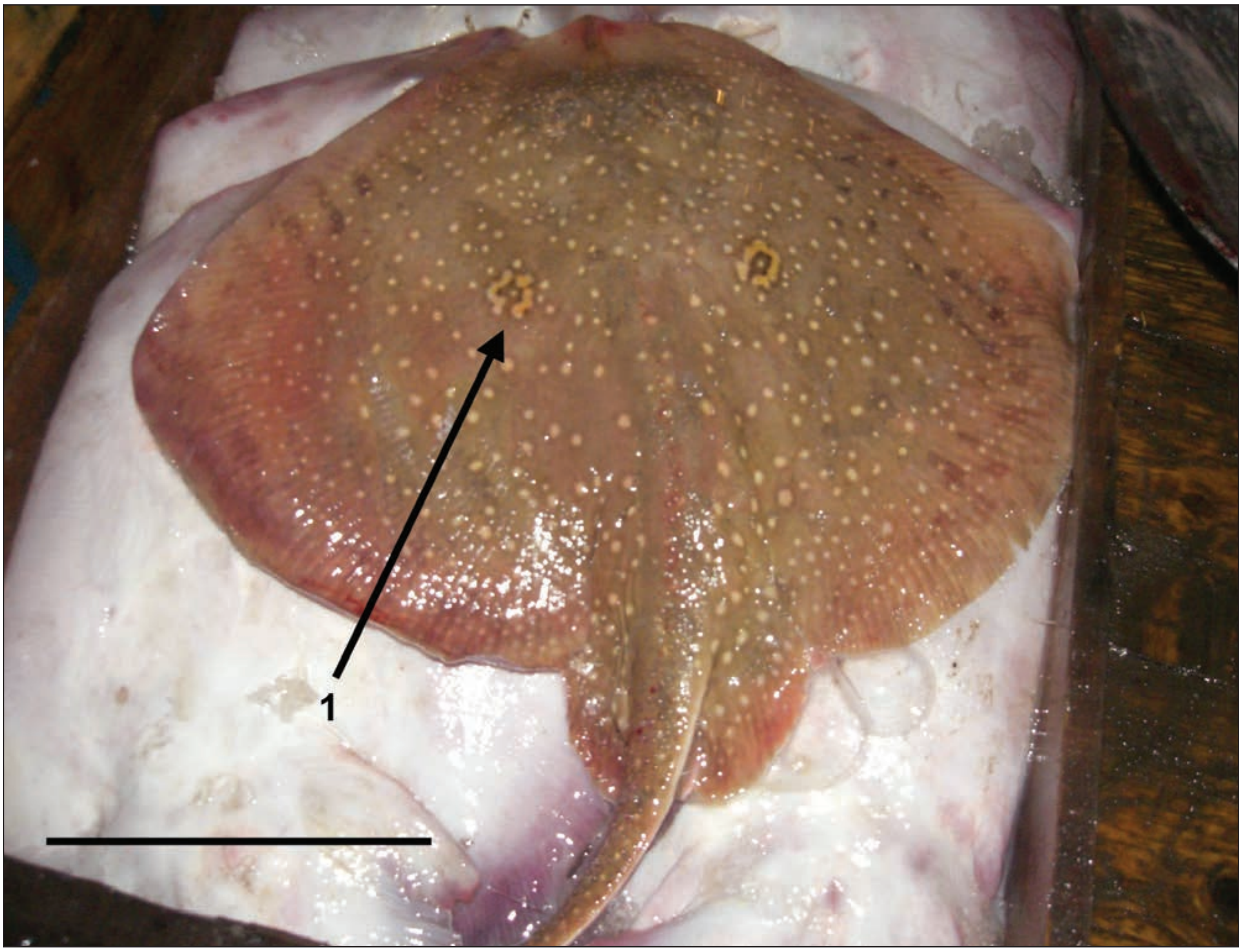

Fig. 4. Dorsal surface of the specimen of rough ray* Raja radula *Delaroche, 1809, captured off Annaba (2019), with the arrow (1) indicating a circular eyespot with a dark centre surrounded by a yellowish inner ring and a brown outer ring, scale bar = 200 mm (photo: Farid Hemida).
Sl. 4: Hrbtna površina primerka hrapave raže,* Raja radula *Delaroche, 1809, ujetega v vodah pri Annabi (2019), s puščico (1), ki kaže okroglo lažno oko s temnim središčem, rumenkastim notranjim obročem in rjavim zunanjim obročem, merilo = 200 mm (foto: Farid Hemida).

Gibraltar, where the species is relatively abundant in temperate waters (Ellis *et al*., 2012). This could explain why more specimens were recorded from the western than from the eastern coast of Algeria.

Furthermore, the decline and rarity of *R. undulata* catches can partly be attributed to climate change, as the warming of Mediterranean waters discourages new migrations of specimens (Ben Raïs Lasram & Mouillot, 2009), as well as to fishing pressure. Unfortunately, no statistical data are available in relation to the abundance and distribution of the species in the Mediterranean, unlike the situation in the eastern Atlantic (Ellis *et al*., 2012). Further in-depth studies employing biological tools are needed to provide new records of *R. undulata* and help determine the true status of this species in all regions of the Mediterranean Sea.

O POJAVLJANJU VALOVITO PROGASTE RAŽE, *RAJA UNDULATA* (RAJIDAE), IZ ALŽIRSKE OBALE (JUGOZAHODNO SREDOZEMSKO MORJE)

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POVZETEK

Avtorji poročajo o dosedanjih ulovih valovito progaste raže Raja undulata *Lacépède, 1802 ob alžirski obali. Navajajo primerek odraslega samca, ujetega ob Annabi na vzhodnem delu alžirske obale, ki je meril 501 mm v premeru diska (DW) in 792 mm v totalno dolžino (TL), telesno maso (TBW) pa so ocenili na 3200 g. Drugi primerki so bili ujeti v vodah pri Tipasi v osrednjem delu alžirske obale. V prispevku opisujejo primerke in razpravljajo ter komentirajo o pojavljanju te vrste na lokalnem prostoru in v širšem Sredozemskem morju.*

Ključne besede: Rajidae, *Raja undulata*, razširjenost, alžirska obala, selitev, vzhodni Atlantik, Sredozemsko morje

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received: 2023-12-07 DOI 10.19233/ASHN.2024.06

FIRST RECORD OF *HIMANTURA* MÜLLER & HENLE, 1837 IN LIBYAN WATERS: A COMPREHENSIVE DISCUSSION OF MISIDENTIFICATION ISSUES AND ECOLOGICAL IMPLICATIONS IN THE MEDITERRANEAN SEA

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ABSTRACT

The Dasyatidae family encompasses about a hundred stingray species distributed across the Atlantic, Indian, and Pacific Oceans. In the Mediterranean Sea, six stingray species are documented, including Himantura uarnak. *Despite records of the* Himantura *genus in the Mediterranean Sea since the 1950s, their existence remained largely unstudied until a comprehensive examination that revealed the presence of four species within the* H. uarnak *species complex, one of which is* Himantura leoparda. *This study marks the first documentation of the* Himantura *in Libyan waters. The finding was established based on three records between 2021 and 2023. Citizen science initiatives have played a significant role in detecting and tracking these stingray species in the Mediterranean. This research underscores the need for further investigation into the diversity and distribution of these enigmatic stingray species.*

Key words: taxonomical approach, Lessepsian immigrants, elasmobranchs, citizen science, stingray, biological invasions

PRIMA DOCUMENTAZIONE DI *HIMANTURA* MÜLLER & HENLE, 1837 NELLE ACQUE LIBICHE: DISCUSSIONE COMPLETA DI PROBLEMI DI IDENTIFICAZIONE ERRATA E IMPLICAZIONI ECOLOGICHE NEL MEDITERRANEO

SINTESI

La famiglia Dasyatidae comprende circa cento specie di razze, distribuite negli oceani Atlantico, Indiano e Pacifico. Nel Mediterraneo sono documentate sei specie di trigoni, tra cui Himantura uarnak. *Nonostante le segnalazioni del genere* Himantura *nel Mediterraneo fin dagli anni '50, la loro esistenza è rimasta in gran parte poco studiata fino ad un esame approfondito che ha rivelato la presenza di quattro specie all'interno del complex rappresentato da* H. uarnak, *tra cui* Himantura leoparda. *Questo studio segna la prima documentazione del genere* Himantura *nelle acque libiche. Tre avvistamenti tra il 2021 e il 2023 sono stati utilizzati per confermare questa scoperta. Le iniziative di citizen science hanno svolto un ruolo significativo nel rilevare e monitorare queste specie di trigoni nel Mediterraneo. Questa ricerca sottolinea la necessità di ulteriori indagini sulla diversità e distribuzione di queste enigmatiche specie di trigoni.*

Parole chiave: approccio tassonomico, migranti lessepsiani, elasmobranchi, citizen science, trigoni, invasioni biologiche

INTRODUCTION

The Dasyatidae family comprises 107 species across 19 genera of coastal marine, brackish, and freshwater fishes. In the Mediterranean Sea, only two species of the *Himatura* genus have been recorded to date (Ali *et al*., 2010, 2013; Myers *et al*., 2021), namely, *Himantura leoparda* Manjaji-Matsumoto & Last, 2008, and *Himantura uarnak* (Gmelin, 1789). This genus is marine and predominantly found in the Indo–West Pacific region.

The honeycomb stingray, *H. uarnak*, is a widely distributed Indo-Pacific species, documented from the Indo-Pacific to the Red Sea, eastern Africa to northern Africa, and the Philippines (McEachran & Capapé, 1984). Recent observations indicate its expansion from the Red Sea into the eastern Mediterranean through the Suez Canal (Golani *et al*., 2002). This species is a Lessepsian immigrant, reported from Turkish waters (Ben-Tuvia, 1966; Başusta *et al*., 1988), the Egyptian coast (El Sayed, 1994), and the Levant Basin (Mouneimne, 1977; Golani, 2005; Ali *et al*., 2010). *H. leoparda* has a widespread distribution in the tropical Indo-Pacific region, spanning from South Africa, eastern India, and Sri Lanka, through southern India, including the Philippines, southern Japan, Taiwan, New Guinea, and northern Australia from Coral Bay to the Cape York Peninsula (Manjaji-Matsumoto & Last, 2008). Similarly to its close relative *H. uarnak*, *H. leoparda* has entered the Mediterranean Sea through the Suez Canal, with its first recorded appearance off the Turkish coast (Yucel *et al*., 2017). Subsequently, a second record was documented from the coast of Lebanon (Bariche *et al*., 2020).

These two species are part of the *H. uarnak* species complex that includes *H. leoparda*, *H. tutul*, *H. uarnak*, and *H. undulata* (Borsa *et al*., 2013; Last *et al*., 2016). The species of this complex, while exhibiting similar general morphological and chromatic characteristics, can be differentiated through accurate analysis of specific features (e.g., color pattern on dorsal surface, arrangement of mid-scapular denticles, disc shape).

Drawing from citizen science contributions, we report herein the first observation of the *Himantura* genus in Libyan waters. We discuss the likely introduction pathway of these specimens in the Mediterranean Sea, highlighting the importance of citizen science initiatives in the early detection and monitoring of non-native fishes in the region.

MATERIAL AND METHODS

Three separate occurrences of the *Himantura* genus have been documented in the waters off Libya between 2021 and 2023, using a combination of citizen science and social media. The first record, reported on 15 July 2021, involved the capture of an individual by longline gear at a depth of 54 m near the Al-Tamim coastline in eastern Libya (Fig. 1a). A second sighting occurred on 12 July 2023, when a recreational fisherman shared a live stream on his Facebook account, revealing an adult male of the *Himantura* sp. caught in a set gill net at a depth of 15 m in the Gulf of Bomba (Fig. 1b). Most recently, on 18 August 2023, an underwater video footage by a spearfisher showed a *Himantura* sp. specimen swimming at a depth of 7 m off Ras Alteen in eastern Libya (see the video in supplementary material).

RESULTS

Given that all the three reports were documented solely through photos or videos, without the possibility of physically examining the animal, a cautious approach was warranted. This decision was influenced by the substantial difficulty arising from the great similarities displayed by the species within this genus and the identification errors that had occurred in previous studies. For these reasons, it was decided we would refrain from specifying the species and maintain identification at the genus level. All the specimens were captured/observed in coastal shallow waters, in the depth range of 7–54 m.

The genus *Himantura* is characterized by the following features (Last *et al*., 2016): large size, with adults reaching 130–160 cm disc width (DW); a robust, sub-oval to rhombic disc with a broadly rounded to narrowly angular pectoral-fin apex; snout broadly angular and moderately elongate (1.7–2.8 times combined orbit and spiracle length), the eye small and protruding. Nasal curtain broadly skirt-shaped, mouth narrow with 4–5 oral papillae (lateral papillae always present). Tail very long and whip-like (length 2.5–3.7 times disc width), with a narrow and oval to almost circular base in cross-section. Pelvic fins small and almost entirely concealed by the disc. Dorsal fold and ventral folds absent, caudal sting close to tail base (distance from pectoral-fin insertion to caudal sting base is 1.7–2.3 times interspiracular width). With 1–3 thorns in mid-scapular region or in row on nape, and no other scapular thorns present. Denticle band well-developed and with a diffused edge, patchy dermal denticles on the rest of the disc in adults. No enlarged median thorns on tail, but small thorns and denticles present posteriorly in adults. Dorsal surface with strong color pattern (spots, ocelli, and/or reticulations), ventral surface white. Posterior tail typically banded in young individuals.

Not all of these characteristics were visible or examinable in the available photos and video, due to the long distance at which the animal was observed

Fig. 1: New records of the genus* Himantura *in the Mediterranean Sea (Libya): a) specimen caught on 15 July 2021; b) specimen caught on 12 July 2023.
Sl. 1: Novi podatki o pojavljanju vrst iz rodu* Himantura *v Sredozemskem morju (Libija): a) primerek ulovljen 15. julija 2021; b) primerek ulovljen 12. julija 2023.

(video) and the fact that the specimens were unfortunately damaged and only visible dorsally (photos). Nevertheless, based on the discernible color pattern and the overall body morphology we could still confidently identify the genus as *Himantura*.

DISCUSSION

Although the number of cartilaginous alien fish recorded in the Mediterranean Sea is significantly lower than that of their bony counterparts, their impact on the ecosystem could be dramatically more substantial (Bradai *et al.*, 2012). The settlement of the *Himantura* in Libyan waters, documented through photographic and video materials, raises significant concerns regarding the repercussions of these non-native mesopredators on the native fauna of the coastal Mediterranean marine ecosystem. Mesopredators are organisms positioned in the middle of the food chain and are typically carnivorous (Peterson *et al.*, 2001; Tiralongo *et al.*, 2020a). The intrusion of non-native mesopredators into marine ecosystems can have multifaceted consequences (Ingeman, 2016). Firstly, the mesopredator can exert direct predation pressure on native species, potentially leading to changes in population dynamics and community structure. Native organisms lacking evolutionary adaptations to cope with the alien predator may experience elevated predation risk, which can lead to population declines or changes in behavior and distribution patterns due to competition with non-indigenous species. Secondly, the ingression of a mesopredator can have indirect effects on native fauna through trophic interactions. Changes in the abundance or behavior of one species can trigger cascading effects throughout the ecosystem, influencing the abundance and behavior of other species.

Overall, the potential implications of such species for native fauna underscore the importance of closely monitoring the spread and impact of mesopredators like *Himantura* in the Mediterranean Sea. Understanding ecological interactions and dynamics is crucial for implementing effective management and conservation strategies aimed at mitigating any negative effects on the native marine ecosystem.

However, the main challenge lies in resolving the taxonomic ambiguity associated with the two *Himantura* species found in the Mediterranean, namely *H. leoparda* and *H. uarnak*. In fact, the morphological and color similarities between the two species compromise classification accuracy and have likely contributed to past misidentifications (Borsa *et al.*, 2013; Last *et al.*, 2016). Therefore, further taxonomic investigations are required that will encompass both morphological and chromatic analyses, and, above all, genetic studies. This comprehensive approach is necessary to ensure proper species identification and determine the abundance and Mediterranean distribution of the species. Notably, the risk of misidentification may extend to other similar species within the genus *Himantura* currently unreported, but possibly present in the Mediterranean Sea. Knowledge about their distribution and behavior is crucial for informing effective management and conservation strategies and for a comprehensive understanding of the ecological impact of these elusive alien species on the Libyan marine ecosystem and the broader region. In this regard, some authors have already underscored the invaluable role of citizen scientists and the social media in data collection, enhancing the understanding of marine ecosystems, and aiding in the detection of invasive species (Azzurro & Tiralongo, 2020; Tiralongo *et al.,* 2020b; Al Mabruk *et al.,* 2021). This collaborative effort not only promotes scientific engagement but also enriches the dataset of records on species of interest, offering a more comprehensive perspective on the presence, behavior, and potential ecological impacts of non-indigenous species in the Mediterranean Sea. Finally, the most plausible explanation for the presence of these species in Mediterranean waters, considering their natural distribution range, is their ingression through the Suez Canal.

Supplementary material: https://archive.org/details/395291011-6731596236895022-4453523919132992277-n

PRVI ZAPIS O POJAVLJANJU RODU *HIMANTURA* MÜLLER & HENLE, 1837 V LIBIJSKIH VODAH: CELOSTNA RAZPRAVA O PROBLEMU NAPAČNE IDENTIFIKACIJE IN EKOLOŠKIH POSLEDICAH V SREDOZEMSKEM MORJU

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POVZETEK

Morski biči (družina Dasyatidae) štejejo približno 100 vrst, ki so razširjene v Atlantskem, Indijskem in Tihem oceanu. Sredozemsko morje naseljuje šest vrst, vključno z vrsto Himantura uarnak. *Čeprav obstajajo zapisi o pojavljanju vrst iz rodu* Himantura *v Sredozemskem morju že od leta 1950, je bilo pojavljanje tega rodu v veliki meri neraziskano, dokler ni celovita raziskava razkrila obstoj štirih vrst v kompleksu vrste* H. uarnak, *med katerimi je tudi vrsta* Himantura leoparda. *Pričujoča raziskava je obelodanila prvo pojavljanje vrst iz rodu* Himantura *v libijskih vodah. Temelji na treh najdbah v obdobju med 2021 in 2023. Pri odkrivanju in sledenju teh vrst morskih bičev v Sredozemskem morju je imela pomembno vlogo ljubiteljska znanost. Ta raziskava narekuje potrebo po nadaljnjih raziskavah pestrosti in razširjenosti teh enigmatičnih morskih bičev.*

Ključne besede: taksonomski pristop, lesepske selivke, hrustančnice, ljubiteljska znanost, morski biči, bioinvazija

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received: 2024-02-01 DOI 10.19233/ASHN.2024.07

RECENT OCCURRENCES OF *RHINOPTERA MARGINATA* AND *MOBULA MOBULAR* IN TURKISH AEGEAN AND MEDITERRANEAN WATERS

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ABSTRACT

The monitoring of commercial fisheries and internet media screening have revealed recent captures of the Lusitanian cownose ray, Rhinoptera marginata *(Geoffroy St. Hilaire, 1817), and the devil fish,* Mobula mobular *(Bonnaterre, 1788), in Turkish Aegean and Mediterranean waters. The capture ratios of 0.56 individuals/year for* R. marginata *over a 25-year period and 0.74 individuals/year for* M. mobular *over a 51-year period confirm that the occurrence of both batoids in Turkish waters is rare. Although further research is required, available data suggest that the Bay of İskenderun could represent a feeding or nursery ground or perhaps only a migration corridor for* R. marginata. Similarly*, the zooplankton-rich summer waters of the Bay of Antalya could serve as a feeding ground for* M. mobular.

Key words: Myliobatiformes, rarity, vulnerability, batoids

PRESENZA RECENTE DI *RHINOPTERA MARGINATA* E *MOBULA MOBULAR* NELLE ACQUE TURCHE DELL'EGEO E DEL MEDITERRANEO

SINTESI

Il monitoraggio della pesca commerciale e lo screening dei media su Internet hanno rivelato la recente cattura di Rhinoptera marginata *(Geoffroy St. Hilaire, 1817)* e *di* Mobula mobular *(Bonnaterre, 1788) nelle acque turche del Mar Egeo e del Mediterraneo. I rapporti di cattura di 0,56 individui/anno per* R. marginata *in un periodo di 25 anni e di 0,74 individui/anno per* M. mobular *in un periodo di 51 anni confermano che la presenza di entrambi i batoidi nelle acque turche è rara. Sebbene siano necessarie ulteriori ricerche, i dati disponibili suggeriscono che la baia di İskenderun potrebbe rappresentare una zona di alimentazione o di nursery o forse solo un corridoio di migrazione per* R. marginata*. Allo stesso modo, le acque estive della baia di Antalya, ricche di zooplancton, potrebbero servire come area di alimentazione per* M. mobular.

Parole chiave: Myliobatiformes, rarità, vulnerabilità, batoidi

INTRODUCTION

The Mediterranean Sea is a hot spot for marine biodiversity and a complex region, with approximately 17,000 marine species and strong interaction of ecological and human influences (Coll *et al.*, 2010). Among the 759 confirmed species of marine fishes reported to inhabit the Mediterranean Sea in an updated and evidence-based checklist (Kovačić *et al.*, 2021), there are 88 species of chondrichthyans (sharks, batoids, and chimaeras) representing 11.59% of the regional ichthyofauna, which makes the Mediterranean Sea a "chondrichthyan-rich" basin (Serena *et al.*, 2020; Barone *et al.*, 2022). When considering chondrichthyan diversity in the Mediterranean Sea, there are 38 species of batoids accounting for 43.18% of the total chondrichthyan fauna, with a greater richness of batoids (79%) in the eastern Mediterranean (Serena *et al.*, 2020).

Contrary to this description of the eastern basin being a "batoid-rich region", the results of the International Mediterranean Trawl Survey (MEDITS) conducted in this area during the 2012–2015 period show no records of two batoid species (GSAs 22, 23 and 25; Follesa *et al.*, 2019), namely: *Rhinoptera marginata* (Geoffroy St. Hilaire, 1817) (Myliobatiformes: Rhinopteridae) and *Mobula mobular* (Bonnaterre, 1788) (Myliobatiformes: Mobulidae). However, several regional studies have recently revealed that these two batoids have been captured in Turkish Aegean and eastern Mediterranean waters as bycatch in commercial fisheries (Başusta *et al.*, 2012; Ceyhan & Akyol, 2014; Yağlıoğlu *et al.*, 2015; Başusta & Özgür Özbek, 2017). Since the batoids in question are considered either rare (*R. marginata*) or vulnerable (*M. mobular*) (GFCM, 2018), filling the gaps in the knowledge about these species and collecting photographic evidence of them is of critical importance (Tsikliras & Dimarchopoulou, 2021; Barone *et al.*, 2022). The present article reports recent occurrences of *R. marginata* and *M. mobular* in the Aegean and eastern Mediterranean waters of Turkey, enhancing their data-deficient records with new information, and providing a review of previous sightings or captures of the two species in the mentioned region.

MATERIAL AND METHODS

Study area

The described specimens (*Rhinoptera marginata* and *Mobula mobular*) have been sighted or captured in the northern Aegean Sea and the eastern Mediterranean Sea, which are defined as geographical subareas (GSAs) 22 and 24, respectively, by the General Fisheries Commission for the Mediterranean (GFCM) (Fig. 1).

Data acquisition

Data on *R. marginata* bycatch throughout the marine area extending from Foça (GSA 22) to Silifke (GSA 24) were acquired from WWF-Türkiye observers or collaborating fishers. Furthermore, the data and images of a single specimen of *M. mobular* sighted off Gökçeada (northeastern part of GSA 22) and the related video footage uploaded to the website of a mainstream news portal by a commercial swordfish harpooner were obtained from the following link: https://www.aa.com.tr/tr/turkiye/nesli-tehlike-altinda-olan-dev-vatoz-gokceadada-goruntulendi/1846028. The Image Capture function of the VLC Media Player was used to capture still images of *M. mobular* (Fig. 2) from the video footage. The present study was supported by the WWF-Türkiye Wildlife Programme within the scope of the Cartilaginous Fish (Chondrichthyes) Data Generation project.

The photographs of *R. marginata* specimens and the video footage of *M. mobular* are stored in the archive of the first author and are available on request for further inspection. Since online communities and website administrators may react negatively to researchers using their online content, all internet content scraping activity was performed responsibly, following the ethical code proposed by Monkman *et al.* (2017), to avoid compromising any personal data or images. Species identification follows Barone *et al.* (2022), and taxonomic nomenclature follows Froese and Pauly (2024). The IUCN Red List status of the elasmobranchs identified in the Mediterranean Sea is aligned with Otero *et al.* (2019). The evidence criteria for occurrences are based on Kovačić *et al.* (2020). The basic data, such as disc width (DW, cm), sex, type of fishing gear, and location of capture, were obtained from WWF-Türkiye observers or through collaboration with local fishers. The review of previous sightings or captures of *R. marginata* and *M. mobular* in Turkish waters is based on the literature available and presented in Table 1 (Geldiay, 1969; Ulutürk, 1987; Başusta, 1998; Kabasakal, 2002; Başusta *et al.*, 2012; Ceyhan & Akyol, 2014; Yağlıoğlu *et al.*, 2013, 2015; Başusta & Özgür Özbek, 2017; Gönülal & Güreşen, 2017).

RESULTS

Description of the examined specimens

Rhinoptera marginata (Geoffroy St. Hilaire, 1817)

Transversally lozenge-shaped disc with sharply angled outer corners; head elevated from disc, with

Fig. 1: Localities of past and present sightings or captures of** Rhinoptera marginata **(above) and** Mobula mobular **(below) in Turkish waters. The numbers on the maps correspond to those in Table 1. Illustrations of species in the lower left corner of each map are adapted from Serena (2005).

Sl. 1: Lokalitete recentnih in novejših opazovanj ali ulova vrst** Rhinoptera marginata **(zgoraj) in** Mobula mobular **(spodaj) v turških vodah.

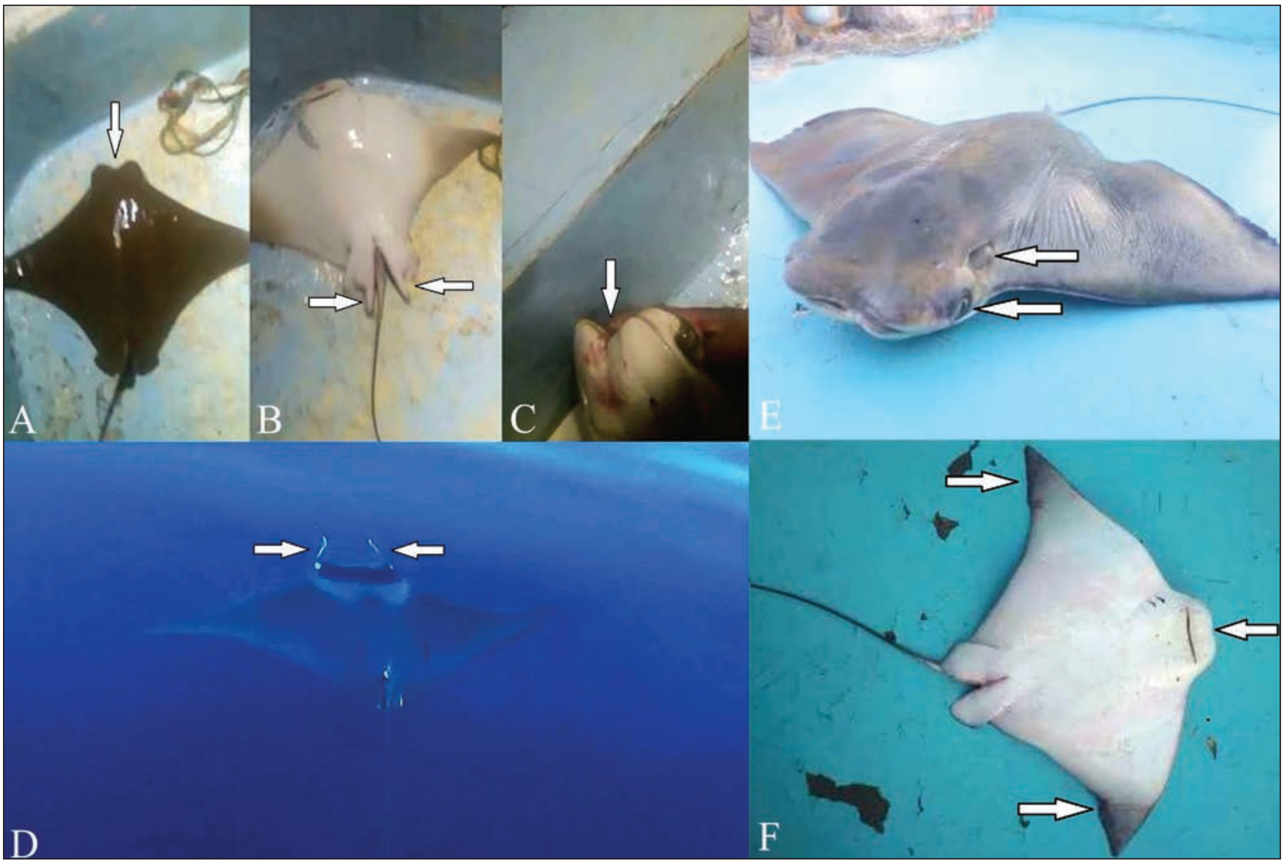

Fig. 2: Recent images of *Rhinoptera marginata* ***(sp. 13 and 14 in Tab. 1 and Fig. 1) and*** *Mobula mobular* ***(sp. 38 in Tab. 1 and Fig. 1) individuals. Definitions of arrows: in A and C, ↓ points at the concave front edge of the head resulting in a deeply incised subrostral lobe; in B, → and ← indicate the claspers of*** *R. marginata* ***(sp. 13 in Table 1); in D, → and ← indicate the cephalic fins of*** *M. mobular* ***(sp. 38 in Table 1); in E, top ← indicates a laterally located spiracle, bottom ← points at the eye; in F, → indicate sharp and darker tips of the pectoral fins, and ← indicates the concave front edge of the head of*** *R. marginata* ***(sp. 14 in Table 1) (Photos: archives of WWF Turkey).***

Sl. 2: Recentni posnetki primerkov vrst *Rhinoptera marginata* ***(primerka 13 in 14 v Tab. 1 in Sl. 1) in*** *Mobula mobular* ***(primerek 38 v Tab. 1 in Sl. 1). Razlaga puščic: v A in C, ↓ kaže na konkavni prednji rob glave in globoko zajedo subrostralne krpe; v B, → in ← kažeta klasperja primerka vrste*** *R. marginata* ***(primerek 13 v Tab. 1); v D, → in ← kažeta naglavna izrastka primerka vrste*** *M. mobular* ***(primerek 38 v Tab. 1); v E, zgoraj ← kaže spirakel na boku, spodaj ← označuje oko; v F, → označujeta ostri in temni konici prsnih plavuti, in ← kaže konkavni prednji rob glave primerka vrste*** *R. marginata* ***(primerek 14 v Tab. 1) (Fotografije: arhiv WWF Turkey).***

eyes and spiracles located on sides; snout short, with short subrostral lobe deeply notched medially. Colour uniformly greenish brown to bronze dorsally; underside whitish, with disc margins and wing tips darker, tail dark (Fig. 2).

Mobula mobular (Bonnaterre, 1788)

Very broadly lozenge-shaped disc with very broad head marked off from the body disc; anterior parts of pectoral fins separated from pectoral wings to form two long, thin, vertically oriented cephalic fins; small dorsal fin on tail base level with inner pelvic fin margins. Dorsal surface plain brown to bluish-black, sometimes with a blackish collar across the head; underside white, but dark spots and blotches may occur (Fig. 2).

Sighting or capture data related to unpublished specimens

On 20 June 2021, a male of *R. marginata* was incidentally captured by a commercial bottom long-liner in the Bay of Antalya and released alive. Since the claspers of the specimen were hard and longer than the tips of the pelvic fins, the individual

Tab. 1: Review of past and present sightings and captures of *Mobula mobular* **and** *Rhinoptera marginata* **in Turkish waters. Abbreviations as follows: NEAS, northeastern Aegean Sea; NEMS, northeastern Mediterranean Sea; CAS, central Aegean Sea; M, male; F, female. Evidence criteria based on Kovačić** *et al.* **(2020) are as follows: (1) collection-verified presence, (2) publication-evidence from photo, (3) publication - expert providing individual collected data, (4) publication - expert performing broad study.**

Tab. 1: Pregled historičnih in današnjih opazovanj in ulovov vrst *Mobula mobular* **in** *Rhinoptera marginata* **v turških vodah. Okrajšave: NEAS, severovzhodno Egejsko morje; NEMS, severovzhodno Sredozemsko morje; CAS, centralno Egejsko morje; M, samec; F, samica. Na dokazih temelječi podatki sledijo kriterijem po Kovačić in sod. (2020): (1) prisotnost v zbirki, (2) fotografija v objavi, (3) objava - podatke zagotovil strokovnjak, (4) objava - strokovnjak je opravil obsežno raziskavo.**

Rhinoptera marginata (Geoffroy St. Hilaire, 1817)								
No	**Date**	**Locality**	**DW (cm)**	**Sex**	**Type of fishing gear**	**Type of record**	**Criteria**	**Remarks**
1	Before 1996	Bay of İskenderun NEMS	63.2	---	Pelagic trawl	Capture	3	Published in Başusta (1998)
2-4	Before 1999	Gökçeada NEAS	---	---	Trammel net	Capture	4	Published in Kabasakal (2002)
5-8	Before 1999	Off Kuşadası CAS	---	---	---	Capture	4	Published in Kabasakal (2002)
9	Before 2010	Bay of İskenderun NEMS	---	---	Bottom trawl	Capture	3	Published in Yağlıoğlu *et al.* (2015)
10	December 2010	Bay of İskenderun NEMS	82.4	F	Bottom trawl	Capture	3	Gravid female carrying one near-term pup in the uterus, published in Başusta *et al.* (2012)
11	December 2010	Bay of İskenderun NEMS	87.4	F	Bottom trawl	Capture	3	Gravid female carrying one near-term pup in the uterus, published in Başusta *et al.* (2012)
12	April 2011	Bay of İskenderun NEMS	23	M	Bottom trawl	Capture	3	Near term embriyon, published in Başusta *et al.* (2012)
13	20 Jun 2021	Bay of Antalya NEMS	---	M	Bottom long line	Capture	2	Unpublished record by WWF Türkiye MedBycatch observers, released alive (Fig. 2)
14	21 Oct 2021	Bay of Antalya NEMS	---	---	Gill net	Capture	2	Unpublished record by WWF Türkiye MedBycatch observers, captured at a depth of 46 m (Fig. 2)
Mobula mobular **(Bonnaterre, 1788)**								
No	**Date**	**Locality**	**DW (cm)**	**Sex**	**Type of fishing gear**	**Type of record**	**Criteria**	**Remarks**
1	Before 1969	Bay of İzmir CAS	---	---	---	Capture	3	Published in Geldiay (1969)
2	2 Jun 1980	Gökçeada NEAS	---	---	---	Capture	1	Taxidermied cephalic part is preserved in the field museum of Gökçeada with registration number PSC20170513-31. Mentioned in Ulutürk (1987) and Gönülal & Güreşen (2017)
3	Before 1999	Bozcaada NEAS	---	---	---	Sighting	4	Published in Kabasakal (2002)
4	Before 1999	Bay of Antalya NEMS	---	---	---	Sighting	4	Published in Kabasakal (2002)
5	18 Mar 2012	Bay of İskenderun NEMS	140.4	M	Purse seining	Capture	3	Single specimen released alive, published in Yağlıoğlu *et al.* (2013)
6	Before 2013	Off Fethiye NEMS	---	---	Swordfish long line	Capture	3	Single specimen released alive, published in Ceyhan & Akyol (2014)
7-36	10 Mar 2017	Bay of Antalya NEMS	---	---	Purse seining	Capture	1	Published in Başusta & Özgür Özbek (2017). Detailed morphometric measurements are available in the relevant reference, and DWs of 1 male and 1 female were 272 cm and 270 cm, respectively, which are currently are on display at Marine Biology Museum of the Antalya, Metropolitan Municipality
37	Summer 2019	Gökçeada NEAS	---	---	---	Sighting	4	Unpublished record
38	19 May 2020	Gökçeada NEAS	~200	---	---	Sighting	2	Unpublished record, sighted by commercial swordfish harpooner nearly 10 km off northeastern coast of Gökçeada, where the water depth was 400-500 m (Fig. 2)

was assumed to be a mature male. On 21 October 2021, a second Lusitanian cownose ray was captured by a commercial gill-netter in the Bay of Antalya at a depth of 46 m.

In summer 2019, a single specimen of *M. mobular* was sighted by a swordfish harpooner off the northern coast of the island of Gökçeada. On 19 May 2020, a second devil fish with an estimated DW of about 200 cm was sighted by the same fisher nearly 10 km off the northeastern coast of Gökçeada, where the water depth ranged between 400 and 500 m.

DISCUSSION AND CONCLUSIONS

The descriptions of the observed specimens are consistent with those for *R. marginata* and *M. mobular* provided by Ebert and Stehmann (2013) and Barone *et al.* (2022). The review of available data has revealed that 14 Lusitanian cownose rays (prior to the 1996–2021 period) and 38 devil fishes (prior to the 1969–2020 period) were sighted or captured in Turkish Aegean and Mediterranean waters (Tab. 1). The bycatch of both batoid species in commercial fishing in Turkish Aegean and Mediterranean waters has also been mentioned in previous studies (Başusta, 1998; Kabasakal, 2002; Başusta *et al.*, 2012; Ceyhan & Akyol, 2014; Yağlıoğlu *et al.*, 2013, 2015; Başusta & Özgür Özbek, 2017). Considering the periods in which the species were sighted or captured, the capture ratios of 0.56 individuals/year for *R. marginata* over a 25-year period and 0.74 individuals/year for *M. mobular* over a 51-year period confirm that the occurrence of both batoids in Turkish waters is rare.

Available literature and recent captures confirm the contemporary occurrence of *R. marginata* in Turkish seas (Başusta *et al.*, 1998; Kabasakal, 2002; Başusta *et al.*, 2012; Bilecenoğlu *et al.*, 2014; Yağlıoğlu *et al.*, 2015); however, the population status of this species in the region has not been investigated, which is true for the Mediterranean as a whole (Ferretti *et al.*, 2016). *R. marginata* is rare in the Mediterranean and was only found in two out of 6,336 hauls made (in the eastern Ionian Sea) during the first phase of the International Trawl Survey (MEDITS) conducted between 1994 and 1999 at depths of 10–800 m (Baino *et al.*, 2001). In the second phase of the MEDITS survey (2012–2015), *R. marginata* was not found at all (Follesa *et al.*, 2019). Judging from the available literature and recent captures, *R. marginata* appears to occur mostly in the eastern Mediterranean basin (Başusta *et al.*, 1998; Kabasakal, 2002; Başusta *et al.*, 2012; Yağlıoğlu *et al.*, 2015), but the available data are insufficient to estimate its population trends. Based on an incidental capture of two gravid females and one near-term embryo, Başusta *et al.* (2012) assumed that the Bay of İskenderun may be a nursery ground for *R. marginata* in the northeastern Mediterranean Sea. According to Yağlıoğlu *et al.* (2015), the Bay of İskenderun may also serve as a feeding ground or merely as a migration corridor. Further evidence is required to confirm any of these assumptions.

Although recent sightings of *M. mobular* have consisted of solitary specimens, the species is known to aggregate in certain regions of the eastern Mediterranean Sea (e.g. in the Bay of Antalya and off the Gaza Strip), where it is targeted (Abudaya *et al.*, 2017) or captured as bycatch (Başusta & Özgür Özbek, 2017) in commercial fishing. Başusta and Özgür Özbek (2017) reported a capture of 30 devil fishes (sp. 7–36 in Table 1) in commercial purse-seining in the Bay of Antalya on 10 March 2017, while not speculating on the reasons for the mass capture. In a recent study investigating the distribution and community structure of surface water mesozooplankton in this area during summer, İşinibilir *et al.* (2022) identified 157 species/groups, with copepods, cladocerans, doliolids, meroplankton, and appendicularians representing the most important zooplankton groups. Since *M. mobular* is a filter-feeding epi- and benthopelagic ray (Ebert & Stehmann, 2013), the zooplankton-rich summer waters of the Bay of Antalya may serve as a feeding ground for the species. A similar assumption was made for another filter-feeding elasmobranch, the basking shark, *Cetorhinus maximus* (Gunnerus, 1765), which inhabits the neighbouring Bay of Mersin, where the annual average zooplankton biomass in coastal waters has been found to be about nine times higher than in open waters (Zenginer & Beşiktepe, 2007; Kabasakal, 2013). In the Adriatic Sea, occurrences of *M. mobular* have also been related to the spatial distribution of schools of small pelagic teleosts, such as sardines and anchovies (Holcer *et al.*, 2013).

The Bay of Antalya incident of 10 March 2017 notwithstanding, the largest mass capture of *M. mobular* in the eastern Mediterranean Sea occurred in February 2013, off the shores of the Gaza Strip, when over 200 giant devil fish were landed by fishers (Abudaya *et al.*, 2017). Although the capture off the Gaza Strip was erroneously reported as a 'mass stranding' event, it was, according to Abudaya *et al.* (2017), actually an instance of seasonal, local opportunistic target fishery that served as an important source of local consumption. Mancusi *et al.* (2020) also ascribed the highest occurrence of *M. mobular* off the Gaza Strip to two specific events in March 2006 and February 2013, when 279 and 299 specimens were landed, respectively.

Whether captured as solitary individuals or in masses, every individual of *R. marginata* and *M. mobular* captured increases the risk to their populations in the entire Mediterranean Sea. According to Dulvy *et al.* (2021), overfishing alone affects 67.3% of the 1,199 chondrichthyan species worldwide, and cannot be ruled out for the Mediterranean Sea either (Carpentieri *et al.*, 2021). In the Mediterranean-specific risk assessment, *R. marginata* has been classified as "data deficient" and *M. mobular* as "endangered" (Otero *et al.*, 2019). Currently, only *M. mobular* is protected by law in Turkish waters. To ensure better management of both batoids, their breeding and nursery grounds, as well as areas of seasonal aggregations should be identified and fishers should be encouraged to release incidentally captured individuals alive. From this perspective, the recently announced Important Shark and Ray Areas (ISRAs) in GSAs 22 and 24 may be the beginning of a process that will protect critically endangered rare batoids from commercial fishing pressure (Jabado *et al.* 2023).

ACKNOWLEDGMENTS

Authors thank commercial fishers for generously sharing their experiences and field observations. Special thanks go to two anonymous reviewers for their comments, which improved the content and quality of the manuscript.

RECENTNO POJAVLJANJE VRST *RHINOPTERA MARGINATA* IN *MOBULA MOBULAR* V TURŠKIH EGEJSKIH IN SREDOZEMSKIH VODAH

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POVZETEK

Monitoring komercialnega ulova in pregled spletnih medijev je razkril recentne ulove kravjenosega skata, Rhinoptera marginata *(Geoffroy St. Hilaire, 1817), in sredozemske mante,* Mobula mobular *(Bonnaterre, 1788), v turških egejskih in sredozemskih vodah. Letni ulov, ki je bil pri vrsti* R. marginata *0,56 osebkov/leto v obdobju 25 let, in pri vrsti* M. mobular *0,74 osebkov/leto v obdobju 51 let, je potrdil, da sta v turških vodah obe vrsti skatov redki. Čeprav so potrebne nadaljnje raziskave, razpoložljivi podatki kažejo, da bi lahko zaliv Iskenderun predstavljal prehranjevalno okolje, jaslice, ali morda selitveni koridor za vrsto* R. marginata*. Podobno bi lahko bile v poletnem času z zooplanktonom bogate vode Antalijskega zaliva pomembno prehranjevalno okolje za vrsto* M. mobular.

Ključne besede: Myliobatiformes, redkost, ranljivost, skati

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received: 2023-12-15 DOI 10.19233/ASHN.2024.08

ON THE OCCURRENCE OF THE GREATER PIPEFISH *SYNGNATHUS ACUS* LINNAEUS, 1758 IN THE SOUTH-EASTERN MEDITERRANEAN, TURKEY

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ABSTRACT

On 28 October 2022, one specimen of the greater pipefish Syngnathus acus *Linnaeus, 1758 was captured in Cevlik, Bay of Iskenderun (south-eastern Mediterranean Sea, Turkey) by a commercial trawler at a depth of 18 m. This paper reports the first occurrence of* S. acus *in the Bay of Iskenderun, confirming the presence of the species in the area, and represents one of the rare occurrences of* S. acus *on the eastern Mediterranean coast of Turkey, in general. All measurements, counts, and color descriptions of the* S. acus *specimen agree with previous descriptions of the species.*

Key words: Sygnathidae, pipefish, conservation, Iskenderun Bay, Mediterranean Sea

PRESENZA DEL PESCE AGO *SYNGNATHUS ACUS* LINNAEUS, 1758 NEL MEDITERRANEO SUD-ORIENTALE, TURCHIA

SINTESI

Il 28 ottobre 2022, un esemplare di pesce ago Syngnathus acus *Linnaeus, 1758 è stato catturato a Cevlik, nella baia di Iskenderun (Mediterraneo sud-orientale, Turchia) da un peschereccio a strascico commerciale, a una profondità di 18 m. Il presente lavoro riporta la prima segnalazione di* S. acus *nella baia di Iskenderun, confermando la presenza della specie nell'area, e rappresenta una delle rare presenze di* S. acus *lungo la costa mediterranea orientale della Turchia. Tutte le misure, i conteggi e le descrizioni dei colori dell'esemplare di* S. acus *concordano con le precedenti descrizioni della specie.*

Parole chiave: Sygnathidae, pesce ago, conservazione, baia di Iskenderun, Mediterraneo

INTRODUCTION

Pipefishes (*Syngnathus*) are a genus group in the diverse family of the Syngnathidae, consisting of 34 species with a worldwide geographical range (Dawson, 1986; Kuiter, 2001; Froese & Pauly, 2023).

The greater pipefish *Syngnathus acus* Linnaeus, 1758 is one of the nine species of the *Syngnathus* genus found in the Mediterranean (Dawson, 1986; IUCN, 2023). It feeds on small invertebrates and fish larvae, including harpacticoid copepods, amphipods, cypris larvae, and decapod crustaceans (Taşkavak *et al.*, 2010).

The distribution range of *Syngnathus acus* includes the eastern Atlantic Ocean, as well as the Mediterranean, Aegean, and Black Seas (Eschmeyer, 2023; Froese & Pauly, 2023). It is considered a rare occurrence in the Mediterranean waters of Turkey and has been categorized as near-threatened in the Turkish seas (Fricke *et al.*, 2007).

In Turkey, *S. acus* was first recorded in the Black Sea (Bennet, 1835), followed by the Sea of Marmara (Devedjian, 1915). Later, it was also reported from the Aegean and Mediterranean Seas by Slastenenko (1955–1956) and Erazi (1942).

Although the Turkish checklists (Bilecenoglu *et al.*, 2002) already mentioned *S. acus* in Turkish marine waters, the present is the first record of the species from the Bay of Iskenderun (south-eastern Mediterranean coast of Turkey).

MATERIAL AND METHODS

A single specimen of *S. acus* was caught by a commercial trawler at a depth of 18 m in Cevlik, Bay of Iskenderun (36º07′ N, 35º54′ E) on 28 October 2022 (Fig. 1). The specimen was brought to the laboratory, where it was identified, photographed, and measured. The length measurements were taken using a digital caliper and recorded to the nearest 0.01 mm, the total body mass was measured using an analytical balance and recorded to the nearest 0.1 g (Fig. 2). All morphometric measurements and counts

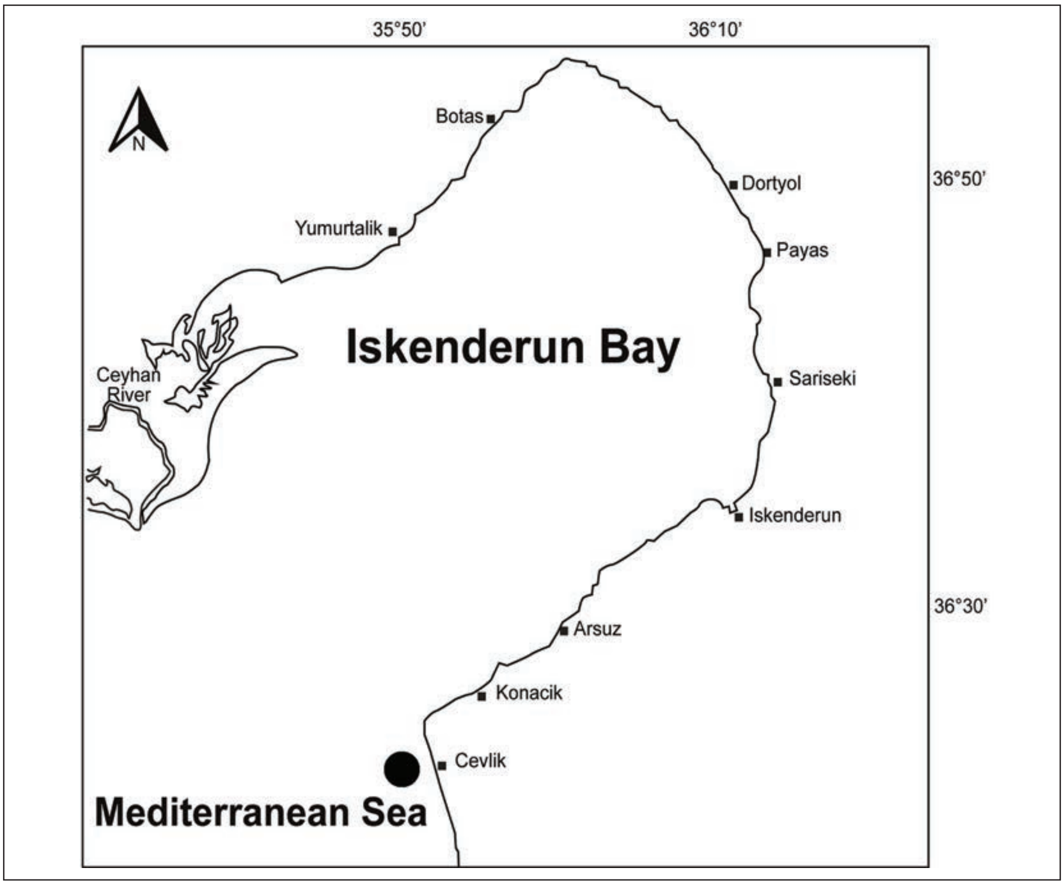

Fig. 1: Map showing the capture site (•) of the greater pipefish* Syngnathus acus *Linnaeus, 1758 in the Bay of Iskenderun (south-eastern Mediterranean).
Sl. 1: Zemljevid obravnavanega območja z označeno lokaliteto (•) ulova velikega morskega šila* Syngnathus acus *Linnaeus, 1758 v zalivu Iskenderun (jugovzhodno Sredozemsko morje).

Fig. 2: The specimen of greater pipefish *Syngnathus acus* ***from the Bay of Iskenderun (Cevlik), south-eastern Mediterranean, Turkey.***
Sl. 2: Primerek velikega morskega šila *Syngnathus acus* ***Linnaeus, 1758 v zalivu Iskenderun (Cevlik) (jugovzhodno Sredozemsko morje).***

Fig. 3: General view of the head and snout of *Syngnathus acus.*
Sl. 3: Posnetek glave in gobca vrste *Syngnathus acus.*

as well as the morphological description and color agree with the descriptions provided by Dawson (1986). The specimen was deposited in the Museum of the Faculty of Marine Sciences and Technology, Iskenderun Technical University, with catalog number MSM-PIS/2022-2 (Fig. 2).

RESULTS AND DISCUSSION

The captured *S. acus* specimen measured 14.5 cm in total length. The body was slender and elongate, the snout cylindrical and longer than half of head length, and of equal or inferior diameter compared to the eye (Fig. 3). An elongated lump was found on top of the head behind the eye (Muus & Nielsen, 1999; Kottelat & Freyhof, 2007). Some morphometric measurements of the *S. acus* specimen (in centimeters) are provided in Table 1.

S. acus differs from other Mediterranean species of its genus in the following combination of characters: distal margins of the body rings: 18–19; dorsal fin rays: 36–45; pectoral fin rays: 17–21. Color: body light greenish to dark brown, with variable dark dots and vertical, maroon and beige vertical stripes. The dorsal fins are dark spotted.

S. acus is a demersal species, commonly inhabiting estuary areas (Dawson, 1986) with rocky and sandy substrates, but also associated with algal, seagrass

Tab. 1: Morphometric measurements and meristic counts recorded of the greater pipefish** Syngnathus acus **caught in the south-eastern Mediterranean, Turkey.
Tab. 1: Morfometrične meritve in meristična štetja primerka velikega morskega šila** Syngnathus acus**, ujetega v zalivu Iskenderun, jugovzhodno Sredozemsko morje, Turčija.

Morphometric measurements	Value	
	cm	%
Metric		
Total length, TL	14.5	-
Body height, BH	0.40	2.75 %TL
Body width, BW	0.27	1.86 %TL
Oxipital height of the head, OHH	1.66	11.44 %TL
Head length, HL	1.93	13.31 %TL
Mouth height, MH	0.20	10.36 %HL
Mouth width, MW	0.12	6.22 %HL
Eye diameter, ED	0.28	14.50 %HL
Dorsal fin length DFL	1.43	9.86 %TL
Meristic		
Dorsal fin ray number, DfRN	33	
Pectoral fin ray number, PfRN	12	
Preanal ring number, Pr.RN	41	
Postanal ring number, Po.RN	17	
Caudal fin ray number, CfRN	9	

meadows, and other vegetated habitats (Malavasi *et al.*, 2004; Franco *et al.*, 2006; Matić-Skoko *et al.*, 2007). While its minimum and maximum depth range is 0–110 m, it commonly occurs at depths of 3–15 m (Froese & Pauly, 2023). The male specimen carries the eggs in a brood pouch under the tail (Vincent *et al.,* 1995). The recorded maximum total length for this pipefish species is 50 cm (Muus & Nielsen, 1999).

Although *S. acus* has been known in the Turkish sea (Bilecenoglu *et al.*, 2002; Bilecenoglu *et al.*, 2014), no specimens have previously been reported from the southeastern Mediterranean waters of Turkey. This species has no commercial importance in fisheries, it is caught as incidental catch.

Currently, in the Mediterranean, greater pipefishes are affected by habitat loss and degradation from coastal development and tourism activities, as well as by fishing gear such as trawls and dredges (IUCN, 2016; Vincent *et al.*, 2011; Caldwell & Vincent, 2012). Despite the occurrence of this species in the Mediterranean, its population structure and potential threats have yet to be established in more detail.

Since 2013, *S. acus* has been classified as a "least concern (LC)" species by the International Union for Conservation of Nature (IUCN) (Smith-Vaniz, 2015; IUCN, 2023). In the eastern Mediterranean Sea coast of Turkey, it can be considered exceptionally rare. Consequently, no specific conservation measures are in place for this species in the Mediterranean Sea and in the Turkish Mediterranean waters (IUCN, 2023). The data presented herein are therefore essential in terms of determining the species' status.

CONCLUSIONS

S. acus is not targeted by fisheries in the region. The studied *S. acus* specimen was an incidentally captured bycatch from the Iskenderun coast. This paper is the first report on the occurrence of this species from the southeastern Mediterranean (Bay of Iskenderun). Further research should be conducted to determine the population size and threat status of the Syngnathid species in the region. Hence, the current study will be useful in the field of fisheries science and, at the same time, contribute to fisheries management.

O POJAVLJANJU VELIKEGA MORSKEGA ŠILA *SYNGNATHUS ACUS* LINNAEUS, 1758 V JUGOVZHODNEM SREDOZEMSKEM MORJU, TURČIJA

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POVZETEK

28. oktobra 2022 so v Cevliku v zalivu Iskenderun (jugovzhodno Sredozemsko morje, Turčija) s komercialno vlečno mrežo na globini 18 m ujeli primerek velikega morskega šila Syngnathus acus *Linnaeus, 1758. Avtorji poročajo o prvem zapisu o pojavljanju te vrste na obravnavanem območju in enega od redkih opazovanj* S. acus *na vzhodni sredozemski obali Turčije nasploh. Vse meritve, štetja in barvni vzorec sovpadajo s predhodnimi podatki o pojavljanju te vrste.*

Ključne besede: Sygnathidae, morsko šilo, ohranjanje narave, zaliv Iskenderun, Sredozemsko morje

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received: 2024-01-31 DOI 10.19233/ASHN.2024.09

FIRST RECORD OF ROCHE'S SNAKE BLENNY *OPHIDION ROCHEI* MÜLLER, 1845 (OSTEICHTHYES: OPHIDIIFORMES) IN THE NORTH-EASTERN MEDITERRANEAN

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ABSTRACT

A single specimen of Ophidion rochei Müller, 1845 was collected in November 2018 at a depth of 70 m in the *northeastern Mediterranean, Turkey (Cevlik coast, Bay of Iskenderun). The total length of the captured* O. rochei *specimen was 21.6 cm, the body weight 23.5 g.* O. rochei *is endemic to the Mediterranean Sea, but this species is extremely rare in the eastern part of the Mediterranean. It has been classified as "data deficient (DD)" by the International Union for Conservation of Nature (IUCN). This ichthyological note is important as it represents the first record of this species in the northeastern Mediterranean waters of Turkey and fills a gap for* Ophidion *fishes in the Turkish marine fish checklist for the Mediterranean region.*

Key words: Ophidiidae, first sighting, eastern Mediterranean, Iskenderun Bay, Turkey

PRIMA SEGNALAZIONE DEL GALLETTO PINNEGIALLE *OPHIDION ROCHEI* MÜLLER, 1845 (OSTEICHTHYES: OPHIDIIFORMES) NEL MEDITERRANEO NORD-ORIENTALE

SINTESI

Un singolo esemplare di Ophidion rochei *Müller, 1845 è stato catturato a novembre 2018 a 70 m di profondità nel Mediterraneo nord-orientale, in Turchia (costa di Cevlik, baia di Iskenderun). La lunghezza totale dell'esemplare di* O. rochei *era di 21,6 cm, e il peso corporeo di 23,5 g. La specie è endemica nel Mediterraneo, ma è estremamente rara nella parte orientale del bacino in questione. È stata classificata come "data deficient (DD)" dall'Unione Internazionale per la Conservazione della Natura (IUCN). Questa nota ittiologica è importante in quanto rappresenta il primo ritrovamento della specie nelle acque mediterranee nord-orientali della Turchia e colma una lacuna per le specie del genere* Ophidion *nella checklist dei pesci marini nella parte turca del Mediterraneo.*

Parole chiave: Ophidiidae, primo avvistamento, Mediterraneo orientale, Baia di Iskenderun, Turchia

INTRODUCTION

The family Ophidiidae consists of 50 genera and 272 species distributed across the Atlantic, Indian and Pacific Oceans (Fricke *et al.*, 2023). In the Mediterranean Sea, four valid species belonging to three ophidiiform genera can be found (Abdul Malak, 2011; IUCN, 2023), all of which have a wide geographical range and also occur in the marine waters of Turkey. They are *Benthocometes robustus* (Goode & Bean, 1886), *Ophidion barbatum* Linnaeus, 1758, *Ophidion rochei Müller, 1845*, and *Parophidion vassali* (Risso, 1810) (Bilecenoglu *et al.*, 2014; IUCN, 2023).

In the Mediterranean, *O. rochei* was reported from the Adriatic waters in 2002 (Dulčić *et al.*, 2002). In 2013, two specimens were collected from the Lebanese coast (off Daoura) by Bariche & Fricke (2020), and recently, the species has also been recorded in Syrian waters by Othman *et al*. (2020).

To date, two snake blenny species of the genus *Ophidion* have been reported for marine demersal habitats of Turkey (Aksiray, 1987; Fricke *et al.*, 2007), namely the snake blenny *O. barbatum*, and the Roche's snake blenny *O. rochei* (Whitehead *et al.*, 1984–1986; Mater & Meriç, 1996). The Roche's snake blenny *O. rochei* has been recorded in the Aegean, Marmara, and Black Seas by Whitehead *et al*. (1984–1986).

Even so, *O. rochei* has not been included in the checklist of the marine fishes of Turkey from the Mediterranean marine waters (Bilecenoglu *et al.*, 2014). Moreover, neither a specific location nor any detailed information about this fish in Turkish marine waters has been provided (Bilecenoglu *et al.*, 2002; Bilecenoglu *et al.*, 2014).

This study is the first substantiated record of the Roche's snake blenny *O. rochei* from the eastern Mediterranean waters of Turkey, and the first sighting and confirmation of *O. rochei* in the Bay of Iskenderun, Turkey.

Fig 1: Map showing the capture point (•) of the *Ophidion rochei* ***Müller, 1845 in the northeastern Mediterranean.***
Sl. 1: Zemljevid obravnavanega območja z označeno lokaliteto ulova (•) primerka *Ophidion rochei* ***Müller, 1845 v severovzhodnem Sredozemlju.***

Fig. 2: The** Ophidion rochei **from the northeastern Mediterranean, Turkey.
Sl. 2: Primerek vrste** Ophidion rochei **iz severovzhodnega Sredozemskega morja, Turčija.

MATERIAL AND METHODS

One specimen of Roche's snake blenny *O. rochei* was recorded in a trawl survey on 12 December 2018, in the Bay of Iskenderun, Turkey, at a depth of 70 m (36°07′ N, 35°85′ E), (Figs. 1 and 2). The specimen was caught off Cevlik (Samandağ/Hatay), 4 km north-west of Samandağ, by a commercial trawl net with a 22 mm mesh size, over sandy and muddy bottoms.

The morphometric measurements of the specimen were taken to the nearest 0.1 mm using a caliper. Some morphometric characteristics are given as percentages of total length (TL%) and head length (HL%). All measurements, counts, morphological descriptions, and colors agree with the descriptions provided by Casadevall *et al.* (1996) and Nielsen *et al.* (1999). The Roche's snake blenny specimen is deposited in the Museum of the Faculty of Marine Sciences and Technology, Iskenderun Technical University, with the catalog number MSM-PIS/2018-6.

RESULTS AND DISCUSSION

The captured specimen of Roche's snake blenny *O. rochei* measured 21.6 cm in total length (TL) and weighed 20.3 g in total weight (Fig. 2). The body was long, eel-shaped, and lateralized. The head was naked and without scales, the mouth large, with the upper jaw longer than the lower. The dorsal and anal fins were elongated and fused with the caudal fin. Color: dorsal side brownish, ventral side whitish, with black margins on dorsal, anal, and caudal fins.

The morphometric characteristics of the *O. rochei* specimen are provided in Table 1 and compared to other specimens previously reported from the Sea of Azov (Diripasko *et al.*, 2020) and Syrian waters (Othman *et al.*, 2020).

The Roche's snake blenny, *O. rochei*, is a demersal species and occurs mostly on sandy substrates (Nielsen *et al.*, 1999) at depths ranging from 10 to 150 m (Nielsen *et al.*, 1999; IUCN, 2023). The species is found in the Mediterranean Sea (western and northern regions), the Marmara Sea (Whitehead *et al.*, 1984-1986; Fischer et al., 1987), the Black Sea (Svetovidov, 1964), as well as the Sea of Azov (Diripasko *et al.,* 2020), and the Kerch Strait (Shaganov, 2013) (Nielsen, 2016; Knudsen *et al.,* 2015).

The Roche's snake blenny spawn is commonly found benthically in the continental shelf areas of tropical and temperate waters. The species reaches a maximum length of 29.3 cm in both males and females (Matallanas & Riba, 1980). *O. rochei* lays oval pelagic eggs that float in a gelatinous mass (Breder & Rosen, 1966). Casadevall *et al*. (1993) reported that individuals of *O. rochei* produce pelagic eggs between July and October. The number of eggs varies between 15 and 18 thousand. Juveniles are pelagic and feed on planktonic organisms.

The studied *O. rochei* individual was captured in the 70 m depth range, which is consistent with the literature (Froese & Pauly, 2023). Our specimen measured 21.6 cm in TL, which is more than the individual caught on the Syrian coast in 2019 (14.3 cm TL) reported by Othman *et al*. (2020), but still less than the longest recorded individual caught off the coast of Spain (29.3 cm TL), which was reported by Matallanas & Riva (1980), and less than the second longest specimen (27.7 cm TL), also from the Spanish coast, reported by Casadevall *et al*. (1996).

Ophidion species are active fish, but since they are not strong swimmers, they do not undertake long migrations and only travel from deep water to the shore seasonally for reproduction. *O. rochei* is a nocturnal carnivore that usually hides on the sandy bottom during

Tab. 1: Morphometric comparison of the *Ophidion rochei* ***specimens from the Sea of Azov and from the eastern Mediterranean Sea (percentages are provided in parentheses).***
Tab. 1: Morfometrična primerjava primerkov vrste *Ophidion rochei* ***iz Azovskega morja in vzhodnega Sredozemskega morja (deleži so podani v oklepajih).***

Characters	**Measurements (cm)**		
	This study (n=1)	**Diripasko *et al.* (2020) (n=1)**	**Othman *et al.* (2020) (n=1)**
Total length	21.6	17.2	14.3
Maximum body depth	2.3 (10.6 %TL)	2.5 (14.7 %TL)	1.5 (10.5 %TL)
Head length	4.2 (19.4 %TL)	3.4 (20.0 %TL)	2.5 (17.5 %TL)
Snouth length	0.8 (19.0 %HL)	0.7 (21.2 %HL)	0.6 (24.0 %HL)
Eye length	0.9 (21.4 %HL)	-	0.6 (24.0 %HL)
Eye horizontal length	1.1 (26.2 %HL)	0.8 (23.8 %HL)	-
Interorbital width	1.0 (23.8 %HL)	0.5 (14.2 %HL)	-
Length of upper jaw	1.8 (42.8 %HL)	1.8 (54.4 %HL)	-
Length of lower jaw	1.6 (38.1 %HL)	1.6 (42.7 %HL)	-
Weight (g)	23.5	22.6	11.94

the day and is active at night (Jardas, 1996). Adult specimens feed mainly on decapods and small teleost fish. The single adult presented in this study was probably accidentally caught by the trawl net while moving from deep to shallow waters to feed.

Although *O. rochei* and *O. barbatum* are morphologically very close, they differ in the inclination of the head and the shape of the mouth (when closed, the upper and lower lip are perfectly aligned in *O. rochei,* while in *O. barbatum* the upper lip is protruding), in the beginning of the scales (at the edge of the operculum in *O. barbatum*, much further back in *O. rochei*), and in the number of gill rakers on the anterior first gill arch (3–4 in O. rochei, 5–6 in O. barbatum). In addition, in contrast to *O. barbatum*, *O. rochei* has no scales on the ventral part of the posterior two-thirds of the body, with the skin there completely bare.

The Roche's snake blenny is a non-commercial fish, not targeted by fisheries and only accidentally caught in nets as bycatch. Therefore, there are no conservation measures in place specific to this species.

Although endemic to the Mediterranean, *O. rochei* is extremely rare in the eastern part of the Mediterranean Basin. Its presence on the eastern Mediterranean coast of Turkey is probably due to environmental changes and the related alterations in feeding and breeding patterns. *O. rochei* has been classified as a "Data Deficient (DD)" species in the global and Mediterranean assessments by the International Union for Conservation of Nature (IUCN) since 2008 (Kara, 2011; Knudsen *et al*., 2015; IUCN, 2023). By providing new data on *Ophidion* species, this study represents an important contribution to the knowledge on the biodiversity of fish fauna.

CONCLUSIONS

This ichthyological note is very important as it represents the first substantiated record of *O. rochei* from the Mediterranean coasts of Turkey, specifically the northeastern coast. Until now, no specific location or detailed information was provided about this species in relation to the Mediterranean coast of Turkey. Therefore, this study fills the data gap for *O. rochei* in the Turkish marine fish checklist for the Mediterranean region.

ACKNOWLEDGMENTS

The authors would like to thank the boat captain and staff for their help in providing the specimen.

PRVI ZAPIS O POJAVLJANJU HUJA VRSTE *OPHIDION ROCHEI* MÜLLER, 1845 (OSTEICHTHYES: OPHIDIIFORMES) V SEVEROVZHODNEM SREDOZEMSKEM MORJU

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POVZETEK

Novembra 2018 so na globini 70 m v severovzhodnem Sredozemskem morju (obala Cevlik, zaliv Iskenderun, Turčija) ujeli primerek vrste Ophidion rochei *Müller, 1845. Primerek je meril 21,6 cm telesne dolžine in tehtal 23,5 g. Vrsta* O. rochei *je endemična v Sredozemskem morju, v njegovem vzhodnem delu je zelo redka. V Mednarodni Zvezi za varstvo narave so jo označili s kategorijo "pomanjkljivi podatki" (data deficient, DD). Ta ihtiološka novica je pomembna, saj predstavlja prvi zapis o pojavljanju te vrste v severovzhodnih sredozemskih vodah Turčije in odpravlja vrzel v seznamu morskih rib Turčije v Sredozemskem morju.*

Ključne besede: Ophidiidae, prvo opazovanje, vzhodno Sredozemsko morje, zaliv Iskenderun, Turčija

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received: 2023-12-04 DOI 10.19233/ASHN.2024.10

FLUCTUATING ASYMMETRY IN *CHELON AURATUS* FROM THE LIBYAN MEDITERRANEAN COAST AND THE AIN ZIANA LAGOON

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ABSTRACT

The present study represents the first research of morphological asymmetry in the eye lens diameter and three otolith features (otolith length, width, and weight) examined in the mullet species Chelon auratus *collected from the Mediterranean coast and the Ain Ziana Lagoon, Libya. The asymmetry value for the eye lens diameter was the highest among the four morphological characters studied, and higher for the Ain Ziana Lagoon than for the Mediterranean coast of Libya. The study also showed that the asymmetry value increased with the fish's total length. Plausible reasons for asymmetry in the four morphological traits examined are discussed in relation to the inconstancy in growth induced by ecological factors, including differences in water temperature, salinity, depth, and contaminants present in the marine waters of Libya and the Ain Ziana Lagoon.*

Key words: *Chelon auratus,* ecological factors, Mugilidae, pollution, otolith, morphology

ASIMMETRIA FLUTTUANTE IN *CHELON AURATUS* LUNGO LA COSTA MEDITERRANEA LIBICA E NELLA LAGUNA DI AIN ZIANA

SINTESI

Il presente studio rappresenta la prima ricerca di asimmetria morfologica nel diametro della lente oculare e nei tre caratteri otolitici (lunghezza, larghezza e peso dell'otolito) esaminati nel cefalo dorato Chelon auratus, *pescato lungo la costa mediterranea e nella laguna di Ain Ziana, in Libia. Il valore di asimmetria per il diametro della lente oculare è stato il più alto tra i quattro caratteri morfologici studiati, e più alto per la laguna di Ain Ziana rispetto alla costa mediterranea della Libia. Lo studio ha anche mostrato che il valore di asimmetria aumenta con la lunghezza totale degli esemplari. Le ragioni plausibili dell'asimmetria nei quattro caratteri morfologici esaminati sono discusse in relazione all'incostanza della crescita indotta da fattori ecologici, tra cui le differenze di temperatura dell'acqua, salinità, profondità e contaminanti presenti nelle acque marine della Libia e nella laguna di Ain Ziana.*

Parole chiave: *Chelon auratus*, fattori ecologici, Mugilidae, inquinamento, otoliti, morfologia

INTRODUCTION

Otoliths are the bony structures located in the inner ear cavity of all teleost fish, which function as a balance organ in addition to supporting hearing. For years, otoliths have been used to gather evidence related to taxonomy, age, and fish size (Mendoza, 2006). In addition, otoliths have been studied extensively in various aspects of fish biology (hearing and balance in fish), larval fish ecology, species identification, fish stock identification, and environmental reconstruction of fish habitats (Mendoza, 2006). Over recent periods, otolith morphological features, mainly shape, length, width, area, thickness, and weight, have been studied to assess genetic and environmental impacts and as biomarkers (Jawad *et al*., 2010, 2011, 2012a, 2012b, 2012c, 2016, 2020; Jawad, 2012, 2013; Abu El-Regal *et al*., 2016; Al-Busaidi *et al*., 2017; Mejri *et al*., 2018; 2020; Ben Labidi *et al*., 2020a, 2020b; Osman *et al*., 2020; Khedher *et al*., 2021; Mejri *et al*., 2022a, 2022b; Ben Mohamed *et al*., 2023; Bouriga *et al*., 2023; Adjibayo Houeto *et al*., 2024). These investigations have revealed that otolith shape is species specific (Sadighzadeh *et al*., 2014) and that variations in otolith shape, structure, and development may be affected by ontogenetic, genetic, and environmental factors (Ider *et al*., 2017; Fashandi *et al*., 2019), including sex, growth, maturity, and patterns of fishery exploitation (Begg & Brown, 2000), or by individual characteristics, such as genotype (Jawad *et al*., 2020) or physiological state (Campana & Neilson, 1985). Nonetheless, the potential reasons for the intra-individual variation, chiefly asymmetry in shape between the right and left otoliths, have been insufficiently studied (Mille *et al*., 2015). In a healthy environment, the otoliths on both sides of the head are morphologically symmetrical (Panfili *et al*., 2002), even though there can be some interspecific variations in size and shape (Popper & Lu, 2000). Where a weight difference (i.e., mass asymmetry) between the masses of the left and right otoliths is observed (Ambuali *et al*., 2011; Jawad & Sadighzadeh, 2013; Al Balushi *et al*., 2017; Yedier *et al*., 2018), it may be an indication of previous developmental disturbances in fish caused by different types of impact, such as genetic or environmental stress (Valentine *et al*., 1973; Grønkjaer & Sand, 2003). While these can be either substantial (Scherer *et al*., 2001) or minor (Takabayashi & Ohmura-Iwasaki, 2003), any asymmetrical increase or decrease in otolith mass can harmfully affect critical life functions in fish, particularly the sense of hearing, balance, and linear acceleration (Popper & Lue, 2000; Panfili *et al*., 2005).

C. auratus is a marine species, but sometimes enters fresh and brackish water niches (Riede, 2004). It typically inhabits depth ranges of 10–20 m (Thomson, 1990). The maximum fork length *C. auratus* can reach is 610 mm, with the common fork length being 300 mm (Thomson, 1990). The largest recorded weight for this species is 2.5 kg (Fazli *et al*., 2008). The golden grey mullet is distributed in the eastern Atlantic region, spanning from Scotland to Cape Verde, and is also present in the Mediterranean and Black Seas. Similarly, it is reported from coastal waters ranging from southern Norway to Morocco, and is rare off Mauritania (Thomson, 1986). This species is neritic and frequently forms schools, typically inhabiting lagoons and lower estuaries (Thomson, 1990). Young juveniles disperse to coastal lagoons and estuaries primarily during winter and spring (Kottelat & Freyhof, 2007). *C. auratus* feeds on small benthic organisms and detritus, occasionally consuming insects and plankton (Ben-Tuvia, 1986). Reproduction occurs at sea from July to November. The females are oviparous, producing pelagic, non-adhesive eggs (Breder & Rosen, 1966).

In the context of differences in otolith shape among conspecific individuals, numerous researchers have suggested that these may be influenced by ecological factors, primarily water temperature, salinity, food availability, depth, and substrate features (Hüssy, 2008; Morat *et al*., 2012). Studies investigating the effects of environmental factors on otolith shape in Libyan waters are exceedingly rare. The first to study asymmetry in the external morphology of fish from Libyan waters was Jawad (2000, 2003), who suggested that environmental factors contribute to variations in fish body shape. Furthermore, there are only two studies examining asymmetry in the eye lens diameter of certain fish species collected from Libyan waters, but none addressing asymmetry in otolith features. Hence, it is imperative to employ scientific methods to assess the health of both the environment and its organisms. Accordingly, the current investigation was undertaken to determine, for the first time, the level of asymmetry in the golden grey mullet collected from the Mediterranean Sea coasts of Libya and the Ain Ziana Lagoon. This study examines otolith features, including length, width, and weight, as well as the eye lens diameter. The results are significant given the ongoing expansion of anthropogenic impacts on the environment, which may further affect the condition of the fish habitat.

MATERIAL AND METHODS

Study area

The present study was performed on specimens collected from the Mediterranean coasts of Libya (32°14′56″ N, 19°56′42″ E) and from the Ain Ziana Lagoon (32°12′56″ N, 20°09′16″ E). Libya is situated in the southern Mediterranean, and its coastline, a

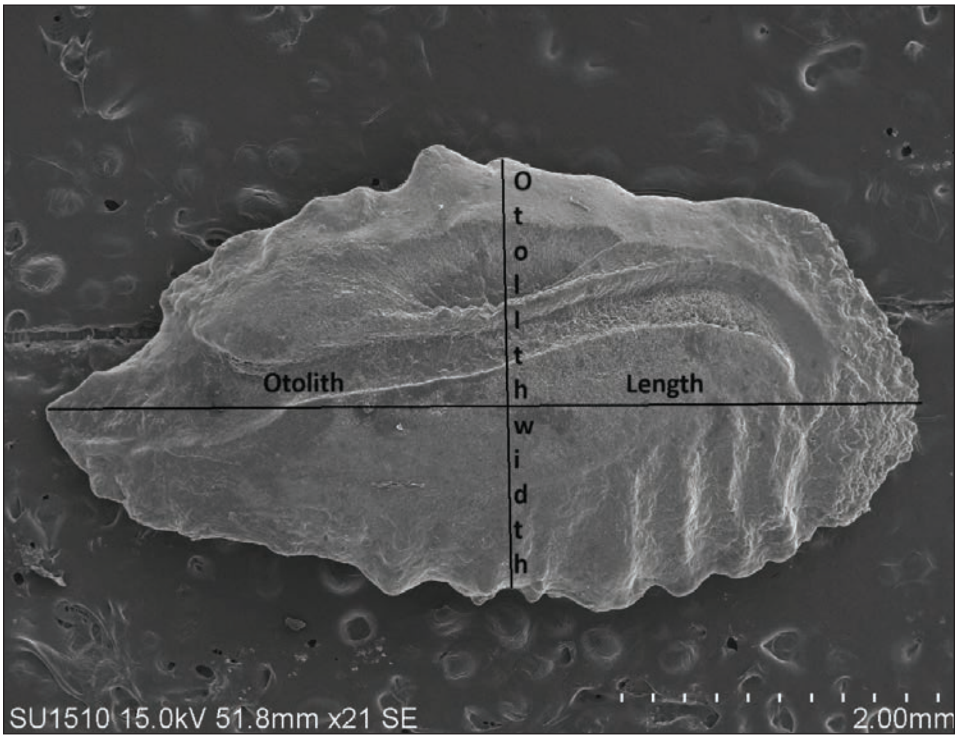

Fig. 1: SEM image of an otolith of *C. auratus****, 159 mm TL (total length), showing otolith length and width.***
Sl. 1: SEM posnetek otolita vrste *C. auratus* ***(159 mm totalne dolžine), ki kaže dolžino in širino otolita.***

segment of the North African coast spanning approximately 2000 km, is characterised by diverse topography and a wide range of niches (Wikipedia, 2023). Libyan marine waters cover an area of 350,000 km^2 (Wikipedia, 2023), which is bordered by the Levantine Sea to the east, the Strait of Sicily to the west, and the Ionian Sea, including the island of Crete, to the north (Wikipedia, 2023).

Lagoon habitats are a common feature of the southern Mediterranean coast regions. Aside from other topographies, the Libyan coast is home to four important coastal lagoon environments: Farwa in the west, and Ain Zayanah, the Khalige Al-Bomba Lagoon, and the Ain Al-Ghazalah Cove in the east (UNESCO, 1986), with Ain Zayanah being the largest (Guerre, 1980). Ain Zayanah is a brackish water lagoon located about 15 km east of Benghazi city, spanning an area of 50 ha. It is 5 km long and several hundred meters wide, with an average depth of 2 m; it is linked to the sea by a canal created by the overflow of water from underground springs (Amer & El-Toumi, 2018). These springs discharge brackish water with a salinity of 10‰ into the lagoon at a rate of 4.5 m3/sec (Guerre, 1980; UNESCO, 1986; Azafzaf *et al*., 2006), reducing the lagoon's water salt content to 16–28‰. The lagoon water has a temperature ranging from 14°C to 28°C and a pH of 7.8 (Guerre, 1980; Reynolds *et al*., 1995). Fish specimens collected from the two investigated localities were classified into three length groups: 200–300 mm, 301–400 mm, and 401–500 mm.

Sample collection

A total of 275 adult specimens of *C. auratus* were collected, consisting of 119 from Libyan Mediterranean waters (60 females, 59 males) and 156 from the Ain Ziana Lagoon (83 females, 73 males). The total length (TL) of the specimens ranged from 203 to 496 mm in females and 203 to 465 mm in males from the Libyan Mediterranean coast, and from 208 to 496 mm in females and 208 to 499 mm in males from the Ain Ziana Lagoon. All specimens were caught aboard coastal boats using gillnets ranging 5–13 m in length, during the period from 18 April 2019 to 7 January 2020. The sex of the individuals was determined by microscopic examination of the gonads.

Otolith extraction

The right and left otoliths were removed from all fish samples collected from the two locations, rinsed with distilled water, stored in Eppendorf tubes, and kept in dry storage for 24 hours to eliminate moisture. The fish's total length was measured using an electronic board, and total weight (TW) was recorded using a Sartorius TE 313S analytical balance with an accuracy of 0.0001 g. The maximum otolith length (OL) and width (OW) (both measured to an accuracy of 0.1 mm) were determined using image analysis software (Digimizer 5.7.2) (Fig. 1).

Statistical analyses

The t-test was used to confirm the differences in length, width, and weight between the left and right otoliths for each specimen. The variation in otolith weight between males and females was also validated using the t-test.

Following Valentine *et al*. (1973), asymmetry in otolith length, width, weight, and eye diameter was calculated using the squared coefficient of asymmetry variation (CV^2_a) for the two otolith dimensions:

$CV^2_a = (S_{r-1} X100/X_{r+1})^2$

where S_{r-1} is the standard deviation of signed changes and X_{r+1} is the mean of the feature, which is calculated by adding the absolute scores for both sides and dividing them by sample size. The study of asymmetry in this commercially valuable species is important for understanding its impact on the settlement of fish larvae in the fishing grounds. Although bilateral asymmetry values and measurement errors are typically small and normally distributed around a mean of zero (Merilä & Bjöklund, 1995), individual variations in measurement-taking can still influence the analysis (Palmer, 1994). Therefore, in the present study, all measurements were performed by a single person to minimise potential errors (Lee & Lysak, 1990; StatSoft, Inc., 1991) and were repeated twice. Coefficients of asymmetry were compared across the total length classes using ANOVA test. Additionally, Tukey's HSD post hoc test was employed to assess significant differences in pairwise comparisons of length classes (StatSoft, Inc., 1991).

RESULTS

The asymmetry values for otolith length (OL), width (OW), and weight (OWe) in the *C. auratus* collected from the Mediterranean Sea and the Ain Ziana Lagoon, Libya, are presented in Table 1. Among all the features examined, the eye diameter exhibited the highest asymmetry value (91.74), with otolith length showing the highest asymmetry value among otolith features alone (88.82) (Tab. 1).

The study revealed an increase in asymmetry levels for the three otolith characteristics (length, width, and weight), as well as for the eye diameter, correlating with increasing fish size (Tab. 2).

The highest percentage of asymmetry among the characteristics examined in *C. auratus* from both locations was observed in the eye diameter of female specimens (86%) (Tab. 1). The percentage of individuals with asymmetry increased with the fish size (Tab. 2).

The divergence coefficients of the different length groups in the *C. auratus* collected from the Mediterranean Sea and the Ain Ziana Lagoon, Libya, were found to be not significant ($P > 0.5$).

DISCUSSION

The present investigation aimed to assess bilateral asymmetry in three otolith features and one body morphometric character of *C. auratus*. Any irregularity in the four morphological features of this mullet species may decrease the capability of young individuals to orient themselves in their habitats and cause them to disperse to other niches (Gagliano *et al*., 2008).

Asymmetry in the eye diameter has previously also been detected and reported in *Coptodon zillii* (Jawad, 2000), which might suggest that this morphological feature may be more susceptible to environmental changes compared to the other three features examined in this study. Consequently, notable variance in eye lens diameter values can be taken as an indicator of environmental stress in the Ain Ziana Lagoon habitat. In contrast, the lowest bilateral asymmetry in both populations investigated was found in otolith weight, which suggests that this feature is less susceptible to environmental factors such as contamination or adverse environmental events (Jawad, 2003). As previously noted by Helling *et al*. (2003), bilateral asymmetry in fish otoliths may result in irregular swimming movements and interference with accurate sound reception, ultimately affecting the fish's ability to navigate its habitat (Lychakov & Rebane, 2005).

Similar findings to those obtained in the present study have been reported by several authors investigating various fish species across different geographical regions. For instance, Mejri *et al*. (2020) examined asymmetry in otolith shape, length, width, and area in *Pagellus erythrinus* from the Gulf of Tunis. They observed intra- and inter-population asymmetry in these features and proposed an explanation within the context of developmental instability induced by genetic and environmental stress. In study of specimens of *Lutjanus bengalensis* collected off Muscat in the Arabian Sea, Jawad (2012) reported higher levels of asymmetry in otolith width compared to length. They observed a tendency of asymmetry in both width and length to increase with fish size and attributed this phenomenon to the presence of numerous pollutants

Tab. 1: Squared coefficient of asymmetry (CV^2a) values and character means (X_{r-l}) of* C. auratus *sampled from the Mediterranean Sea coast and the Ain Ziana Lagoon, Libya.
Tab. 1: Vrednosti kvadratnega koeficienta asimetrije (CV^2a) in značilnih povprečij (X_{r-l}) pri primerkih vrste* C. auratus*, vzorčenih na sredozemski obali Libije in v laguni Ain Ziana.

Character	CV2a + S.D.	N	Character means (mm) ± S.D.	% of individuals with asymmetry
Mediterranean coast of Libya				
Otolith length				
Females	88.82 ± 0.524	60	7.35 ± 0.242	68
Males	86.74 ± 0.165	59	7.96 ± 0.219	67
Otolith width				
Females	84.55 ± 0.219	60	5.22 ± 0.218	79
Males	84.95 ± 0.218	59	6.35 ± 0.223	78
Otolith weight				
Females	67.54 ± 0.146	60	0.0449 ± 0.176	83
Males	66.78 ± 0.149	59	0.0689 ± 0.177	81
Eye diameter				
Females	91.82 ± 0.211	60	13.1 ± 0.173	86
Males	91.74 ± 0.218	59	8.06 ± 0.169	85
Ain Ziana Lagoon				
Otolith length				
Females	89.92 ± 0.553	83	7.84 ± 0.265	74
Males	89.64 ± 0.145	73	7.36 ± 0.239	73
Otolith width				
Females	85.35 ± 0.220	83	4.1 ± 0.234	55
Males	85.75 ± 0.215	73	4.09 ± 0.262	54
Otolith weight				
Females	67.99 ± 0.148	83	0.0333 ± 0.266	44
Males	68.01 ± 0.136	73	0.0333 ± 0.195	43
Eye diameter				
Females	92.42 ± 0.218	83	12.45 ± 0.182	86
Males	92.53 ± 0.217	73	7.33 ± 0.143	85

in the area. Similar findings were reported by Jawad (2012) and Jawad *et al*. (2012a) for *Sardinella sindensis* and *Sillago sihama* from the Persian Gulf near Bandar Abbas, and by Jawad *et al*. (2020) in studies of *Sarotherodon melanotheron* and *Coptodon guineensis* from Lake Ahémé and the Porto-Novo Lagoon, in Bénin. Here, however, the trend of asymmetry increasing with fish length was observed only in otolith width. Conversely, Al-Busaidi *et al*. (2017) reported that both the length and width measurements of otoliths in *Lutjanus ehrenbergii* from the Arabian Sea off Muscat city were well correlated with fish length, and they also found symmetry between the left and right otoliths. Kontaş *et al*. (2018), on the other hand, studied fluctuating asymmetry of otolith area, length, perimeter, and width in four groups of *Merlangius merlangus* collected from the Middle Black Sea, finding the highest degree of asymmetry in otolith area and lowest in otolith length. They noted no significant association between the asymmetry values of the four otolith features and total fish length, suggesting that asymmetry in these characteristics might be a result of pressure from various contaminants in the Black Sea. Chakour & Elouizgani (2018) observed substantial asymmetry in otolith length, perimeter, and width in three groups of *Solea lascaris* from three main harbours along the central Atlantic coast of Morocco and concluded that the variations in these features are likely associated with environmental characteristics and adaptations of each fish group to their habitats. Finally, Abu El-Regal

Tab. 2: Squared coefficient of asymmetry (CV^2_a) and mean values of otolith length and width (in mm), and weight (in g) by size classes of* C. auratus *from the Mediterranean Sea coast and the Ain Ziana Lagoon, Libya.

Tab. 2: Vrednosti kvadratnega koeficienta asimetrije (CV^2_a) in srednje vrednosti dolžine in širine otolita (v mm), ter mase (v g) velikostnih razredov pri primerkih vrste* C. auratus, *vzorčenih na sredozemski obali Libije in v laguni Ain Ziana.

Character	CV2a + S.D.	N	Character means (mm) ± S.D.	% of individuals with asymmetry
Mediterranean coast of Libya				
Otolith length				
Females				
200 – 300	88.82 ± 0.524	15	7.31 ± 0.242	76
301 – 400	88.92 ± 0.514	25	7.32 ± 0.231	78
401 - 500	91.24 ± 0.514	19	7.36 ± 0.167	81
Males				
200 – 300	86.94 ± 0.135	14	7.92 ± 0.223	75
301 – 400	87.89 ± 0.223	26	7.94 ± 0.215	77
401 - 500	87.99 ± 0.322	20	7.96 ± 0.218	80
Otolith width				
Females				
200 – 300	83.85 ± 0.317	15	5.12 ± 0.209	65
301 – 400	84.87 ± 0.219	25	5.14 ± 0.211	67
401 - 500	85.67 ± 0.334	19	5.17 ± 0.220	73
Males				
200 – 300	83.95 ± 0.328	14	6.32 ± 0.218	64
301 – 400	84.23 ± 0.255	26	6.33 ± 0.217	65
401 - 500	84.76 ± 0.277	20	6.34 ± 0.232	71
Otolith weight				
Females				
200 – 300	68.34 ± 0.126	15	0.0442 ± 0.165	83
301 – 400	68.89 ± 0.154	25	0.0444 ± 0.172	89
401 - 500	69.05 ± 0.239	19	0.0447 ± 0.185	93
Males				
200 – 300	68.78 ± 0.139	14	0.0676 ± 0.166	80
301 – 400	68.88 ± 0.219	26	0.0678 ± 0.154	86
401 - 500	69.08 ± 0.122	20	0.0681 ± 0.164	90
Eye diameter				
Females				
200 – 300	91.99 ± 0.127	15	13.23 ± 0.153	45
301 – 400	92.52 ± 0.178	25	13.87 ± 0.169	57
401 - 500	92.82 ± 0.244	19	13.99 ± 0.188	79
Males				
200 – 300	91.89 ± 0.222	14	8.36 ± 0.178	42
301 – 400	91.95 ± 0.229	26	8.84 ± 0.193	55
401 - 500	92.17 ± 0.222	20	8.89 ± 0.173	73
Ain Ziana Lagoon				
Otolith length				
Females				
200 – 300	91.32 ± 0.523	23	7.89 ± 0.252	86
301 – 400	91.82 ± 0.433	42	7.91 ± 0.250	89
401 - 500	92.72 ± 0.233	18	7.93 ± 0.276	92
Males				
200 – 300	89.99 ± 0.123	15	7.39 ± 0.253	84
301 – 400	90.19 ± 0.224	44	7.41 ± 0.282	86
401 - 500	90.79 ± 0.256	14	7.49 ± 0.276	90
Otolith width				
Females				
200 – 300	85.95 ± 0.232	23	4.13 ± 0.228	43
301 – 400	86.25 ± 0.240	42	4.29 ± 0.217	54
401 - 500	86.95 ± 0.251	18	4.31 ± 0.223	73
Males				
200 – 300	85.95 ± 0.219	15	4.12 ± 0.234	41
301 – 400	86.25 ± 0.223	44	4.19 ± 0.274	50
401 - 500	86.75 ± 0.286	14	4.21 ± 0.282	70
Otolith weight				
Females				
200 – 300	68.49 ± 0.163	23	0.0335 ± 0.248	82
301 – 400	68.79 ± 0.123	42	0.0339 ± 0.265	89
401 - 500	68.99 ± 0.176	18	0.0343 ± 0.232	94
Males				
200 – 300	68.78 ± 0.226	15	0.0336 ± 0.187	80
301 – 400	68.88 ± 0.281	44	0.0339 ± 0.193	87
401 - 500	68.99 ± 0.271	14	0.0341 ± 0.184	92
Eye diameter				
Females				
200 – 300	92.72 ± 0.139	23	12.54 ± 0.154	45
301 – 400	92.83 ± 0.182	42	12.59 ± 0.184	58
401 - 500	92.97 ± 0.191	18	12.68 ± 0.224	72
Males				
200 – 300	92.73 ± 0.220	15	7.38 ± 0.164	42
301 – 400	92.84 ± 0.234	44	7.78 ± 0.194	53
401 - 500	92.95 ± 0.229	14	7.98 ± 0.171	69

et al. (2016) discovered asymmetry in the length and width of otoliths in *Chlorurus sordidus* and *Hipposcarus harid* from Hurghada on the Red Sea coast of Egypt, observing the asymmetry increased with the fish's length (age) and attributing the changes to the presence of contaminants in the region.

Previous studies of asymmetry in fishes collected from the Mediterranean Sea coasts of Libya and the Ain Ziana Lagoon (Jawad, 2000, 2001) revealed significant pollution levels. The Libyan coasts along the Mediterranean Sea have a long history of pollution from various sources (Hamouda & Wilson, 1989; Soliman *et al*., 2015; Obeidat, 2016; Bago *et al*., 2018; Bonsignore *et al*., 2018; Omar, 2022). Additionally, the topography of the Ain Ziana Lagoon allows for water exchange between the Libyan coastal waters and the lagoon itself, facilitating the transport of pollutants into the lagoon.

Previous studies have reported water temperatures along the Libyan coast of the Mediterranean Sea and in the Ain Ziana Lagoon to range from 16 to 17°C, with salinity standing at 38.5‰ (Shaltout & Omstedt, 2014; Al-Asadi, 2015). Fablet *et al*. (2009) speculated that temperature might be the primary environmental factor affecting otolith growth. This is because fish are highly sensitive to temperature fluctuations, with some reacting to changes as small as 0.03°C (Trojette *et al*., 2015). Salinity can also directly influence marine habitats, potentially altering the chemical composition and shape of otoliths in fish (Rebaya *et al*., 2017). Martin & Wuenschel (2006) suggested that differences in the chemical composition of otoliths may be associated with variations in individual responses to the combined effects of salinity, temperature, and concentrations of common elements such as Cl, Mg, K, Na, and Ca. Consequently, it is conceivable that the differences in otolith shape observed in the present study can be explained by fluctuations in environmental factors such as water temperature and salinity (Cañás *et al*., 2012). Other contributing factors may include life-history features associated with otolith shape (Mérigot *et al*., 2007), as well as biological and behavioural traits, such as swimming activity (Lord *et al*., 2012).

Comparing our findings with those of Reis *et al*. (2023) on asymmetry in otoliths of four mullet species, including *C. auratus*, from the Aegean Sea, Turkey, we observe similar levels of asymmetry in otolith length and width, with Reis *et al*. (2023) reporting values of 89.82 and 87.65 for these categories, respectively. This similarity may reflect common environmental factors affecting otolith features in both the Aegean Sea and the Mediterranean coast of Libya. Additionally, the absence of topographical barriers between the two seas could facilitate the dispersion of pollutants.

Some researchers have suggested that genetic factors may be responsible for asymmetry observed on both sides of the otoliths (Panfili *et al*., 2005). However, the present study cannot address this issue due to the lack of genetic information available for the *C. auratus* mullet species that was examined.

This study contributes additional data on otolith morphology and morphometry, as well as on body morphometrics, specifically the eye lens diameter, which serve as effective indicators for discriminating and detecting fluctuating asymmetry between the right and left sides in the mullet species selected for this study. The observed asymmetry in these morphometric features can be associated with ecological factors such as water temperature, salinity, and pollutants.

CONCLUSIONS

In the present study, three otolith features and one morphological character were investigated in the *C. auratus* mullet species. The fish specimens were collected from two locations in Libya, the Mediterranean Sea coast and the Ain Ziana Lagoon. The four studied characters showed different levels of asymmetry, with the highest observed in the eye diameter. The asymmetry values in fish specimens collected from the Ain Ziana Lagoon were higher than in those from the Mediterranean Sea coast. Moreover, asymmetry seems to be linked to fish length, with larger fish length groups exhibiting higher degrees of asymmetry in both localities. The differing levels of asymmetry observed in relation to the four characteristics examined in *C. auratus* appear to be attributable to the variation in growth processes during fish development.

ACKNOWLEDGEMENTS

The authors would like to thank the Department of Zoology, Faculty of Science, University of Benghazi, Libya for allowing the research on its premises.

NIHAJOČA ASIMETRIJA PRI ZLATEM CIPLJU IZ LIBIJSKE SREDOZEMSKE OBALE IN LAGUNE AIN ZIANA

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POVZETEK

*Avtorja predstavljata prvo raziskavo morfološke asimetrije v premeru očesne leče in treh lastnostih otolita (dolžina, širina in masa otolita) pri zlatih cipljih (*Chelon auratus*), zbranih na sredozemski obali in laguni Ain Ziana v Libiji. Vrednost asimetrije v premeru očesne leče je bila med najvišjimi med štirimi morfološkimi znaki in višja za laguno Ain Ziana kot za sredozemsko obalo Libije. Poleg tega se je asimetrija povečevala s totalno dolžino ribe. Avtorja razpravljata o možnih razlogih za asimetrijo v štirih raziskanih morfoloških lastnostih, ki jo povezujeta z nekonstantno rastjo, ki jo povzročajo ekološki dejavniki kot so razlike v temperature vode, slanosti, globini in prisotnimi onesnaževali v morskih vodah Libije in lagune Ain Ziana.*

Ključne besede: *Chelon auratus,* ekološki dejavniki, Mugilidae, onesnaževanje, otolit, morfologija

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received: 2024-01-08 DOI 10.19233/ASHN.2024.11

SALARIA BASILISCA (ACTINOPTERYGII: BLENNIIDAE) IN MEDITERRANEAN WATERS: NEW BIOLOGICAL AND ECOLOGICAL DATA EMERGING FROM THE COLLABORATION BETWEEN CITIZEN SCIENTISTS AND RESEARCHERS

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ABSTRACT

Salaria basilisca *is a blenny (Blenniidae) endemic to the Mediterranean Sea. Our current understanding of its biology and ecology is limited, and only a few scattered data are available regarding its abundance and distribution. This paper introduces the first targeted study aiming to expand our knowledge of* S. basilisca *with new data obtained through the discovery of a stable population of the species in Sicily. Several couples guarding nests were observed in August 2022 in Marsala (southwestern Sicily). The species inhabits shallow seabed areas covered with seagrass, with its spatial distribution varying between daylight and nighttime hours. Finally, the paper underlines the importance of collaboration between citizen scientists and researchers in natural sciences, as some of these new data were collected through citizen science.*

Key words: combtooth blennies, Mediterranean Sea, cryptobenthic fish, citizen science, rare species

SALARIA BASILISCA (ACTINOPTERYGII: BLENNIIDAE) IN ACQUE MEDITERRANEE: NUOVI DATI BIOLOGICI ED ECOLOGICI EMERSI DALLA COLLABORAZIONE TRA SCIENZIATI CITTADINI E RICERCATORI

SINTESI

Salaria basilisca *è una bavosa (Blenniidae) endemica del Mediterraneo. Le nostre attuali conoscenze sulla sua biologia ed ecologia sono limitate e sono disponibili solo pochi dati sparsi sulla sua abbondanza e distribuzione. Questo lavoro rappresenta il primo studio mirato ad ampliare le conoscenze su* S. basilisca *con nuovi dati ottenuti grazie alla scoperta di una popolazione stabile della specie in Sicilia. Nell'agosto del 2022 sono state osservate diverse coppie che custodivano nidi a Marsala (Sicilia sud-occidentale). La specie abita fondali poco profondi e ricoperti da fanerogame, con la sua distribuzione spaziale che varia tra le ore diurne e notturne. Il lavoro infine sottolinea l'importanza della collaborazione tra scienziati cittadini e ricercatori di scienze naturali, poiché alcuni di questi dati sono stati raccolti grazie al contributo della citizen science.*

Parole chiave: blennidi, Mar Mediterraneo, pesci criptobentonici, citizen science, specie rare

INTRODUCTION

The Blenniidae family consists of small-sized coastal fishes with worldwide distribution, mainly inhabiting shallow marine waters and reaching their highest diversity in tropical and subtropical areas (Nelson, 1994). Currently, more than 400 species of fish belonging to this family are recognised as valid (Eschmeyer *et al*., 2023). Most of them are cryptobenthic, living inside small holes, crevices, and encrusting organisms on hard substrates (Miller, 1996; Orlando-Bonaca & Lipej, 2007; Duci *et al*., 2009; Tiralongo *et al*., 2016a). In Italian waters, a total of 21 species of combtooth blennies (Blenniidae) are currently known (Tiralongo, 2015; Azzurro *et al*., 2018). Of these, one species, *Ophioblennius atlanticus* (Valenciennes, 1836), commonly known as the redlip blenny, is a non-indigenous fish of Atlantic origin. It was first recorded in the Mediterranean Sea in 2014 in Malta (Falzon, 2015), and subsequently in Lampedusa (Strait of Sicily) and Catania (Ionian Sea) in Italian waters (Azzurro *et al*., 2018; Ragkousis *et al*., 2020). Another species, *Salaria fluviatilis* (Asso, 1801), commonly known as the freshwater blenny, has a circum-Mediterranean distribution and is known to inhabit fresh waters only, such as rivers and lakes (Tiralongo, 2015). The remaining 19 species inhabit marine coastal waters, with some of them tolerating brackish waters (Tiralongo, 2015; Tiralongo *et al*., 2016a). Among Mediterranean combtooth blennies (Blenniidae), *Hypleurochilus bananensis* (Poll, 1959) and *Salaria basilisca* (Valenciennes, 1836) are the rarest species to be found in Italian waters and in the Mediterranean Sea in general (Tiralongo, 2015; Tiralongo *et al*., 2016b; Tiralongo, 2020). While *H. bananensis* is present in low abundance within confined areas, *S. basilisca* can be locally abundant, yet scattered in distribution. Recent records of *H. bananensis* come from very small coastal areas (lagoons) of the central Tyrrhenian and northern Ionian seas (Tiralongo *et al*., 2016b; Tiralongo, 2024), while the most recent reports of *S. basilisca* have been made from southern Sardinia, in the waters of both western and eastern sides of the Island (Tiralongo, 2015; Tiralongo *et al.*, 2020).

This report documents the first occurrence of *S. basilisca* in Sicily, providing ecological and biological notes on an established population and discussing the presence and distribution of *S. basilisca* in Italian waters and the broader Mediterranean Sea. It also underlines the importance of collaboration between citizen scientists and researchers in the field of natural sciences, as some of these new data were collected through citizen science.

MATERIAL AND METHODS

On 17 July 2022, a specimen of *S. basilisca* was found alive by a marine enthusiast in the shade on the quay of the Marsala nautical club (southwestern Sicily; 37.806844 N, 12.433331 E). The specimen was photographed and released into the nearby area (37.809599 N, 12.435930 E), where it swam to the bottom, which was covered by a *Posidonia oceanica* meadow. Photos were posted in the specialised Facebook group "Fauna Marina Mediterranea", which is administered by one of the authors (FT), with a request for confirmation of the species' identity. The group, which currently hosts more than 27,000 users and several experts from various taxonomic groups, collects data on rare and non-indigenous species and promotes knowledge of the Mediterranean marine fauna through species identification and facilitating debates among people and experts (Tiralongo *et al*., 2020).

Subsequently, the area indicated by the marine enthusiast was explored by snorkeling on 12 and 13 August 2022, in order to investigate the possible existence of a population of *S. basilisca* and collect/document relevant data on its biology and ecology. A total of 16 hours of visual surveys were conducted, both in daytime and at night, in an area extending from 37.808187 N, 12.433749 E to 37.812640 N, 12.438709 E, and including the coastal lagoon called Stagnone of Marsala, a natural reserve (Fig. 1).

An additional record of this species was provided through photographic documentation from Caprera island (northeastern Sardinia). The specimen was photographed by an amateur in July 2018 at a depth of 2 m in a *P. oceanica* meadow.

The species was identified following the description provided by Tiralongo (2015): "Body elongated and laterally well compressed. Head profile steep and arched. […]. Ocular cirri absent. […]. A series of double vertical dark bars irregularly spaced on sides, extending to about halfway up to the dorsal fin. These bands are darker in the dorsal area, while tend to disappear in the rear and ventral part of the body. […]. These bands are generally dark green in color, with the frequent presence of more or less extensive brick-red bands". This allowed us to distinguish *S. basilisca* from a similar marine species of the same genus, namely *Salaria pavo* (Risso, 1810).

RESULTS AND DISCUSSION

The specimen collected in Marsala had an estimated total length of 18 cm. It had probably been discarded by an amateur fisher (Fig. 2a).

During underwater observations, a total of about 30 specimens of *S. basilisca*, including several couples guarding eggs in nests, were recorded in the depth range of 1–3 m (Figs. 2b,c). During the day, the species was observed in the border area between *Cymodocea nodosa* and *P. oceanica* meadows. At night, all specimens hid among *P. oceanica* leaves, and no parental cares were provided to the eggs. At dawn, all specimens returned to the border area between *C. nodosa* and *P. oceanica* and the couples resumed the care of the eggs. Throughout the day, the males fought off sparids (*Diplodus* spp.) and labrids (*Coris julis*) that attempted to eat the eggs, and fanned their tails to oxygenate the egg mass and remove sand from it. The females helped the males to oxygenate and clean the eggs as well as protect them from predators, but they would often move away, disappearing in the *P. oceanica* meadow. We also recorded the presence of

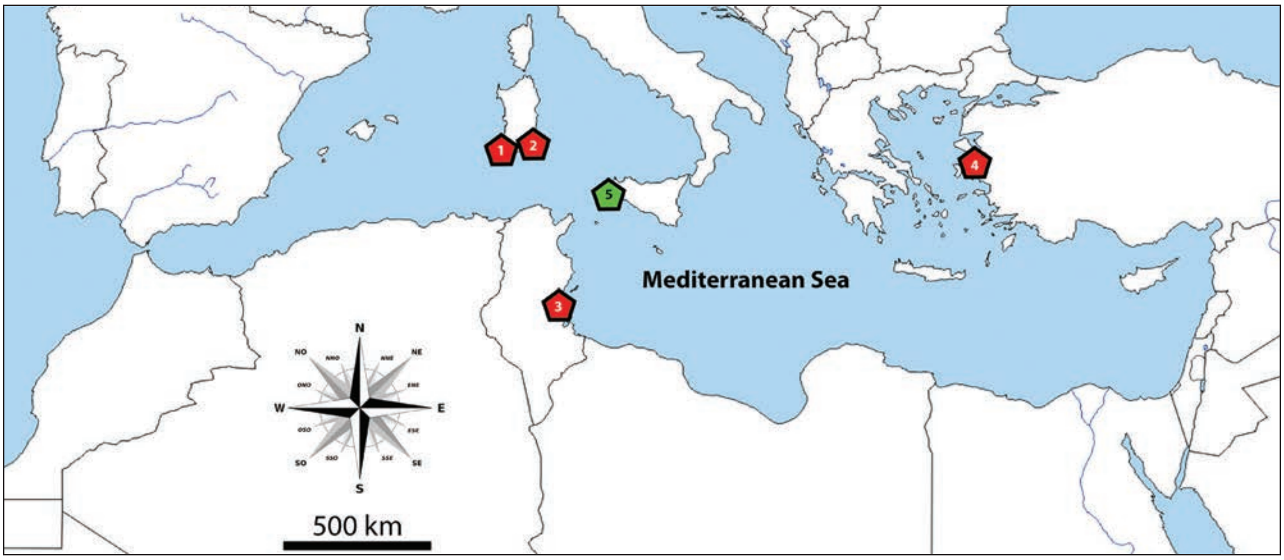

Fig. 1: Documented records of established *Salaria basilisca* ***populations in the Mediterranean Sea. The green polygon (number 5 in black) indicates the new record, the red ones (numbers 1–4 in white) indicate past records; 1 and 2 Sardinia (Tiralongo, 2015; Tiralongo*** *et al.*, ***2020); 3 Tunisia (Dulčić*** *et al.*, ***2008 and references therein; Barhoumi*** *et al.*, ***2009); 4 Turkey (Dulčić*** *et al.*, ***2008 and references therein); 5 new record (Sicily).***

Sl. 1: Dokumentirani zapisi o pojavljanju ustaljenih populacij vrste *Salaria basilisca* ***v Sredozemskem morju. Zeleni poligon (številka 5 v črnem) prikazuje novi zapis o pojavljanju, rdeči poligoni (številke 1–4 v belem) pa prikazujejo stare zapise o pojavljanju; 1 in 2 Sardinija (Tiralongo, 2015; Tiralongo in sod., 2020); 3 Tunizija (Dulčić in sod., 2008 in v delu navedene reference; Barhoumi in sod., 2009); 4 Turčija (Dulčić in sod., 2008 in v delu navedene reference); 5 novi zapis o pojavljanju (Sicilija).***

small sneaker males mimicking the female morphology and behaviour. In the area, we observed a massive presence of sea squirts (Ascidiacea) and, during nighttime, eels (*Anguilla anguilla*). The occurrence of couples of *S. basilisca* taking care of nests with demersal eggs in August suggests that the reproduction period covers at least the early summer period.

The specimen recorded in Sardinia (Caprera) was found alone among *P. oceanica* leaves (photo received by the authors but not included herein due to low quality). Further investigations would be necessary to verify the presence of a stable population of the species in that area.

Salaria basilisca is a species endemic to the Mediterranean Sea. There is limited knowledge about its distribution, and specific data on its biology and ecology are scarce, if not absent. The species appears to be relatively abundant only in a few areas of Italy (southern Sardinia and southwestern Sicily), Tunisia (Gulf of Gabes), and Turkey (Gulf of Izmir), where it forms stable populations (Dulčić *et al.*, 2008; Barhoumi *et al.*, 2009; Tiralongo, 2020). On the other hand, there are dated records of *S. basilisca* from areas where the species is considered very rare: Gulf of Genoa, the Adriatic, Ionian, Tyrrhenian, and Aegean seas (Dulčić *et al.*, 2008 and references therein). However, targeted investigation could lead to the discovery of new stable populations in other Mediterranean areas as well. Indeed, blennies, thanks to their cryptic behaviour and small size, can easily go unnoticed during general fish surveys (Tiralongo *et al.*, 2021).

Salaria basilisca has resulted to be associated with the presence of seagrasses and often with coastal lagoons or adjacent areas. In the area of Marsala, the species concentrated in the border area between meadows of *P. oceanica* and *C. nodosa* during daytime, but preferred the shelter offered by the leaves of *P. oceanica* at night. This behaviour could suggest that predation risk for the eggs is especially high during the day, while at night the eggs can be left unattended. Parental males likely benefit from resting during the night to recover the energy spent during the day in protecting the eggs. Another benefit gained by parental males during the night hours could be the opportunity to feed. In any case, the parental care provided by the males is essential for the development and survival of the eggs. In fact, in addition to cleaning and oxygenating the eggs, similar to what occurs in the congeneric *S. pavo*, it is very likely that males use their anal glands to release substances with antimicrobial activity onto the eggs (Pizzolon *et al.*, 2010). Like for *S. pavo*, we also recorded the presence of small sneaker males mimicking female morphology and behaviour to approach the nests with the aim of parasitic fertilisation (Ruchon *et al.*, 1995; Gonçalves *et al.*, 2005). Furthermore, inside a nest, we observed the presence of a second "female" together with the parental couple. This specimen was larger in size than the parental female and was chased away by the parental male. However, there is still doubt whether it was a larger non-parental female or a female mimicry male.

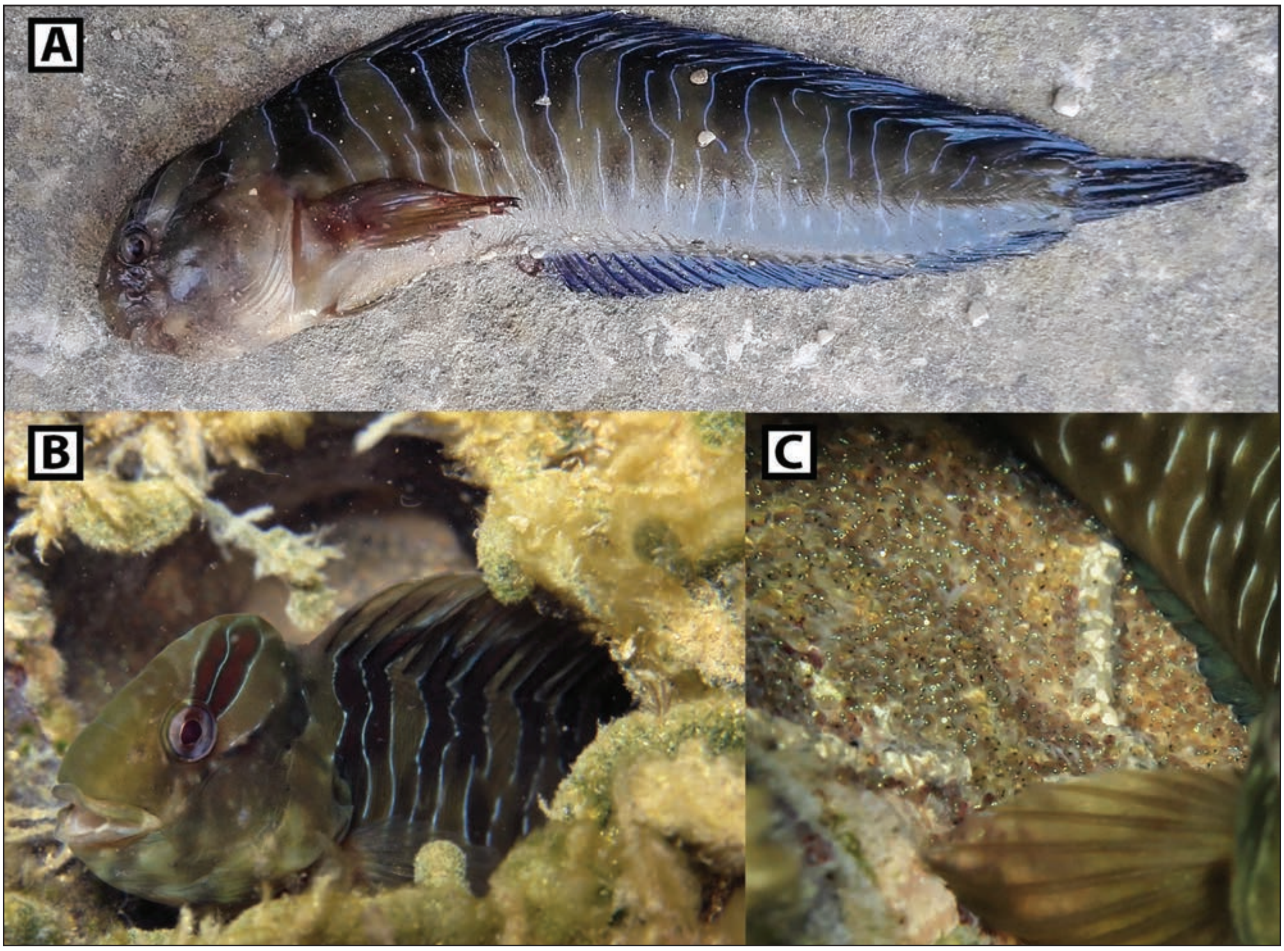

Fig. 2: Specimen of** S. basilisca **found in Marsala on 17 July 2022 (A); male of S. basilisca defending the nest, observed in Marsala on 13 August 2023 (B); eggs of** S. basilisca **(C).
Sl. 2: Primerek vrste** S. basilisca **najden v Marsali 17. julija 2022 (A); samec zebraste babice brani gnezdo, opazovano v Marsali 13. avgusta 2023 (B); jajca vrste** S. basilisca **(C).

In conclusion, this paper provides the first thoroughly documented record of the "enigmatic" blenny species *S. basilisca* from Sicilian waters and the first report of a stable population of this species in the area. It also presents an additional record from a new location in Sardinia (Caprera Island), which is currently the Italian region where the studied species is most abundantly and widely distributed. Last but not least, the paper documents for the first time certain behavioural traits of the species in its habitat, providing new data on the biology and ecology of this little-known and understudied species. Further research focused on areas with stable populations of *S. basilisca*, such as Marsala, is of great relevance for improving our understanding of the biological and ecological aspects of this fish. Furthermore, considering the close association between the species and seagrasses, the decline of meadows of *P. oceanica* (and other seagrass species) could result in the local extinction of the species. This is exemplified by areas where a significant regression of *P. oceanica* has been recorded (Blanco-Murillo *et al.*, 2022). Hence, there is an urgent need to protect high-diversity habitats such as *P. oceanica* meadows in order to prevent biodiversity loss.

Finally, as highlighted by this research, the collaboration between citizen scientists and researchers is vital in studying the biology and ecology of species. This synergy significantly broadens the range of investigations, engaging a wider network of observers and contributing to the collection of more comprehensive and detailed data on the behaviour, distribution, and ecology of the species under study (Tiralongo *et al.*, 2019; Azzurro & Tiralongo, 2020). Such an inclusive approach not only enhances scientific knowledge but also promotes public awareness and active participation in biodiversity conservation.

ACKNOWLEDGEMENTS

We are grateful to Danilo Graffeo for providing us photos and data about the first specimen observed at Marsala.

SALARIA BASILISCA (ACTINOPTERYGII: BLENNIIDAE) V SREDOZEMSKIH VODAH: NOVI BIOLOŠKI IN EKOLOŠKI PODATKI NA PODLAGI SODELOVANJA MED LJUBITELJSKIMI RAZISKOVALCI IN RAZISKOVALCI

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POVZETEK

*Zebrasta babica (*Salaria basilisca*) je endemična babica (družina Blenniidae) v Sredozemskem morju. Naše poznavanje o biologiji in ekologiji te vrste je omejeno, saj obstaja le nekaj razpršenih podatkov o njeni številčnosti in razširjenosti. Avtorja predstavljata prvo tarčno raziskavo z namenom dopolniti poznavanje o vrsti* S. basilisca *z novimi podatki, pridobljenimi z raziskavo stabilne populacije te vrste, odkrite na Siciliji. Več parov, ki so varovali gnezda, so opazovali avgusta 2022 pri Marsali (jugozahodna Sicilija). Vrsta naseljuje plitve predele morskega dna, pokritega z morsko travo, njena prostorska razširjenost pa se razlikuje med dnevnimi in nočnimi urami. Prispevek obenem poudarja pomen sodelovanja med ljubiteljskimi naravoslovci in naravoslovnimi strokovnjaki, saj so bili nekateri od podatkov zbrani s pomočjo ljubiteljske znanosti.*

Ključne besede: prave babice, Sredozemsko morje, kriptobentoške ribe, ljubiteljska znanost, redke vrste

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BIOTSKA GLOBALIZACIJA

GLOBALIZZAZIONE BIOTICA

BIOTIC GLOBALIZATION

received: 2023-12-27 DOI 10.19233/ASHN.2024.12

ADDITIONAL RECORD OF *PTEROIS MILES* (SCORPAENIDAE) IN CROATIAN WATERS (EASTERN ADRIATIC SEA)

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ABSTRACT

One specimen of Pterois miles *was caught by a spearfisherman on 15 August 2023, at a depth of 17–18 m, near Račišće (Island of Korčula, southern Adriatic). This is the first record for this species based on a caught and deposited specimen, and the second documented occurrence for Croatian waters. It confirms the hypothesis that the species is capable of reaching and expanding in the Adriatic Sea.*

Key words: Scorpaenidae, *Pterois miles*, alien species, Croatia, Adriatic Sea

ULTERIORE SEGNALAZIONE DI *PTEROIS MILES* (SCORPAENIDAE) NELLE ACQUE CROATE (MARE ADRIATICO ORIENTALE)

SINTESI

Un esemplare di Pterois miles *è stato catturato da un pescatore subacqueo il 15 agosto 2023, a una profondità di 17-18 m, vicino a Račišće (Isola di Korčula, Adriatico meridionale). Si tratta della prima segnalazione di questa specie basata su un esemplare catturato e depositato e della seconda presenza documentata nelle acque croate. Ciò conferma l'ipotesi che la specie sia in grado di raggiungere ed espandersi nel mare Adriatico.*

Parole chiave: Scorpaenidae, *Pterois miles*, specie aliena, Croazia, Adriatico

INTRODUCTION

The devil firefish, *Pterois miles* (Bennett, 1828), is considered as one of the most invasive species in the Mediterranean Sea (Galanidi *et al.*, 2018). Originally from the Red Sea, the species was first recorded in the eastern Mediterranean in 1991 (Golani & Sonin, 1992). After a lag of approximately twenty years, the devil firefish invasion started and has since continued in the Levantine and the Aegean Seas (Kondylatos *et al.*, 2023), showing a progressive expansion westward into the central and western Mediterranean, and northward into the Adriatic Sea (see Dragičević *et al.*, 2021, Ulman *et al.*, 2022). The last confirmed sightings placed the species in the Adriatic (Montenegro) and the Alboran Seas (Fortič *et al.*, 2023), as well as in the Calabrian Ionian Sea (Langeneck *et al.*, 2023).

This paper reports on an additional record of *P. miles* (Scorpaenidae) in Croatian waters (eastern Adriatic coast).

MATERIAL AND METHODS

A single specimen of *Pterois miles* was caught by a spearfisherman (Fig. 1) on 15 August 2023 at a depth of 17–18 m, near Račišće (Island of Korčula, southern Adriatic) (approx. 42.978813° N, 17.019692° E). The specimen was deeply frozen upon collection from the fisherman and sent to the Institute of Oceanography and Fisheries (Split, Croatia) for analysis. During laboratory analysis, meristic counts of the specimen were recorded and the species was identified according to morphological characters provided by Golani & Sonin (1992).

Fig. 1: The specimen of Pterois miles ***caught in August 2023 by a spearfisherman in the Adriatic Sea, Croatia. (Photo: Luka Srzić).***
Sl. 1: Primerek vrste Pterois miles***, ki ga je ujel podvodni ribič avgusta 2023 v Jadranskem morju, Hrvaška (Foto: Luka Srzić).***

Fig. 2: The specimen of* Pterois miles *caught near Račišće (Island of Korčula, Adriatic Sea, Croatia).
Sl. 2: Primerek vrste* Pterois miles*, ujet blizu Račišća (otok Korčula, Jadransko morje, Hrvaška).

Prior to the dissection, the fresh specimen was measured to the nearest 0.1 millimetre using a digital caliper and weighed to the nearest 0.01 gram. The ovaries and the digestive tract were analysed macroscopically. Due to a severe head wound, it was not possible to extract otoliths from the fish.

The specimen was preserved in 95% ethanol and deposited in the Ichthyological Collection of the Institute of Oceanography and Fisheries in Split under the catalogue number IOR – 1 – PMILES.

RESULTS AND DISCUSSION

The specimen of *Pterois miles* (Figs. 1, 2) was a female measuring 28.1 cm total length and weighing 317 g. Meristic counts were as follows: dorsal fin rays: XIII +11; pelvic fin rays: I + 6; anal fin rays: III +7; pectoral fin rays: XIV. The counts and general characters of the sample were in total agreement with previous descriptions of the species by Golani & Sonin (1992).

The dissected specimen exhibited large and developed ovaries weighing 2.93 g, which allowed us to conclude it was mature and able to reproduce. The stomach contained partly digested remains of four unidentified fish species ranging approximately from 2.3 cm to 4.4 cm in standard length (Fig. 3).

The finding described in this note represents the first record based on a caught specimen of *P. miles* and the second documented for Croatian waters (see Dragičević *et al.*, 2021).

The first sightings of the devil firefish in the Adriatic Sea were along the coasts of Puglia (Italy) and Albania, in July 2019 and August 2020, respectively (Di Martino and Stancanelli, 2021). Additional but unconfirmed sightings of this species have been reported from the southern part of Croatia during 2023. For example, a photo of one specimen supposedly caught near the Pelješac Peninsula was sent to us by a citizen, but we were unable to confirm the record.

This new record now confirms the hypothesis that this species is capable of reaching and expanding in the Adriatic Sea, as Karachle *et al.* (2017) had predicted when they included *P. miles* among the species expected to spread in the ESENIAS (East and South European

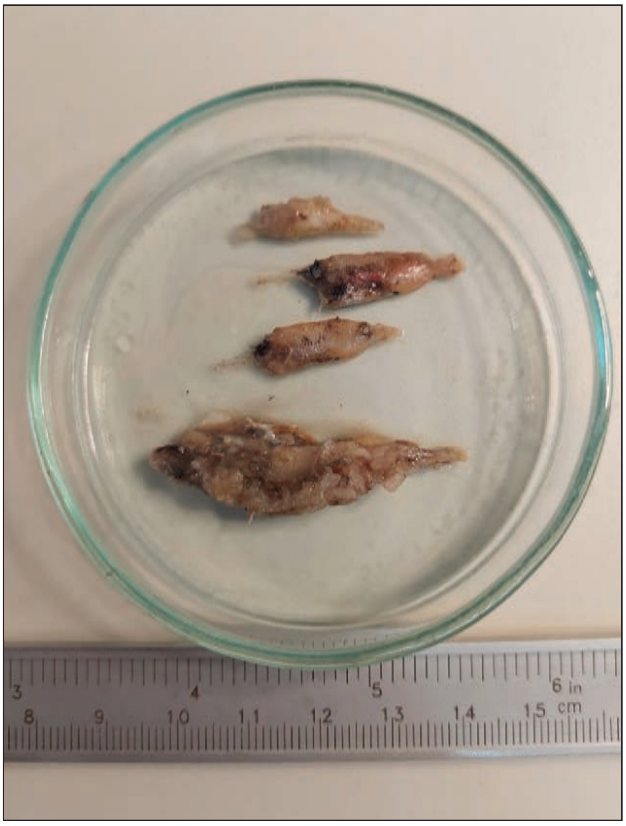

Fig. 3: Four fish of unidentified species found in the stomach of the* Pterois miles *specimen from Croatian waters.
Sl. 3: Štiri primerki nedoločenih rib v želodcu navadne plamenke iz hrvaških voda.

Network for Invasive Alien Species, www.esenias.org/) countries along the coasts of the basin, such as Albania and Montenegro. Keeping track of records of alien species such as *P. miles* by involving fishermen and the general public and motivating them to report such occurrences, is of essential importance, as it helps to foresee and recognize the purposes and significance of eradication and plan population control measures. Currently, there is no evidence that a self-sustaining population exists in this area, and the presence of this species can also be a result of propagule transport from areas with established populations. Migrations of adults are less probable, given that adults are known to exhibit site fidelity (Bos *et al.*, 2018).

The present report highlights the importance of citizen science in the early detection and monitoring of invasive species (Kletou *et al.*, 2016; Özbek *et al.*, 2017; Tiralongo *et al.*, 2024). In fact, the collaborative efforts of local fishermen and marine enthusiasts have already contributed to a timely detection of both previous and herein described records of *Pterois miles* fish in Croatia. Further research is necessary to explore the potential ecological repercussions of this and other alien species on native ecosystems, including their interaction with fisheries, in order to envisage effective management strategies.

ACKNOWLEDGEMENTS

The authors are thankful to Mr. Luka Srzić for providing a specimen of *Pterois miles* and to Mr. Pero Ugarković for informing us about the catch.

DODATNI ZAPIS O POJAVLJANJU NAVADNE PLAMENKE *PTEROIS MILES* (SCORPAENIDAE) V HRVAŠKIH VODAH (VZHODNO JADRANSKO MORJE)

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POVZETEK

*Petnajstega avgusta 2023 je podvodni ribič na globini med 17 in 18 m blizu Račišća (otok Korčula, južni Jadran) ujel primerek navadne plamenke (*Pterois miles*). To je prvi zapis o pojavljanju vrste na podlagi ujetega in shranjenega primerka in drugi dokumentiran zapis o pojavljanju za hrvaške vode. To potrjuje hipotezo, da se lahko vrsta pojavlja in razširja v Jadranskem morju.*

Ključne besede: Scorpaenidae, *Pterois miles*, tujerodna vrsta, Hrvaška, Jadransko morje

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received: 2024-03-21 DOI 10.19233/ASHN.2024.13

ON THE OCCURRENCE OF THE INDO-PACIFIC NAKEDBAND GAPER *CHAMPSODON NUDIVITTIS* (CHAMPSODONTIDAE) IN THE SEA OF MARMARA, TURKEY

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ABSTRACT

On 17 February 2024, twelve specimens of Champsodon nudivittis *were caught by a commercial beam-trawler targeting shrimp in the coastal waters of Karabiga, in the province of Çanakkale, at a depth between 45 and 65 m. This paper presents updated records of* C. nudivittis *in the Mediterranean Sea, including the recent occurrence in the Sea of Marmara, Turkey.*

Key words: extension range, Lessepsian migration, nakedband gaper, Mediterranean

PRESENZA DI *CHAMPSODON NUDIVITTIS* (CHAMPSODONTIDAE) NEL MAR DI MARMARA, TURCHIA

SINTESI

Il 17 febbraio 2024, dodici esemplari di Champsodon nudivittis *sono stati catturati da un peschereccio commerciale a strascico per la pesca dei gamberi nelle acque costiere di Karabiga, nella provincia di Çanakkale, a una profondità compresa tra i 45 e i 65 m. Il presente lavoro presenta le segnalazioni aggiornate di* C. nudivittis *nel Mediterraneo, compresa la recente presenza nel Mar di Marmara, in Turchia.*

Parole chiave: estensione dell'areale, migrazione lessepsiana, *Champsodon nudivittis*, Mediterraneo

INTRODUCTION

The Champsodontidae family contains only one genus, *Champsodon*, and thirteen species (Froese and Pauly, 2024). *Champsodon nudivittis* (Ogilby, 1895) is native to the entire Indo-Pacific at depths down to 355 m (Nemeth, 1994) and found in the Indo-West Pacific, in Madagascar, Indonesia, the Philippines, and Australia (Froese & Pauly, 2024). In the eastern Mediterranean, *C. nudivittis* was first recorded in 2008 in the Bay of Iskenderun, Turkey (Çiçek & Bilecenoğlu, 2009), with reports of two more species from this area, *C. vorax* Günther, 1867 in Lebanon (Bariche, 2010), and *C. capensis* Regan, 1908, also in the Bay of Iskenderun (Dalyan *et al*. 2012), following soon thereafter. However, Stern *et al*. (2019) has argued that only *C. nudivittis* has migrated into the eastern Mediterranean as an alien invasive species according to integrative taxonomic features.

Champsodon nudivittis has rapidly spread throughout the eastern Mediterranean. From the Bay of Iskenderun, it moved westward into the Aegean Sea, reaching the northern Aegean Sea in 2014 (Torcu-Koç *et al*., 2015) and the Sea of Marmara in 2020 (Orfanidis *et al.,* 2021). Thus, *C. nudivittis* appears to be a swift invader in the Mediterranean, gradually extending its range from both sides of the Aegean Sea to the Sea of Marmara. This paper presents updated records of *C. nudivittis* in the Mediterranean Sea, including new occurrences in the Sea of Marmara, Turkey.

MATERIAL AND METHODS

On 17 February 2024, twelve specimens of *C. nudivittis* (Fig. 1) were captured by a commercial beam-trawler targeting shrimp in the coastal waters of Karabiga, in the Turkish province of Çanakkale, in the Sea of Marmara (at 40°28′N, 27°17′E), at a depth between 45 and 65 m (Fig. 2). The specimens were fixed in a 5% formaldehyde solution and deposited in the fish collection of the Faculty of Fisheries, Ege University (ESFM-PIS/2024-001). The specimens were measured to the nearest millimeter. For species identification, we followed Nemeth (1994), Çiçek & Bilecenoğlu (2009), Akyol & Ünal (2015), and Froese & Pauly (2024).

RESULTS AND DISCUSSION

Morphometric and meristic characteristics are provided in Tab. 1. The specimens displayed the following features: body elongated, laterally slightly compressed; mouth oblique, with maxilla extending to below posterior eye margin (Fig. 1A); located between parallel bony ridges on upper part of head a row of five pairs of sensory papillae, not arranged in semicircle, lacrimal bone with two spines projecting anteroventrally, a characteristic

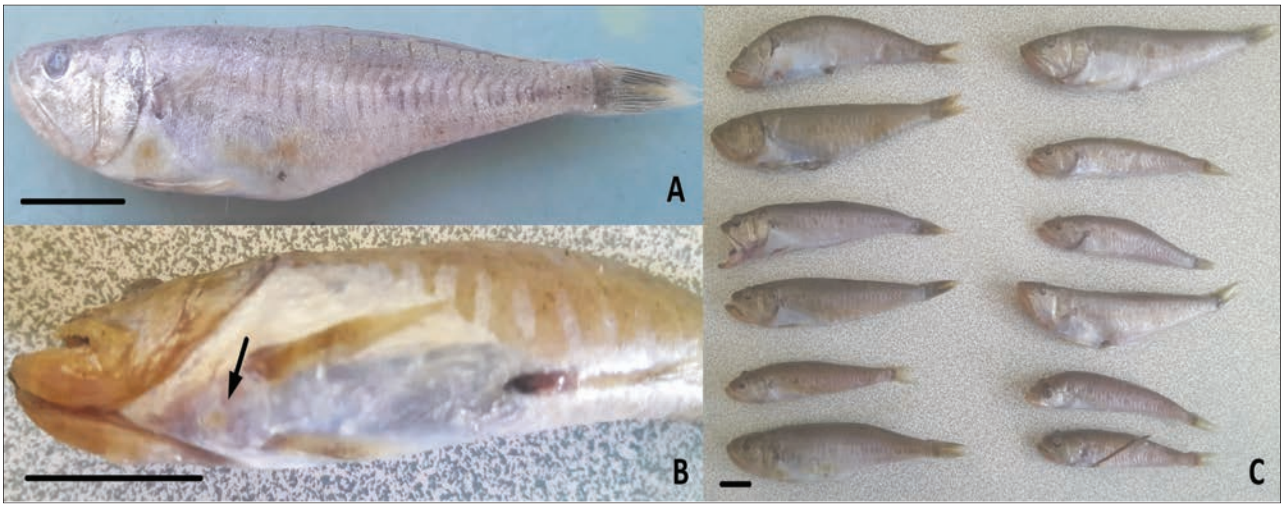

Fig. 1: *Champsodon nudivittis* ***(128 mm TL) caught in the Sea of Marmara: (A) general view, (B) ventral view with scale pattern on breast (arrow), (C) all fishes sampled. Horizontal scale bar: 20 mm.***
Sl. 1: Primerek vrste *Champsodon nudivittis* ***(128 mm TL), ujet v Marmarskem morju: (A) celovit pogled, (B) spodnja stran z vzorcem lusk na oprsju (puščica), (C) vse ujete ribe. Vodoravno merilo: 20 mm.***

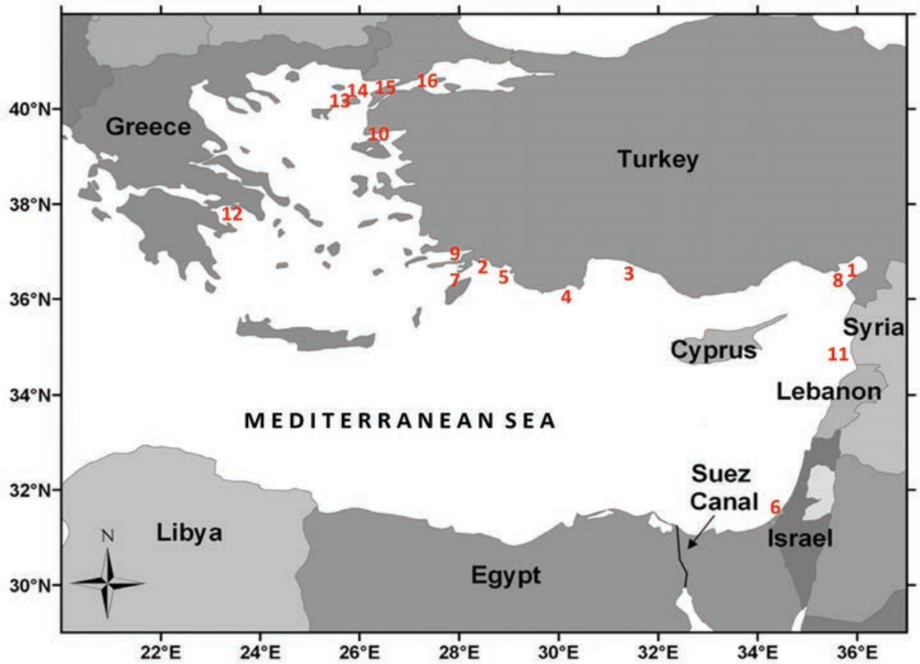

Fig. 2. Records of *Champsodon nudivittis* ***reported in the Mediterranean Sea. Location numbers (1-16) match those in Table 2.***
Sl. 2: Zapisi o pojavljanju vrste *Champsodon nudivittis* ***v Sredozemskem morju. Številke lokalitet (1-16) se ujemajo s tistimi v Tabeli 2.***

Tab. 1: Morphometric and meristic counts of *Champsodon nudivittis* ***specimens (n=12) in the Sea of Marmara.***
Tab. 1: Morfometrična in meristična štetja na primerkih vrste *Champsodon nudivittis* ***(n=12) v Marmarskem morju.***

Morphometrics	**Min.-max. (mean ± S.D.)**
Total length (TL, mm)	89-141 (114.6 ± 17.4)
Standard length (SL, mm)	81-120 (98.5 ± 13.3)
Head length (HL, mm)	20-33 (26.3 ± 4.2)
Eye diameter (mm)	5-7 (5.9 ± 0.8)
Snout length (mm)	6-11 (7.5 ± 1.5)
Body depth (mm)	15-25 (19.3 ± 3.7)
Predorsal length (mm)	25-41 (32.7 ± 5.7)
Preanal length (mm)	40-69 (53.0 ± 10.3)
Prepectoral length (mm)	20-34 (26.8 ± 4.4)
Interorbital width (mm)	4-7 (5.1 ± 1.2)
Meristic counts	
Spines of first dorsal fin	5
Soft rays of second dorsal fin	19-20 (19.6 ± 0.5)
Soft rays of anal fin	17-18 (17.8 ± 0.5)
Soft rays of pectoral fin	13-14 (13.5 ± 0.5)
Soft rays of ventral fin	5

posteroventral spine on the preopercle; scales small, spiny, and non-overlapping; on the belly, scales present in a small patch on the breast (Fig. 1B), but otherwise absent from chin (where distinct small melanophores could be observed instead), from areas between pectoral and pelvic fins, and as far as the anus.

While Çiçek & Bilecenoğlu (2009) assume that the introduction of *C. nudivittis* into the Mediterranean Sea occurred via ballast waters from ships, a native Red Sea population of *C. nudivittis* has been confirmed by Goren *et al*. (2011). Moreover, Goren *et al*. (2011) concluded that the occurrence of *C. nudivittis* in Israel and Turkey indicates the presence of a reproducing population in the Mediterranean. So far, this species has spread both westward and northward; noting the westernmost expansion of the species from the Suez Canal to the Gulf of Saronikos, Greece, over a distance of 2355 km, Kousteni & Christidis (2019) observed that *C. nudivittis* should be considered a species with strong dispersal potential, capable of spreading beyond the biogeographical boundaries of the Levantine basin.

Recent data suggest that *C. nudivittis* is likely to expand westward in the Mediterranean (Kousteni & Christidis, 2019). Known species records documented from various depths (ranging from 30 to

Tab. 2: Records of** Champsodon nudivittis **in the Mediterranean Sea with particular reference to the fishing gear (BT: Beam-trawl; PS: Purse-seine; SP: Shrimp pot; T: Trawl; TN: Trammel net).
Tab. 2: Zapisi o pojavljanju vrste** Champsodon nudivittis **v Sredozemskem morju na podlagi ribolovnega orodja (BT: vlečna mreža z gredjo; PS: zaporna plavarica; SP: vrše za kozice; T: vlečna mreža; TN: trislojna mreža).

Sampling locations (numbers correspond with those on the map)	Depth (m)	Fishing Gear*	Date	N	Size (mm)	References
1. Iskenderun Bay	50	T	18 Jan. 2008	1	114 TL	Çiçek & Bilecenoğlu (2009)
2. Ekincik Bay, Fethiye	55-72	T	12 Nov. 2010	5	47-133 TL	Filiz *et al.* (2014)
3. Gulf of Antalya	140-150	T	23-28 Dec.2010	6	95-130 TL	Gökoğlu *et al.* (2011)
4. Finike Bay	180	T	17 Jan. 2011	4	129-140 TL	Ergüden & Turan (2011)
5. Fethiye Bay, SE Aegean	120-190	T	10-13 Mar. 2011	94	47-133 TL	Filiz *et al.* (2014)
6. Off Ashod, Israel	100	?	31 May 2011	1	89 SL	Goren *et al.* (2011)
7. W Rhodes, Aegean, Greece	150	SP	12 May 2012	2	83-88 TL	Kalogirou & Corsini-Foka (2012)
8. Iskenderun Bay	120	T	2011-2012	296	60-144 TL	Yaglıoglu *et al.* (2014)
9. Gökova Bay, SE Aegean	40	TN	22 Mar. 2014	1	130 TL	Akyol & Ünal (2015)
10. Edremit Bay, NE Aegean	60	T	Mar.-Apr. 2014	3	103-123 TL	Torcu-Koç *et al.* (2015)
11. Off Jableh, Syria	?	T	22 May 2015	1	132 TL	Ali *et al.* (2017)
12. Gulf of Saronikos, Greece	86-92	T	13 Oct.2017	1	116 TL	Kousteni & Christidis (2019)
13. Gökçeada, N Aegean	100-120	T	12 Nov.2019	1	122 TL	Dalyan *et al.* (2021)
14. Gökçeada, N Aegean	100-120	T	5 Jan. 2020	1	117 TL	Dalyan *et al.* (2021)
15. Çanakkale, Marmara Sea	30	PS	22 Nov.2020	1	121 TL	Orfanidis *et al.* (2021)
16. Çanakkale, Marmara Sea	45-65	BT	17 Feb.2024	12	89-141 TL	Present study

190 m) and from twelve intermittent localities in the eastern Mediterranean in the period between 2008 and 2024, indicate a well-established population in this area (Tab. 2, Fig. 2). Finally, the new species records in the Sea of Marmara indicate its tolerance to less saline waters (mean 22 psu, Artüz, 2007).

ACKNOWLEDGEMENTS

The authors thank Mr. Akın Aşık from Şarköy Fishery Cooperatives for providing the *Champsodon nudivittis* specimens.

O POJAVLJANJU ZOBATE KROKODILKE *CHAMPSODON NUDIVITTIS* (CHAMPSODONTIDAE) V MARMARSKEM MORJU, TURČIJA

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POVZETEK

Sedemnajstega februarja 2024 je komercialno plovilo za lov kozic na globini med 45 in 65 metrov v obalnih vodah Karabige (provinca Çanakkale) v vlečno mrežo ujelo 12 primerkov vrste Champsodon nudivittis. *Avtorja poročata o dosedanjih najdbah zobate krokodilke v Sredozemskem morju, upoštevaje tudi recentno najdbo iz Marmarskega morja (Turčija).*

Ključne besede: širjenje areala, lesepska selitev, *Champsodon nudivittis*, Sredozemsko morje

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received: 2024-03-04 DOI 10.19233/ASHN.2024.14

RANGE EXPANSION OF *PRIACANTHUS HAMRUR* (FABRICIUS, 1775) IN THE NORTHEASTERN MEDITERRANEAN (MERSIN BAY, TURKEY)

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ABSTRACT

A single male specimen of Priacanthus hamrur *(Fabricius, 1775) was caught by hook and line at a depth of 35 m in Mersin Bay (Taşucu, Turkey) in February 2024. This is the second record from Turkish waters and the first from Mersin Bay (northeastern Mediterranean coast of Turkey). The finding of a male specimen may suggest successful adaptation and potential establishment of a population in the near future. Also, available records may indicate that the species has migrated westward in the Mediterranean waters of Turkey.*

Key words: Moontail bullseye, Pricanthidae, Occurence, Taşucu coast, Eastern Mediterranean

ESPANSIONE DELL'AREALE DI *PRIACANTHUS HAMRUR* (FABRICIUS, 1775) NEL MEDITERRANEO NORD-ORIENTALE (BAIA DI MERSIN, TURCHIA)

SINTESI

Un singolo esemplare maschio di Priacanthus hamrur *(Fabricius, 1775) è stato catturato con amo e lenza a 35 m di profondità nella baia di Mersin (Taşucu, Turchia) nel febbraio 2024. Si tratta della seconda segnalazione dalle acque turche e della prima dalla baia di Mersin (costa mediterranea nord-orientale della Turchia). Il ritrovamento di un esemplare maschio può suggerire il successo dell'adattamento e il potenziale insediamento di una popolazione nel prossimo futuro. Inoltre, i dati disponibili possono indicare che la specie è migrata verso ovest nelle acque mediterranee della Turchia.*

Parole chiave: occhio di bue lunare, Pricanthidae, occorrenza, costa di Taşucu, Mediterraneo orientale

INTRODUCTION

So far, four species of the genus *Priacanthus* have been reported so far in the Mediterranean Sea: the Atlantic bigeye, *Priacanthus arenatus* Cuvier, 1829, the moontail bulleye, *P. hamrur* (Fabricius, 1775), the elongated bulleye, *P. prolixus* Starnes, 1988, and the arrow bulleye, *P. sagittarius* Starnes, 1988. Another priacanthid, the paeony bulleye, *P. blotchi* Bleeker, 1853, is known from the Red Sea (Golani *et al.,* 2011), but there have been no confirmed reports of its presence in Mediterranean waters.

P. hamrur is widely distributed in the Indo-Pacific, from the Red Sea and southern Africa in the west to French Polynesia in the east, reaching northward and southward to southern Japan and Australia, respectively, and even including Easter Island (Fricke, 1999). The species is commonly found on outer reef slopes and deep lagoon pinnacles at depths ranging from 8 to 80 m at least (Kuiter & Tonozuka, 2001), but may also be seen under ledges or hovering near coral heads during the day (Allen & Erdmann, 2012).

The first record of the arrow bulleye *P. hamrur* in the Mediterranean was reported from the Tunisian coast (off Mahdia) by Abdelmoleh (1981). Although this record remains questionable, the species is included in the checklists for the Mediterranean compiled by Bradai *et al.* (2004) and Golani and Bogorodsky (2010). Some 37 years later, it was reported for the second time in Mediterranean waters, and for the first time from the Bay of Iskenderun, Turkey, by Ergüden *et al.* (2018).

This paper reports a second record of *P. hamrur* from Turkish Mediterranean waters and represents the third consecutive record of this species in the Mediterranean basin. The record suggests a westward migration of the species in the waters of Turkey. This finding importantly contributes to a better understanding of the species' distribution in the region.

MATERIAL AND METHODS

A male specimen of *P. hamrur* Starnes, 1988 was caught with a fishing rod at a depth of 35 m on February

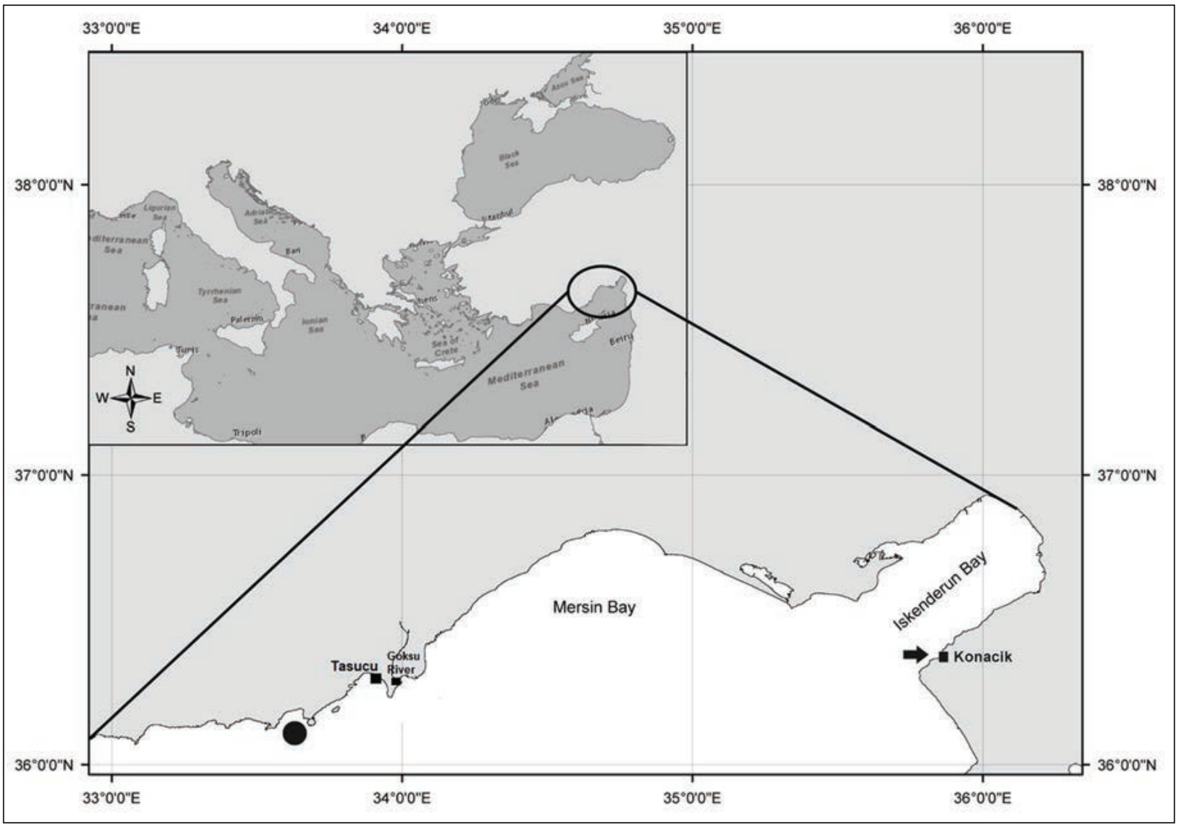

Fig. 1: Map showing the capture sites of** P. hamrur **in the Mediterranean Sea. → Previous record: Konacık (Iskenderun Bay), Turkey; • Present record: Taşucu (Mersin Bay), Turkey.

Sl. 1: Zemljevid obravnavanega območja z označenima lokalitetama ulova primerkov vrste** P. hamrur **v Sredozemskem morju. → Predhodni zapis o pojavljanju: Konacık (zaliv Iskenderun), Turčija; • Pričujoči zapis o pojavljanju: Taşucu (zaliv Mersin), Turčija.

Fig. 2: The specimen of moontail bullseye** P. hamrur **was captured (190 mm, TL) from Mersin Bay, Turkey. Top left corner: photograph taken immediately upon capture.
Sl. 2: Primerek lunastorepega veleokega ostriža** P. hamrur **(190 mm telesne dolžine), ujetega v zalivu Mersin, Turčija. Zgornji levi rob: fotografija posneta takoj po ulovu.

11, 2024, off the Taşucu coast (near Dana Island, Turkey), at 36º12′29′′ N, 33º45′36.9′′ E (Fig. 1). The captured specimen was taken to the laboratory, where morphometric measurements were made using a digital caliper with an accuracy of 0.01 mm. The specimen's gonads were examined under a stereomicroscope and found to be immature. The identification of *P. hamrur* aligns with that provided by Starnes (1988). The measurements and counts, morphological description, and coloration correspond to the descriptions by Starnes (1988), Philip (1994), and Ergüden *et al.* (2018). The specimen was deposited at the Mersin University Marine Life Museum under catalog number MEUFC-24-11-146 (Fig. 2).

RESULTS AND DISCUSSION

The recorded specimen of *P. hamrur* measured 190 mm total length (TL) and 155 mm standard length (SL), and weighed 120.45 g. It displayed the following morphological characteristics: dorsal fin rays: X +14, anal fin rays: III +15, pectoral fin rays; 16, total gill rakers in the first gill arch: 26 (13 on the lower and 13 on the upper limb of the first arch); body laterally compressed, depth at the sixth dorsal fin spine 2.62 times the standard length; soft part of dorsal fin higher than spiny part and angled posteriorly; pectoral fins shorter than pelvic vertebrae; pelvic fins long and extending posteriorly to spiny portion of anal fin; caudal fin distinctly emarginate. Head length 32.69% of standard length (SL); body depth 39.58% of standard length; eyes large, with eye diameter 45.40% of head length; interorbital width 30.92% of head length; distance from upper lip to orbit 41.99% of head length; distance from upper lip to origin of dorsal fin 35.03% of standard length. The meristic and morphometric characteristics of the specimen are presented in Table 1 and compared with previous Mediterranean records.

Coloration of the specimen: body entirely red or pinkish with about 6 red bars and large spots on upper side; dorsal and anal fins red to light pink; membranes of caudal and pelvic fins blackish distally.

P. hamrur is a nocturnal species that naturally occurs at depths ranging between 8 and 250 m (Kuiter & Tonozuka, 2001), but most commonly between 30 and 50 m (Starnes, 2001; Sivakami *et al.,* 2001). Starnes (1988) reported a depth range from the surface down to 440 m. The species frequently feeds on small fish, crustaceans, and other small invertebrates (Fisher *et al.,* 1990).

Although *P. hamrur* and *P. prolixus* share similarities, *P. hamrur* exhibits a more elongated body structure, with the body depth at the sixth dorsal fin spine approximately 2.6 to 2.8 times the standard length (Starnes, 1988). *P. hamrur* also differs from other priacanthid species in the number of gill rakers, having 24–26 compared to 28–31 in *P. arenatus*, 29–31 in *P. prolixus*, and 19–22 in *P. sagittarius* (Starnes, 1988).

P. sagittarius typically lives solitarily but can occasionally form small schools in oceanic locations (Kuiter & Tonozuka, 2001). Male specimens can reach a maximum standard length of up to 450 mm (Heemstra, 1986). Ergüden *et al.* (2018) reported a standard length

Tab. 1: Morphometric measurements of the* P. hamrur *specimen collected from the northeastern Mediterranean, Turkey, and comparison with a previous record from the Mediterranean.
Tab. 1: Morfometrične meritve primerka vrste* P. hamrur *iz severovzhodnega Sredozemskega morja, Turčija, in primerjava s predhodnim zapisom o pojavljanju vrste v Sredozemskem morju.

Measurements (mm)	**This study**	**Ergüden *et al.* (2018)**
Total length	190	367
Standard length	155	285
Head length	50.68	64.77
Head depth	46.35	60.03
Maximum body depth	61.36	109.30
Eye diameter	23.01	26.23
Inter-orbital width	15.67	19.48
Distance between orbit and upper lip	21.28	36.09
Distance between upper lip and dorsal fin	54.30	77.62
Pre-orbital length	12.86	14.73
Post-orbital length	33.88	43.56
Pre-dorsal fin length	43.49	69.56
Post-dorsal fin length	13.75	26.2
Pre-pelvic fin length	52.42	78.85
Pre-pectoral fin length	50.41	67.97
Pre-anal fin length	9.36	15.0
Caudal peduncle length	20.09	26.72
Anal fin length	57.32	117.21
Pelvic fin length	60.77	85.84
Pectoral fin length	33.68	43.13
Meristic characters		
Total number of gill rakers on 1st gill arch	26	26
Scales in lateral line series	78	80
Vertical scale row	47	48
Number of dorsal fin ray spines	X + 14	X + 13
Number of anal spines	III + 15	III + 15
Number of pelvic spines	I + 5	I + 5
Number of pectoral rays	16	16
Number of caudal fin rays	19	20
Weight (g)	120.45	760.59

of 285 mm for *P. hamrur* in Iskenderun Bay (southeastern Mediterranean, Turkey), whereas in our study, the specimen from the northeastern Mediterranean coast of Turkey measured 155 mm standard length. Although a common length of 400 mm has been reported for this species, the specimens observed in the Mediterranean Sea seem to exhibit smaller lengths. Previous records of

Tab. 2: Records of* P. hamrur *from the Mediterranean Sea for the period 1980–2024.
Tab. 2: Zapisi o pojavljanju vrste* P. hamrur *v Sredozemskem morju v obdobju 1980–2024.

References	**Record Date**	**Number of Samples**	**Location**	**Sampling Gear**	**Depth (m)**	**Length, SL (mm)**
Abdelmoleh (1981)	1981	1	Tunisian coast, Mahdia, Tunisia	-	-	-
Ergüden et al. (2018)	December 2017	1	Konacık, Iskenderun Bay, Türkiye	Longline	30	285
This study	February 2024	1	Tasucu, Mersin Bay, Türkiye	Fishing rod	35	155

P. hamrur from the Mediterranean are listed in Table 2 along with the results of our study.

P. hamrur is widely distributed in the Indo-West Pacific and Red Sea and is locally abundant in certain areas of its natural range (Starnes, 2001). It is also a very common commercial species in the southwestern Indian Ocean (Mablouké *et al.,* 2013). The occurrence of *P. hamrur* in the Mediterranean is most likely the result of the species' migration from the Red Sea via the Suez Canal (Ergüden *et al.,* 2018), with climate change and the tropicalization of the Mediterranean accelerating the arrival of alien fish species to Turkish Mediterranean waters (Turan *et al.,* 2016). While a single specimen does not necessarily indicate the presence of an established population in Mersin Bay, the past and present records of two specimens (Gürlek *et al.,* 2017; Ergüden *et al.,* 2018) may suggest a westward migration of the species in the Mediterranean waters of Turkey.

This study reports the first record of *P. hamrur* occurring in Mersin Bay (northeastern Mediterranean Sea), Turkey, and the second confirmed record from the Mediterranean waters of Turkey.

CONCLUSIONS

This new record indicates that the *P. hamrur* species did not enter the Mediterranean by chance. The presence of a male specimen in the waters of Turkey may indicate successful adaptation and potential small aggregations in the near future. This ichthyological note is important as it suggests a westward expansion of the species in Turkish Mediterranean waters.

ACKNOWLEDGMENTS

This study was supported by the Research Fund of Mersin University in Turkey with Project Number: 2021-1-TP2-4301.

ŠIRJENJE AREALA LUNASTOREPEGA VELEOKEGA OSTRIŽA *PRIACANTHUS HAMRUR* (FABRICIUS, 1775) V SEVEROVZHODNEM SREDOZEMSKEM MORJU (ZALIV MERSIN, TURČIJA)

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POVZETEK

Primerek samca lunastorepega veleokega ostriža Priacanthus hamrur *(Fabricius, 1775) so februarja 2024 ujeli na trnek na globini 35 m v zalivu Mersin (Taşucu, Turčija). Gre za drugi zapis o pojavljanju te vrste iz turških voda in prvi iz zaliva Mersin (severovzhodna sredozemska obala Turčije). Najdba samca te vrste kaže na uspešno prilagajanje in možno vzpostavitev populacije v bližnji prihodnosti. Poleg tega razpoložljivi zapisi o pojavljanju kažejo, da se vrsta seli proti zahodu sredozemskih turških voda.*

Ključne besede: lunastorepi veleoki ostriž, Pricanthidae, pojavljanje, obala Taşucu, vzhodno Sredozemsko morje

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received: 2024-02-14 DOI 10.19233/ASHN.2024.15

CONFIRMED OCCURRENCE OF *JAYDIA SMITHI* (APOGONIDAE) AND *SERIOLA FASCIATA* (CARANGIDAE) ON THE SYRIAN COAST (EASTERN MEDITERRANEAN SEA)

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ABSTRACT

The present paper reports additional records of two exotic species collected from Syrian marine waters. The first capture concerns a specimen of Smith's cardinalfish Jaydia smithi *Kotthaus, 1970, the second a specimen of lesser amberjack* Seriola fasciata *(Bloch, 1793). The two specimens confirm the presence of both species in the area, suggesting that viable populations have successfully established.* S. fasciata *displays significant commercial value and a management plan should be implemented within Syrian fisheries to protect the species and prevent its decline in the area.*

Key words: Osteichthyes, Teleostei, exotic species, Syrian marine waters

PRESENZA CONFERMATA DI *JAYDIA SMITHI* (APOGONIDAE) E *SERIOLA FASCIATA* (CARANGIDAE) LUNGO LA COSTA SIRIANA (MEDITERRANEO ORIENTALE)

SINTESI

Il presente lavoro riporta ulteriori ritrovamenti di due specie esotiche nelle acque marine siriane. La prima cattura riguarda un esemplare di Jaydia smithi *Kotthaus, 1970, la seconda un esemplare di ricciola fasciata* Seriola fasciata *(Bloch, 1793). I due esemplari confermano la presenza di entrambe le specie nell'area, suggerendo che le popolazioni vitali si sono stabilite con successo.* S. fasciata *ha un valore commerciale significativo e dovrebbe venir attuato un piano di gestione nell'ambito della pesca siriana per proteggere la specie e prevenirne il declino nell'area.*

Parole chiave: Osteichthyes, teleostei, specie esotiche, acque marine siriane

INTRODUCTION

For several decades, the Syrian coast has been facing a steady and continuous invasion of exotic species, with fishes being the most abundant among them (Saad & Khrema, 2023). Such a phenomenon is the result of the warming of the Mediterranean Sea due to climate change (Ben Raïs Lasram & Mouillot, 2009), which enhances the intrusion of species previously unknown in this sea, either incoming from the Red Sea following the aperture of the Suez Canal or from the eastern tropical Atlantic through the Strait of Gibraltar. The introduction of exotic species is also a consequence of anthropogenic activities such as shipping, mariculture, and aquarium releases (Saad & Khrema, 2023).

The establishment of exotic species in Syrian marine waters (Ali, 2018; Saad & Khrema, 2023) is partly due to the region's geographic location in the eastern Mediterranean Sea and its proximity to the Red Sea, but also, as Gruvel noted (1931), because Syrian marine waters clearly display favorable environmental parameters for the development and production of local fisheries. This opinion has been furtherly confirmed by Foulquié and Dupuy de la Grandrive (2003), and more recently by Ali (2018). Additionally, there are other favourable environmental parameters contributing to the development and production of local fisheries, which play an important role in the country's economy.

Regular investigations conducted along the Syrian coast with the assistance of experienced fishermen, knowledgeable about fishing grounds, have resulted in the collection of additional records of two rare exotic species: Smith's cardinalfish *Jaydia smithi* Kotthaus, 1970 and the lesser amberjack *Seriola fasciata* (Bloch, 1793). This paper describes these two species, along with providing some comments on their distribution in the area and throughout the Mediterranean Sea.

Fig. 2. Specimen of *Jaydia smithi* **(ref. 2329 MSL) collected off Jableh on the Syrian coast, scale bar = 20 mm.**
Sl. 2: Primerek vrste *Jaydia smithi* **(ref. 2329 MSL), ujet v bližini lokalitete Jableh na sirski obali, merilo = 20 mm.**

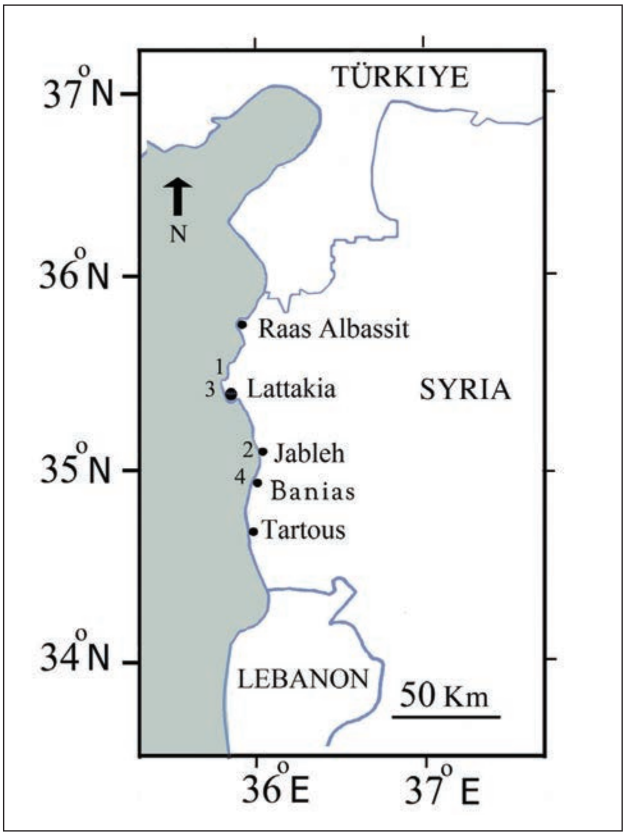

Fig. 1: Map of the Syrian coast indicating the capture sites of *Jaydia smithi.* **1. Off Lattakia (Al-Shawy** *et al.***, 2017). 2. Off Jableh (this study). 4. Off Banias (Ibrahim** *et al.***, 2020); and of** *Seriola fasciata* **3. Off Lattakia (Jawad** *et al.***, 2015), 4. Off Banias (this study).**
Sl. 1: Zemljevid sirske obale z označenimi lokalitetami ulova vrste *Jaydia smithi.* **1. Lattakia (Al-Shawy in sod., 2017). 2. Jableh (ta raziskava). 4. (Ibrahim in sod., 2020); in vrste** *Seriola fasciata* **3. Lattakia (Jawad in sod., 2015), 4. Banias (ta raziskava).**

Fig. 3. Specimen of *Seriola fasciata* **(ref. 2330 MSL) collected off Banias on the Syrian coast, scale bar = 20 mm.**
Sl. 3: Primerek vrste *Seriola fasciata* **(ref. 2330 MSL), ujet v bližini lokalitete Banias na sirski obali, merilo = 20 mm.**

Tab. 1: Morphometric measurements in mm and as percentages of total length (%TL), meristic counts, and total body weight in grams recorded for the specimen of* Jaydia smithi *(ref. 2329 MSL) captured off the Syrian coast.
Tab. 1: Morfometrične meritve, izražene v mm in kot delež celotne dolžine (%TL), meristična štetja in celokupna telesna masa (v gramih) primerka vrste* Jaydia smithi *(ref. 2329 MSL), ujetega v vodah blizu sirske obale.

Reference	**2329 MSL**	
Morphometric measurements	**mm**	**%TL**
Total length	122	100.0
Standard length	100	82.0
Body depth	35	28.7
Head length	23	18.9
Eye diameter	8	6.6
Snout length	5	4.1
Upper jaw length	11	9.0
Lower jaw length	13	10.7
First dorsal fin length	18	14.8
Second dorsal fin length	18	14.8
Pectoral fin length	20	16.4
Pelvic fin length	22	18.0
Anal fin length	26	21.3
Caudal fin length	25	20.5
Pre-dorsal length	40	32.8
Pre-pectoral length	38	31.1
Pre-pelvic length	30	24.6
Pre-anal length	68	55.7
Meristic counts		
Fist Dorsal fin	VII	
Second dorsal fin	I+ 9	
Pectoral fin	14	
Pelvic fin	I + 5	
Anal fin	II+ 8	
Caudal fin	17	
Total body weight (g)	35	

Tab. 2: Morphometric measurements in mm and as percentages of total length (%TL), meristic counts, and total body weight in grams recorded for the specimen of* Seriola fasciata *(ref. 2330 MSL) captured off the Syrian coast.
Tab. 2: Morfometrične meritve, izražene v mm in kot delež celotne dolžine (%TL), meristična štetja in celokupna telesna masa (v gramih) primerka vrste* Seriola fasciata *(ref. 2330 MSL), ujetega v vodah blizu sirske obale.

Reference	**2330 MSL**	
Morphometric measurements	**mm**	**%TL**
Total length	150	100.0
Standard length	121	80.7
Body depth	63	42.0
Head length	43	28.7
Eye diameter	5	3.3
Snout length	7	4.7
Upper jaw length	23	15.3
Lower jaw length	23	15.3
Dorsal fin length	82	54.7
Pectoral fin length	29	19.3
Pelvic fin length	37	24.7
Anal fin length	44	29.3
Caudal fin length	34	22.7
Pre-dorsal length	48	32.0
Pre-pectoral length	45	30.0
Pre-pelvic length	53	35.3
Pre-anal length	86	57.3
Meristic Counts		
First dorsal fin	VIII	
Second dorsal fin	I+30	
Pectoral fin	15	
Pelvic fin	5	
Anal fin	II +I+30	
Caudal fin	19	
Gillrakers	20 (5+15)	
Scale above/below lateral line	20/30	
Total body weight	60	

MATERIAL AND METHODS

On 8 August 2022, a specimen of *Jaydia smithi* was caught using a demersal fixed gill net, at a depth of 10 m over a rocky bottom, 2 km off Jableh city, at 35°22'02″ N, 35°53'45″ E (Fig. 1).

On 2 December 2023, a specimen of *Seriola fasciata* was captured using a purse seine net, at a depth of about 20 m on a sandy bottom, 7 km offshore from the city of Banias, at 35°10'41.48″ N, 35°51'45.30″ E (Fig. 1).

Morphometric measurements for the two specimens were recorded to the nearest millimeter and are detailed, including percentages of total length, meristic counts, and total body weight, in Table 1 for *J. smithi* and Table 2 for *S. fasciata*. Subsequently, the two individuals were preserved in 10% buffered formaldehyde and deposited in the Ichthyological Collection of the Marine Sciences Laboratory, Faculty of Agriculture, Tishreen University, under catalogue numbers 2329 MSL for the *J. smithi* and 2330 MSL for the *S. fasciata* specimens.

RESULTS AND DISCUSSION

Smith's cardinal fish *Jaydia smithi* Kotthaus, 1970

The specimen of *Jaydia smithi* (Fig. 2) measured 122 mm in total length (TL), 100 mm in standard length (SL), and weighed 35 g in total body weight. It was identified via the combination of the following main morphological characters and meristic counts (see Tab. 1): body ovate to elongate, slightly compressed, exceeding 100 mm TL; eye large; mouth terminal and oblique; two separated dorsal fins, the third and fourth spines in the first dorsal fin the longest; second dorsal fin much higher; anal fin origin behind origin of second dorsal fin; caudal fin rounded; color of body yellowish-brown; first dorsal fin with dark spot on top; a series of dark dots on the second dorsal fin forming a horizontal line; edges of second dorsal fin and caudal fin black; pectoral and pelvic fins light grey.

The morphology, morphometric measurements, meristic counts, and color are fully consistent with previous descriptions of *J. smithi* (Golani *et al.*, 2008; Goren *et al.*, 2009; Gökoglu *et al.*, 2010; Al-Shawy *et al.*, 2017; Golani *et al.*, 2021). This finding is an additional record of *J. smithi* from Syrian marine waters, where Al-Shawy *et al.* (2017) and Ibrahim (2020) previously collected five specimens. It also confirms the establishment of the species in the area and the Levant Basin. According to Golani *et al.* (2021), the distribution of *J. smithi* appears to be restricted to the eastern basin. Despite the fact that the species is a Lessepsian migrant (*sensu* Por, 1971), its morphology indicates that it is not a good swimmer and probably not prone to long migrations. Additionally, *J. smithi* does not have local economic value and is currently discarded at sea after capture. This likely explains why it has escaped the attention of researchers.

Lesser amberjack *Seriola fasciata* (Bloch, 1793)

The specimen of *Seriola fasciata* (Fig. 3) measured 155 mm in total length (TL), 121 mm in standard length (SL), and weighed 60 g in total body weight. It was identified via the combination of the following main morphological characters and meristic counts (see Tab. 2): body elongated, oblong, and compressed; head slightly convex; posterior end of upper jaw relatively slender; soft anal fin base distinctly shorter than dorsal fin base; caudal peduncle grooves present and moderately developed, lateral line without scutes; color of body yellowish with eight dark body bars, and a single smaller one at the end of caudal peduncle.

The morphology, morphometric measurements, meristic counts, and color are in total agreement with previous descriptions of *S. fasciata* (Smith-Vaniz, 1986; Massutí & Stefanescu, 1993; Deidun. *et al.*, 2011; Jawad *et al.*, 2015; Golani *et al.*, 2021). *S. fasciata* is known in the western Atlantic from Bermuda and Massachusetts to Brazil, and in the eastern Atlantic from the waters surrounding the Azores, Madeira, Canary, Cabo Verde, and St. Helena islands (Golani *et al.*, 2021).

In the Mediterranean, the species was first recorded in the Balearic Islands (Massutí & Stefanescu, 1993), gradually expanding its distribution throughout the western basin, especially the Italian seas and the Strait of Sicily (Andaloro *et al.*, 2005), including the Maltese Islands (Deidun *et al.*, 2011). *S. fasciata* migrated eastwards and has been recorded from Libya (Elbaraasi *et al.*, 2019), Egypt (El Sayed *et al.*, 2017), the Greek island of Rhodes (Corsini *et al.*, 2006), and the coast of Turkey (Bilecenoglu *et al.*, 2014). Finally, it reached the Levant Basin (Bariche & Fricke, 2020; Golani *et al.*, 2021) and a first record occurred off the coast of Syria (Jawad *et al.*, 2015).

The present specimen is the second record of *S. fasciata* for Syrian marine waters and the fourth for the Levant Basin, where a viable population is successfully established. *S. fasciata* is one of the rare species of Atlantic origin that has been able to expand its distribution so rapidly throughout the Mediterranean. The first record of *S. fasciata* occurred in 1989 (Massutí & Stefanescu, 1993) and within a few years, the species gained commercial value in the Strait of Sicily (Andaloro *et al.*, 2005) and rapidly spread to the eastern basin, reaching the easternmost sectors. Contrary to *J. smithi*, *S. fasciata* possesses the morphology of a good swimmer capable of long migrations and could be considered a Herculean sprinter, analogous to the bluespotted cornetfish *Fistularia commersonii* (Rüppel, 1835), described as a Lessepsian sprinter by Karachle *et al.* (2004). It is evident that *S. fasciata* is finding adequate resources to thrive and reproduce in its new environment, where it is also locally used for human consumption. Therefore, in full agreement with Jawad *et al.* (2015), a management plan should be implemented in Syrian fisheries to protect *S. fasciata* and prevent the decline of this recently established species in the area.

POTRJENO POJAVLJANJE SMITHOVEGA MORSKEGA KRALJIČKA *JAYDIA SMITHI* (APOGONIDAE) IN MALEGA GOFA *SERIOLA FASCIATA* (CARANGIDAE) NA SIRSKI OBALI (VZHODNO SREDOZEMSKO MORJE)

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POVZETEK

Avtorji poročajo o dodatnih zapisih o pojavljanju dveh eksotičnih vrst, ujetih v sirskih morskih vodah. Prvi ulov se nanaša na primerek Smithovega morskega kraljička, Jaydia smithi *Kotthaus, 1970, drugi pa na primerek malega gofa,* Seriola fasciata *(Bloch, 1793). Primerka potrjujeta pojavljanje obeh vrst na obravnavanem območju, kar odpira možnost, da sta se vzpostavili viabilni populaciji obeh vrst.* S. fasciata *je pomembna lovna vrsta, ki ima veliko komercialno vrednost, zato je potrebno v sirskem ribištvu izvajati načrt upravljanja, da se vrsto zaščiti in prepreči njeno upadanje na obravnavanem območju.*

Ključne besede: Osteichthyes, Teleostei, eksotične vrste, sirske morske vode

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received: 2024-02-15 DOI 10.19233/ASHN.2024.16

RANGE EXPANSION OF *SYNODUS RANDALLI* CRESSEY, 1981 IN THE NORTHEASTERN MEDITERRANEAN

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ABSTRACT

This paper reports the expansion of the distribution range of Randall's lizardfish Synodus randalli *in the northeastern Mediterranean Sea. On 20 January 2024, a single specimen of* S. randalli *was caught by a commercial trawl net in Mersin Bay. The occurrence of this species on the Mediterranean coast of Turkey is probably due to its migration from the Red Sea via the Suez Canal. It appears that this species has spread rapidly in a short period of time and may establish itself in the eastern Mediterranean in the near future. This ichthyological note is important as it represents the second consecutive record of the species from the Turkish waters of the northeastern Mediterranean. Furthermore, the present record indicates a westward migration of* S. randalli *in the Mediterranean. This study also contributes important information on the maximum standard length of the species to the FishBase database.*

Key words: Synodontidae, Randall's Lizardfish, Spread, Mersin Bay, Turkey

ESPANSIONE DELL'AREALE DI *SYNODUS RANDALLI* CRESSEY, 1981 NEL MEDITERRANEO NORD-ORIENTALE

SINTESI

Il presente lavoro riporta l'espansione dell'areale di distribuzione di Synodus randalli *nel Mediterraneo nord-orientale. Il 20 gennaio 2024, un singolo esemplare di* S. randalli *è stato catturato da una rete da traino commerciale nella baia di Mersin. La presenza di questa specie lungo la costa mediterranea della Turchia è probabilmente dovuta alla sua migrazione dal Mar Rosso attraverso il Canale di Suez. Sembra che questa specie si sia diffusa rapidamente in un breve periodo di tempo e che possa stabilirsi nel Mediterraneo orientale nel prossimo futuro. Questa nota ittiologica è importante perché rappresenta il secondo ritrovamento consecutivo della specie dalle acque turche del Mediterraneo nord-orientale. La presente segnalazione inoltre indica una migrazione verso ovest di* S. randalli *nel Mediterraneo. Questo studio contribuisce anche a fornire importanti informazioni sulla lunghezza massima standard della specie per il database di FishBase.*

Parole chiave: Synodontidae, *Synodus randalli*, diffusione, baia di Mersin, Turchia

INTRODUCTION

The genus *Synodus* Scopoli, 1777 consists of 47 species distributed across tropical and subtropical regions of the Atlantic, Pacific, and Indian Oceans (Froese & Pauly, 2024; Fricke *et al*., 2024). This genus belongs to the family Synodontidae and is commonly referred to as "Lizardfish". Lizardfish usually live in shallow waters at depths of 0–140 m in various habitats, such as coral and marine reefs, sandy and sand-rock bottoms (Randall *et al*., 1990). Lizardfish are strictly carnivorous and mainly feed on other fish (Froese & Pauly, 2024).

In the Red Sea, the genus *Synodus* is represented by five species (Golani & Fricke, 2018). *Synodus randalli* Cressey, 1981 was previously reported from the Red Sea by Baranes & Golani (1993) as *Synodus doaki* (Randall, 2009). Although this species was previously only known in the Red Sea, it was first reported from the Mediterranean Sea in 2023 by Langeneck *et al.* (2023).

To date, three lizardfish species have been known from the Mediterranean coast of Turkey, one of these, *Synodus saurus* (Linnaeus, 1758), is of Atlantic origin (IUCN, 2024), while the other two species, *Saurida lessepsianus* Russell, Golani & Tikochinski 2015 and *S. randalli* Cressey, 1981, are of Indo-Pacific origin. All three species are non-native species that migrated to the Mediterranean via the Suez Canal (Russell *et al.,* 2015).

This study reports a further range expansion of *S. randalli* from the northern coast of the Levant Basin, Mersin Bay, with the present record indicating a westward migration along the Mediterranean coast of Turkey. The presence of Randall's lizardfish in the northeastern Mediterranean likely indicates the potential of this species to spread throughout the Mediterranean basin and highlights its ability to adapt and colonize new environments.

MATERIAL AND METHODS

On 20 January 2024, a single specimen of *S. randalli* was caught with a trawl net at a depth of 105 m off Yeşilovacık Bay, Mersin Bay (at 36°02′39″ N, 33°36′47″ E) (Fig. 1). The fresh specimen was photographed and transported to the laboratory for identification. The characteristics of the present specimen (Fig. 2) correspond to the description provided by Cressey (1981). Some morphological measurements were made and recorded (Table 1). The specimen was fixed

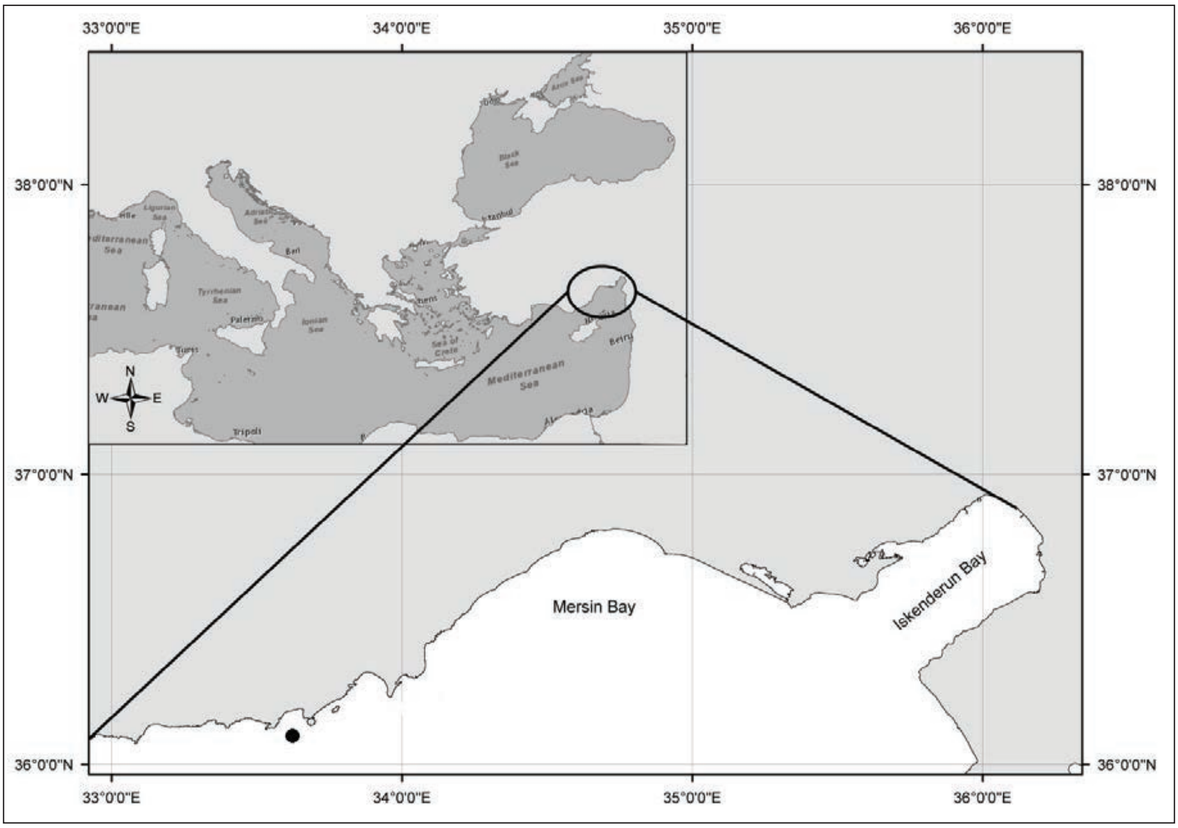

Fig. 1: Map showing the capture site (black circle) of the *Synodus randalli* ***specimen.***
Sl. 1: Zemljevid obravnavanega območja z lokaliteto (črni krogec) ulova primerka vrste *Synodus randalli****.***

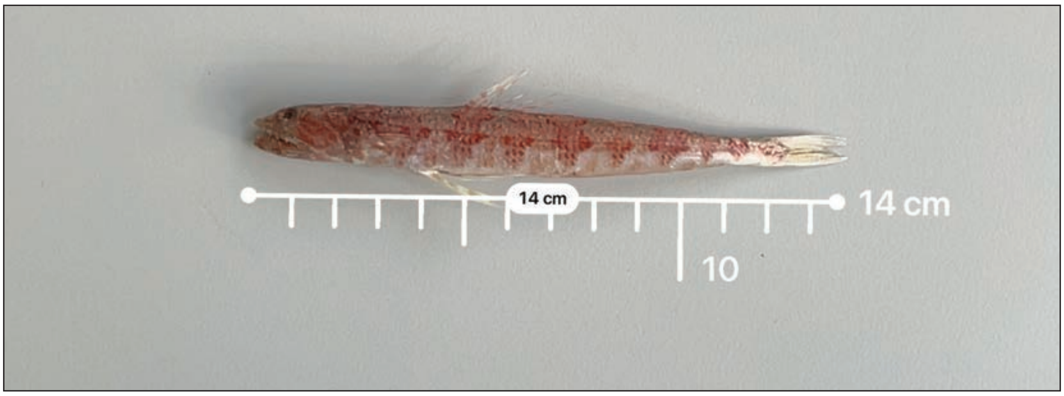

Fig. 2: *Synodus randalli* **Cressey, 1981 in Mersin Bay (northeastern Mediterranean, Turkey).**
Sl. 2: *Synodus randalli* **Cressey, 1981 iz zaliva Mersin (severovzhodno Sredozemsko morje, Turčija).**

in 4% buffered formalin and deposited in the Mersin University Marine Life Museum with catalog number MEUFC-24-11-145.

RESULTS AND DISCUSSION

The captured Mediterranean specimen of *S. randalli* measured 140 mm in total length (TL), 119 mm in standard length, and weighed 18.40 g in total weight. It exhibited the following morphological features: body fusiform, head somewhat depressed, caudal side a little compressed; scales large and cycloid, covering cheeks, operculum and postoral portion of cheeks; a long triangular flap on the anterior nares and no conspicuous black pigmented area on the operculum; snout sharply pointed, broader than long; pectoral fin reaching beyond the line from base of pelvic fin to origin of dorsal fin; outer pelvic ray unbranched and short, fifth branched ray (sixth ray) longest (Cressey, 1981).

The meristic and morphometric characteristics of the specimen are given in Table 1 and compared with previous Red Sea (Cressey, 1981) and Mediterranean records (Langeneck *et al.*, 2023). Color (fresh specimen): a series of reddish brown saddle-like bands found in the body. Dorsal fin with 3 to 4 similarly colored bars, a conspicuous spot exhibited on the adipose fin.

Randall's lizardfish *S. randalli* is distributed in the western Indian Ocean and the Red Sea, in South Africa, Madagascar, Tanzania, and Sudan (Cressey, 1981; Randall, 2009; Fricke *et al.,* 2018; Bogorodsky & Randall, 2019).

S. randalli is a demersal species inhabiting relatively deep waters. Cressey (1981) and Randall (2009) reported a depth range of 6–146 metres for *S. randalli*. However, according to the IUCN (2024), the depth distribution of adults is likely deeper, ranging from about 50 to 150 m. Similarly, the single Mediterranean specimen reported in this study was observed at a depth of 80 m. This depth range aligns with the literature (Cressey, 1981; Langeneck *et al.,* 2023).

Cressey (1981) and Randall (2009) reported a maximum standard length (SL) of 11.3 cm for this species. However, in this study and one previous study (Langeneck *et al.,* 2023), the standard length of this species in the Mediterranean Sea appears to be longer than previously recorded. These new findings are significant and should be considered updates to databases like FishBase. Therefore, the present study contributes new information that is valuable to scientists studying this species.

Langeneck *et al.* (2023) suggest that the species could have been transported to the Mediterranean with ballast waters, but this new finding strengthens the hypothesis that it likely entered the Mediterranean waters through the Suez Canal. In addition, trawlers have reported more frequent sightings of this species in trawl nets in the region lately (personal communication).

The presence of *S. randalli* on the Mediterranean coast of Turkey is likely due to the species' migration from the Red Sea through the Suez Canal. To date, numerous fish species have entered the Mediterranean Sea via the Suez Canal (Cinar *et al.,* 2021; Golani *et al.,* 2020).

It appears that *S. randalli* is rapidly spreading towards the southern Aegean coast of Turkey and will likely colonize the eastern Mediterranean in a short time. As the number of specimens increases, it is also likely that *S. randalli* will accelerate its ability to adapt and further colonize the Mediterranean basin in the near future. This ichthyological note is significant as it represents the second record of the species in the northeastern Mediterranean waters of Turkey, indicating a westward spread of this species in Turkish Mediterranean waters.

Tab. 1: Morphometric measurements of the* Synodus randalli *specimen collected in the northeastern Mediterranean Sea, Turkey, and comparison with previous records from the Mediterranean and Red Seas.
Tab. 1: Morfometrične meritve primerka vrste* Synodus randalli*, ujetega v severovzhodnem Sredozemskem morju, Turčija, in primerjava s podatki iz predhodnih zapisov o pojavljanju v Sredozemskem in Rdečem morju.

Measurements (mm)	**This study**	**Langeneck et al. (2023)**	**Cressey (1981)**
Number of Specimen	1	1	1
Total length	140	187	-
Fork length	129	173	-
Standard length	119	161	113
Head length	31.10	45.56	31.97
Snouth length	7.22	11.21	8.13
Upper jaw length	19.37	28.81	20.22
Lower jaw length	19.06	-	-
Diameter of bony orbit	5.77	11.02	7.68
Least width of bony interorbital	3.55	7.39	3.95
Pre-dorsal fin origin	48.01	66.91	49.72
Pre-adipose origin	94.45	133.79	93.90
Pre-anal fin origin	94.22	133.62	92.88
Pre-pelvic fin origin	41.64	55.80	43.61
Pre-pectoral fin origin	31.88	41.80	40.11
Eye diameter	4.59	6.22	-
Interorbital distance	7.34	-	-
Counts			
Dorsal fin rays	13	13	13
Anal fin rays	8	8	8
Pectoral fin rays	12	12	12
Pelvic fin rays	8	8	8
Caudal fin rays	16	-	-
Lateral line scales	56	58	55
Weight	18.40	51.89	-

CONCLUSIONS

Although the presence of a second specimen off the Levantine coast suggests that the most likely migration route is the Suez Canal and that the species' distribution will expand in the Mediterranean, it remains unclear whether the species can establish a population in the Levant Basin. Therefore, more data and monitoring studies are needed to confirm this hypothesis.

ACKNOWLEDGMENTS

This study was supported by the Research Fund of Mersin University in Turkey with Project Number: 2021-1-TP-2-4301.

ŠIRJENJE AREALA RANDALLJEVEGA MORSKEGA KUŠČARJA *SYNODUS RANDALLI* CRESSEY, 1981 V SEVEROVZHODNO SREDOZEMSKO MORJE

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POVZETEK

Avtorji poročajo o širjenju območja razširjenosti Randalljevega morskega kuščarja Synodus randalli *v severovzhodno Sredozemsko morje. Dvajsetega januarja 2024 so v povlečno mrežo ulovili primerek vrste* S. randalli *v zalivu Mersin. Pojavljanje te vrste ob turški sredozemski obali je najverjetneje povezano z imigracijo iz Rdečega morja skozi Sueški prekop. Kaže, da se vrsta v kratkem časovnem obdobju hitro razširja in se bo morda v vzhodnem Sredozemskem morju v bližnji prihodnosti uveljavila. Ta ihtiološka novica je pomembna, saj predstavlja drugi zaporedni zapis o pojavljanju te vrste v turških vodah severovzhodnega Sredozemskega morja. Pričujoči zapis tudi kaže, da se vrsta* S. randalli *širi proti zahodnemu delu Sredozemskega morja. Poleg tega prispeva pomembne podatke o največji standardni dolžini telesa v podatkovno bazo FishBase.*

Ključne besede: Synodontidae, Randalljev morski kuščar, razširjanje, zaliv Mersin, Turčija

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received: 2024-04-11 DOI 10.19233/ASHN.2024.17

OCCURRENCE OF *CHEILINUS LUNULATUS* (LABRIDAE), *TRIACANTHUS* CF. *BIACULEATUS* (TRIACANTHIDAE) AND OTHER FOUR NON-INDIGENOUS FISH SPECIES NEW TO THE GAZA STRIP WATERS, PALESTINE

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ABSTRACT

Six non-indigenous fish species, all of Indo-Pacific origin, are here reported from the waters of Gaza Strip, Palestine, on the basis of photos and data collected from 2016 to 2023 on dedicated platforms through local citizen scientists and fishers contribute. Two species, Cheilinus lunulatus *and* Triacanthus *cf.* biaculeatus*, are recorded for the first time in the Mediterranean Sea, and other four,* Ambassis *sp.,* Equulites *cf.* elongatus*,* Parupeneus forsskali *and* Heniochus intermedius *are recorded for the first time in the Palestinian waters of Gaza. Although data and material were limited, the results reinforce the useful support of citizen science in monitoring introduction and/or expansion of non-indigenous species in a basin strongly affected by biological invasion, such as the eastern Mediterranean Sea.*

Key words: Levantine Sea, Palestine, Gaza Strip, non-indigenous fish, Lessepsian migration, citizen scientists

PRESENZA DI *CHEILINUS LUNULATUS* (LABRIDAE), *TRIACANTHUS* CF. *BIACULEATUS* (TRIACANTHIDAE) E DI ALTRE QUATTRO SPECIE DI PESCI NON INDIGENI NUOVE PER LE ACQUE DELLA STRISCIA DI GAZA, PALESTINA

SINTESI

Sei specie di pesci non indigeni, tutte di origine Indo-Pacifica, sono qui segnalate per le acque della Striscia di Gaza, Palestina, sulla base di foto e dati raccolti dal 2016 al 2023 su piattaforme dedicate, grazie al contributo di scienziati cittadini e pescatori. Due specie, Cheilinus lunulatus *e* Triacanthus *cf.* biaculeatus*, sono segnalate per la prima volta nel Mediterraneo, e altre quattro,* Ambassis *sp.,* Equulites *cf.* elongatus*,* Parupeneus forsskali *e* Heniochus intermedius *vengono segnalate per la prima volta nelle acque palestinesi di Gaza. Sebbene i dati e il materiale siano limitati, i risultati rafforzano l'utile supporto della scienza dei cittadini (citizen science) nel monitorare l'introduzione e/o l'espansione di specie non indigene in un bacino fortemente colpito dall'invasione biologica, come il mare Mediterraneo orientale.*

Parole chiave: Mar di Levante, Palestina, Striscia di Gaza, pesci non indigeni, migrazione lessepsiana, citizen science

INTRODUCTION

The Mediterranean Sea biodiversity is undergoing profound and fast changes driven by various threats, among which climate changes and biological invasions of organisms mainly introduced via the Suez Canal from the Red Sea and the Indo-Pacific Ocean, in particular in the eastern side of the basin (Galanidi *et al.*, 2023; Galil, 2023).

Citizen science input is particularly useful for monitoring marine biodiversity, including non-indigenous species (NIS) introductions and spreading (Pocock *et al.*, 2024). This is of particular importance in poorly studied areas of the eastern Mediterranean, such as the Palestinian waters of the Gaza Strip, where regular field scientific research and published material is extremely limited. The Gaza Strip is located at the southeast corner of the Mediterranean Sea, about 170 km east to the mouth of the Suez Canal into the Mediterranean, a significant geographical position for the detection of new non-indigenous species entered via the Canal from the Indo-Pacific and the Red Sea ecosystems (Lessepsian migrant species, see Golani & Fricke, 2018), as well as for the monitoring of their spreading (Bariche *et al.*, 2019; Abd Rabou *et al.*, 2023).

In the present study, efforts were made in order to validate ichthyological material of particular interest from the Gaza Strip waters obtained mainly through the input of Palestinian citizen scientists and fishers via social media platforms. The first finding in the eastern Mediterranean waters (Palestinian waters) of the non-indigenous *Cheilinus lunulatus* (Forsskål, 1775) and *Triacanthus* cf. *biaculeatus* (Bloch, 1786) is here described. The occurrence of other three non-indigenous fish species already known in the wider area, namely *Equulites* cf. *popei* (Whitley, 1932), *Parupeneus forsskali* (Fourmanoir & Guézé, 1976) and *Heniochus intermedius* Steindachner, 1893, is furthermore documented in the present study for the first time in Palestinian waters, where also a glassfish *Ambassis* Cuvier, 1828 sp. is here newly recorded. The presence of the above NIS fishes new to the Gaza Sea increases knowledge on the diversity of fish communities in this restricted zone of the Levantine Sea highly affected by the occurrence of species of Indo-Pacific/Red Sea origin.

MATERIAL AND METHODS

Photos of six fishes unknown to fishers operating in the Gaza Strip waters, Palestine, were submitted between 2016 and 2023 to the social media citizen science platform for Libyan waters called 'Marine Biology in Libya' (https://www. facebook.com/MarineBiologyinlibya) or transmitted directly to the authors by fishers.

All fishes were caught in the marine waters of the Gaza Strip. None of the specimens was preserved. In some occasions, the authors were unable to trace back the name of observer/fisher who submitted photos to the above platform, or to obtain information on the exact location of capture in the Gaza Sea and/or the fishing method used, as well as further data as depth of capture and bottom type. Efforts for identification of the fishes to species level through the available photographic material were applied by the authors, but in some cases they faced substantial impediments in achieving results with certainty for the following reasons: a) photos transmitted through the mentioned above social media were of low quality, b) fishes were positioned hastily, careless to show the fin rays or other body characteristics and c) any object of known size was placed nearby the fish in order to approximate their size and some proportions of the body. All the above obstacles and the lack of samples unfortunately prevented an accurate description of morphological and meristic characters of the specimens.

RESULTS

The following six fish were recognized as new species or genus for the Palestinian waters.

AMBASSIDAE
Ambassis Cuvier, 1828 sp.

Two similar fish specimens were caught by fishing rod in the Gaza Port (31°31'27.2"N, 34°25'46.4"E) at 0-6 m of depth. The first specimen, with an approximate total length of 50 mm, was captured on 1 January 2021 (Fig. 1A1) and the second, with an approximate total length of 40 mm, on 10 August 2022 (Fig. 1A2). The quality of the available photos was extremely low. The body was translucent dorsally, darker in Fig. A1, brighter in Fig. A2; a horizontal silver band along mid-body (Fig. 1A2); a visible dark membrane around second dorsal-fin spine (Fig. A1); black lineation along base of dorsal and anal fins apparently extending to caudal peduncle in both specimens; caudal fin dark (Fig. A1) or pale with dark edges (Fig. A2). The specimens were assigned to the genus *Ambassis*, being impossible to distinguish from Fig. 1A1, A2 some fundamental features, such as the presence or absence of cheek scales, the continuous or interrupted lateral line and the smooth or serrate interopercle that allow to separate species (Allen, 1999; Anderson & Heemstra, 2003; Stern *et al.*, 2022; Froese & Pauly, 2024).

Remarks. Twenty species belong to the *Ambassis* genus (Nelson *et al.*, 2016; Froese & Pauly, 2024); seven species of *Ambassis* occur in brackish to marine waters of the Western Indian Ocean, of which two species, *A. dussumieri* Cuvier, 1828 and *A. urotaenia* Bleeker 1852, are present in the Red Sea (Anderson &

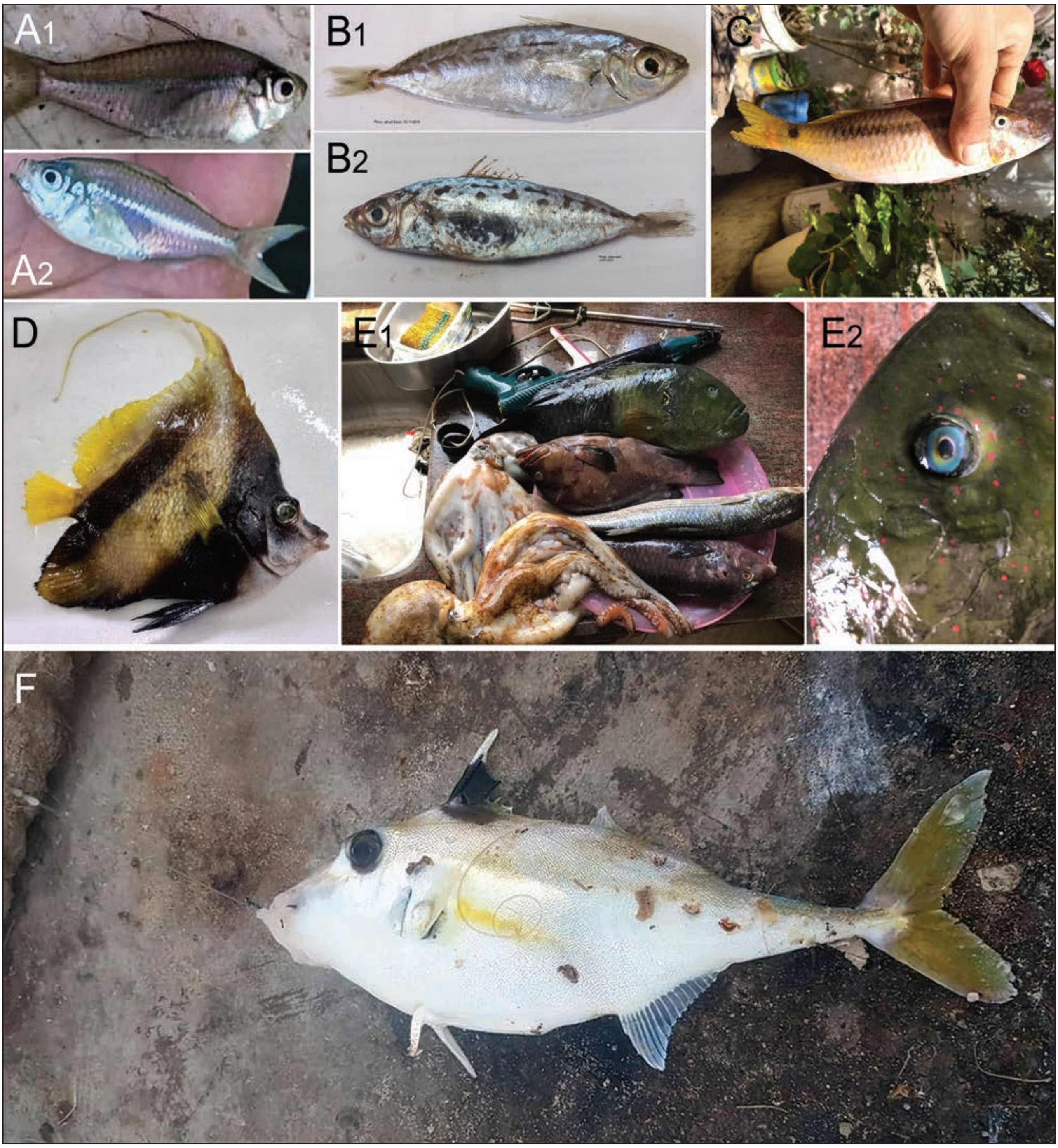

Fig. 1: Non-indigenous fishes from the Gaza Strip waters, Palestine. A1-A2: *Ambassis* ***sp. (Photo A1: Abdullah Jaber; Photo A2: Mahmoud Ahmed Jafeer); B1-B2:*** *Equulites* ***cf.*** *popei* ***(Photos B1, B2: Jehad Y. Salah); C:*** *Parupeneus forsskali****; D:*** *Heniochus intermedius* ***(Photo: Jehad Y. Salah); E1:*** *Cheilinus lunulatus* ***among a spear fishing catch and E2: detail of the red spots on its head (Photos E1, E2: Mohammad Al Nahhal); F:*** *Triacanthus* ***cf.*** *biaculeatus****.***

Sl. 1: Tujerodne vrste rib iz voda ob Gazi (Palestina). A1-A2: *Ambassis* ***sp. (Foto A1: Abdullah Jaber; Foto A2: Mahmoud Ahmed Jafeer); B1-B2:*** *Equulites* ***cf.*** *popei* ***(Fotografiji B1, B2: Jehad Y. Salah); C:*** *Parupeneus forsskali****; D:*** *Heniochus intermedius* ***(Foto: Jehad Y. Salah); E1:*** *Cheilinus lunulatus* ***med ulovljenimi ribami s podvodno puško in E2: detajl rdečih peg na njeni glavi (Fotografiji E1, E2: Mohammad Al Nahhal); F:*** *Triacanthus* ***cf.*** *biaculeatus****.***

Heemstra, 2003; Golani & Fricke, 2018). Very recently, in October 2021, the tropical schooling Malabar glassy perchlet *A. dussumieri* was recorded for the first time in the Mediterranean from an artificial bay of a power plant in Tel Aviv, Israel, by Stern *et al.* (2022), who discussed the potential invasiveness of the species in the basin.

LEIOGNATHIDAE

Equulites cf. *popei* (Whitley, 1932)

Two specimens of approximately 80 mm in total length were caught with trammel net in the waters off Gaza Strip, at about 20-30 m of depth, one on 10 November 2016 and one on 10 July 2023, respectively (Fig. 1B1, B2). Body elongate, slender and moderately compressed; snout sharp and pointed; protractile mouth. Colour: body silvery, upper sides characterized by dark linear patches along lateral line and other irregular patches. The specimens belonged evidently to the *Equulites elongatus* group and they were assigned to *Equulites* cf. *popei* following Golani *et al*. (2011), Sakinan *et al*. (2017) and Suzuki & Kimura (2017, 2024).

Remarks. The Pope's ponyfish *E. popei* is distributed in the Indo-West Pacific, including the Red Sea up to the Gulf of Suez (Golani & Fricke, 2018). In the Mediterranean Sea, *E. popei* has been recorded for the first time as *E. elongatus*, in 2011 off the Israel coasts (Golani *et al*., 2011). Later the species has spread in the waters of the Levantine Sea, in the regions of Mersin, Antalya and Iskenderun, Turkey (Yokeş, 2015; Irmak *et al*., 2015; Mavruk *et al*., 2019; Ergüden *et al*., 2019), Lebanon (Gerovasileiou *et al*., 2017) and Syria (Ibrahim *et al*. 2020). The species is considered a Lessepsian migrant as the former colonizer *Equulites klunzingeri* (Steindachner, 1898) (Golani, 2021). In 2016, another Leiognathidae new to the Mediterranean Sea, *Leiognathus berbis* Valenciennes, 1835, was reported from the Syrian waters (Alshawy *et al*., 2016), but later it was considered a misidentification and excluded from the list of the non-indigenous species of the basin (Zenetos *et al*., 2022). Recently, in 2021, the ponyfish *Equulites leuciscus* (Günther, 1860) was recorded for the first time in the Levantine Sea waters, at Antalya, Turkey (Kebapcioglu & Cinbilgel, 2022). Noteworthy is that *E. leuciscus* is listed among the marine bony fishes of the Gaza waters, Palestine, in the study conducted between 2017 and 2018 by Abu Amra (2018), however this record has not been validated.

MULLIDAE

Parupeneus forsskali (Fourmanoir & Guézé, 1976)

On 14 May 2022 a specimen of about 180 mm of total length (Fig. 1C) was caught off the Gaza Port with trammel net at 8-10 m of depth. The specimen was identified as *P. forsskali* for the characteristic black stripe running from the snout through eye and along lateral line to below the end of second dorsal fin and also for the black spot on each side of the caudal peduncle.

Remarks. The natural range of *P. forsskali* is the northwestern Indian Ocean, including the Red Sea up to the Gulf of Suez (Golani & Fricke, 2018). The Red Sea goatfish has been observed in the Mediterranean waters since 2000 and later in 2004, in Mersin, Turkey (Çinar *et al*., 2006). Recorded successively from Lebanon (Bariche et al., 2013), Israel (Sonin *et al*., 2013), Syria (Ali *et al*., 2016), Greece and Cyprus (Vagenas *et al*., 2024a), *P. forsskali* is now established, and sometimes abundant, in many eastern Mediterranean regions (Vagenas *et al*., 2024b). The species is considered a Lessepsian migrant (Golani, 2021). It is possible that the photo of a damaged mullid reported as *Upeneus niebuhri* Guézé, 1976 by Abu Amra (2018) corresponds to a *P. forsskali* specimen.

CHAETODONTIDAE

Heniochus intermedius Steindachner, 1893

On 14 February 2023, a specimen of about 100 mm of total length, was caught with gillnet on a mixed bottom of sand and rocks in the waters off the Gaza Strip at about 10 m of depth (Fig. 1D). Body disc-shaped and compressed; head small and concave in its dorsal profile; snout elongated; caudal fin truncate. Colour: body yellow-whitish; two broad black bands, one covering the eye, the operculum and extending ventrally and to the base of the dorsal fin, the other extending diagonally in the posterior part of the body; anterior and posterior part of dorsal fin, the pectoral and caudal fins yellow; posterior and anterior part of anal and the pelvic fins black. In this case, the characteristic body shape and the colour pattern of the specimen allowed identifying it with certainty as *H. intermedius* (Khalaf & Disi, 1997; Debelius, 2011; Bariche, 2012).

Remarks. The natural range of *H. intermedius* is the northwestern Indian Ocean and the Red Sea; thus it is considered a Lessepsian migrant into the Mediterranean (Khalaf & Disi, 1997; Golani & Fricke, 2018). The Red Sea bannerfish *H. intermedius* was recorded for the first time in the basin in 2002, off Mersin, Turkey (Gökoğlu *et al*. 2003), and later in Lebanon (Bariche, 2012), Israel (Tsadok *et al*. 2015), Malta (Evans *et al*., 2015), Cyprus (Bariche *et al*., 2020), Egypt (Al Mabruk *et al*. 2021) and Syria (Ibrahim *et al*., 2022; Saad *et al*., 2022).

LABRIDAE

Cheilinus lunulatus (Forsskål, 1775)

A labrid specimen of about 300 mm in total length was captured on 16 May 2022 at east of the Gaza Port with speargun at 16-22 m of depth (Fig. 1E1, E2). Body blackish with a broad green bar across in abdominal region; each scale of body with a vertical pale line; head green, shading to blackish posteriorly, with small orange-red spots and opercular flap black with a whitish mark; dorsal fin blackish, pectoral fin bright yellow, shading to hyaline distally. The specimen was assigned to *C. lunulatus* following the description of the terminal male phase colour of the species given by Gomon & Randall (1984).

Remarks. The Broomtail wrasse *C. lunulatus* occurs in the northwestern Indian Ocean and the Red Sea (Golani & Fricke, 2018). The occurrence of this species in the Mediterranean waters is here reported for the first time and monitoring of its eventual spreading in the eastern part of the basin is recommended.

TRIACANTHIDAE

Triacanthus cf. *biaculeatus* (Bloch, 1786)

On 22 April 2021, a specimen of approximately 180 mm of total length was fished with simple line, on sandy bottom in shallow waters off the Gaza Strip (Fig. 1F).

The following meristic and morphological characteristics are visible in Fig. 1F: 5 dorsal fin spines, the second shorter than the length of the first, and 17 anal fin rays. Body deep and compressed; mouth small, terminal; outline of head between the first dorsal-fin spine and eyes almost straight, slightly concave from eye to mouth; gill opening a relatively short vertical slit in front of pectoral fin base; caudal fin forked with internal margins of lobes slightly rounded. Approximate proportions obtained from Fig. 1F: head length 23.7, distance from eye to upper end of gill opening 7.8, eye diameter 5.1, preorbital length 14.2, postorbital 5.1, body depth 37.5, all as % of standard length. Colour: lightly silver creamy; a yellow longitudinal strip at midside of body, behind the pectoral fin; dark posterior of eye and under the eye; black membrane between the first and third spines of dorsal fin a, the remaining paler; first dorsal fin spine white toward the tip; region around the base of first dorsal fin dark; caudal fin yellowish with bluish edges and inner margins; second dorsal, pectoral and anal fins pale.

Seven species in four genera are recognized in the Family Triacanthidae all over the world (Nelson et al., 2016), of which the genus *Triacanthus* includes two species, *Triacanthus biaculeatus* (Bloch, 1786) and *Triacanthus nieuhofii* Bleeker, 1852 (Matsuura, 2015; Froese & Pauly, 2024). These two species differ mainly for the coloration of spinous dorsal fin and the outline of the head. In *T. biaculeatus* the spiny dorsal-fin membrane is dark between first and third spines, and usually equally dark between third and fifth, while the outline of head from base of first dorsal-fin spine to above eye is slightly convex or almost straight; in *T. nieuhofii* the spiny dorsal-fin membrane is very dark between first and second spines, slightly to much less darker between second and third spines, and pale between third and fifth spines, while the outline of head between base of first dorsal-fin spine and eyes somewhat convex in front of spine and then straight or slightly concave over eye (Hutchins, 1984; Matsuura, 2001; Psomadakis *et al.*, 2015; Ghazi *et al.*, 2018; Goutham-Bharathi *et al.*, 2024). The body shape and the general aspect as well as the body proportions of the *Triacanthus* from Gaza approached the descriptions of *T. biaculeatus* (Matsuura, 2001; Karna *et al.*, 2018; Goutham-Bharathi *et al.*, 2024), but, since the colour of spinous dorsal fin and the outline of head are not clearly discernible in Fig. 1F, the specimen is prudently assigned to *T.* cf. *biaculeatus*.

Remarks. The Short-nosed tripodfish *T. biaculeatus* is widespread in the Indo-West Pacific area from the Persian Gulf, Gulf of Oman, Arabian Sea, Bay of Bengal, and Japan, China, South China Sea including Gulf of Thailand, Indonesia, northern Australia; the Silver tripodfish *T. nieuhofii* is reported from the Arabian Sea, Bay of Bengal, Andaman Sea, Indonesia, South China Sea to northern Australia (Matsuura, 2015; Mohanty *et al.*, 2018; Eagderi *et al.*, 2019; Froese & Pauly, 2024). The above two *Triacanthus* spp. have not been recorded among the ichthyofauna of the Gulf of Aqaba and the Red Sea (Sanzo 1930; Khalaf & Disi, 1997; Golani & Fricke, 2018), up to 2023, when the occurrence of *T. biaculeatus* has been documented for the first time in the southeastern waters of the Red Sea (Goutham-Bharathi *et al.*, 2024). Both *Triacanthus* spp. are small benthic fish, found on sandy or muddy flat bottoms in coastal waters to 60 m, *T. biaculeatus* also in estuarine waters and in mangrove systems at juvenile stages; they feed on benthic invertebrates (Krishnamurthy & Prince Jeyaseelan, 1981; Hutchins, 1984; Matsuura, 2001). Both triacanthid species are sold fresh in markets. The Short-nosed tripodfish *T. biaculeatus* is listed among the commercially important marine ornamental fishes from Persian Gulf and Indian Ocean waters (Jayasankar 1998; Hosseinzadeh Sahafi, 2000; Mahapatra & Lakra, 2015). It is the first time that a species of Triacanthidae is reported from the Mediterranean Sea.

DISCUSSION

As already mentioned, the lack of samples of the fishes from the waters off the Gaza Strip reported in the present study as well as the scarcity and the low quality of the available photographic material rendered in some cases arduous achieving species identification through a description of morphological and meristic characters, as for the glassfish *Ambassis* sp. In the case of the ponyfish a high similarity with *E. popei* was observed and it was consequently assigned to *E.* cf. *popei*, while the resemblance of the tripodfish to *T. biaculeatus* conduced to assign to *T.* cf. *biaculeatus* the specimen from Gaza. In the three remaining cases, those regarding the goatfish, the bannerfish and the wrasse, photos allowed their identification to species level respectively as *P. forsskali*, *H. intermedius* and *C. lunulatus*.

All the above six fishes are non-indigenous of Indo-West Pacific origin, with two of them, *C. lunulatus* and *T.* cf. *biaculeatus*, recorded here for the first time in the Mediterranean waters. Nevertheless, the eventual success of these two latter species as new entries into the basin needs validation through further records, being their findings based on single, casual observations.

The native range of the higher percentage of Lessepsian migrant fishes is the Indo-West Pacific Ocean and the Red Sea (Golani *et al*., 2020), a range that corresponds also to that of the Broomtail wrasse *C. lunulatus*. Consequently, its arrival from the Red Sea in the eastern Mediterranean, if confirmed, could be explained via the Lessepsian migration process through the Suez Canal corridor. On the other hand, for the two triacanthid species known, *T. biaculeatus* and *T. nieuhofii*, only *T. biaculeatus* has been recently detected in the southeastern Red Sea (Goutham-Bharathi *et al*., 2024). Other findings in the Mediterranean Sea will give the opportunity first of all to identify with accuracy the species under question and eventually postulate a pathway of introduction. As mentioned above, juveniles of *T. biaculeatus* occur also in estuarine waters. If the occurrence of *T. biaculeatus* will be ascertained, the Delta of Nile and the lagoons of Egypt, located not far, at west to the Gaza Strip waters, could provide suitable habitats for the juveniles of this species, as observed for other Indo-West Pacific/Red Sea non-indigenous fishes introduced to the Mediterranean (Kara & Quignard, 2018).

The NIS *P. forsskali*, *E.* cf. *popei* and *H. intermedius* from the Red Sea entered via the Suez Canal into the Mediterranean Sea. After their adaptation to the new Mediterranean environment and the establishment of a reproducing population, these Lessepsian migrant fishes have colonized the eastern waters of the basin, as mentioned in the respective Remarks given above. Although their presence was expected in the Gaza Sea, the documentation of their occurrence in this specific area under study fills a gap of knowledge regarding their successful establishment and spreading in the wider Levantine region.

Given that the first glassfish from Gaza, here reported as *Ambassis* sp., have been captured and photographed in winter 2021 and summer 2022 in the Gaza Port, there is a high probability that they are *A. dussumieri,* a species detected in October 2021 for the first time in a similar artificial habitat in the nearby Mediterranean waters of Israel (Stern *et al*., 2022). Its finding, if confirmed as *A. dussumieri*, could therefore support the existence of a large and established population of this schooling species in the eastern Levant, as forecasted by Stern *et al*. (2022).

Up to date, the NIS bony fishes of Indo-Pacific/Red Sea origin reported from the waters off the Gaza Strip, all considered Lessepsian migrants, approach a number of 40 species, approximately 30 % of the marine bony fishes reported in the fishery activities of the region (Liebmann, 1934; Haas & Steinitz, 1947; Abu Amra, 2018; Bariche *et al*., 2019; Abd Rabou *et al*., 2023). Taking into account that validation of at least five NIS fishes listed in Abu Amra (2018) is required, the number of Lessepsian migrant fishes detected in the restricted marine region under study is anyway high, being 39 % of the at least 106 Lessepsian fish species known in the whole eastern sector of the Mediterranean (Golani *et al*., 2020, 2021). Various Lessepsian fishes in fact give a large contribution to the marine fishery production along the 42 Km coastal waters of the Gaza Strip (Hussein *et al*., 2022).

The addition of the six NIS fishes reported here corroborates the importance of the Gaza Sea for documenting both the arrival of new Indo-Pacific/Red Sea NIS into the Mediterranean as well as the distribution expansion of already known NIS.

The present study underlines furthermore the usefulness of citizen scientists' observations for the improvement of biodiversity knowledge of the basin and the utility of social media and new technologies in the fast achievement of new information, especially in poorly known Mediterranean regions such as the waters off the Gaza Strip (Bariche *et al*., 2019; Abd Rabou *et al*., 2023) and the North African countries (Corsini-Foka & Zava, 2022). On the other hand, the data reported in the present study testify the limitedness of this type of diffusion, when new technologies are not appropriately used. In fact, the excessive importance given to the rapid dispersion of information, through social media and platforms, often predominates at the expense of the quality of the material supplied, material that in many cases appears insufficient to support a scientifically substantiate new knowledge. Therefore, this rapidly transmitted information is subjected to the risk to be likewise rapidly lost, due to the absence or scarcely accurate methodology in documenting the findings by citizen scientists and sensitized fishers, as discussed in Deidun *et al*. (2022).

ACKNOWLEDGEMENTS

The authors warmly thank Mr Abdullah Jaber, Mr Mahmoud Ahmed Jafeer, Mr Mohammad Al Nahhal, Mr Zakaria Baker for sharing photos and information on the fishes studied in the present work. They are also grateful to anonymous reviewers for their constructive comments on the first version of the manuscript.

PRVO POJAVLJANJE VRST *CHEILINUS LUNULATUS* (LABRIDAE), *TRIACANTHUS* CF. *BIACULEATUS* (TRIACANTHIDAE) IN ŠE ŠTIRIH TUJERODNIH VRST V VODAH OB GAZI, PALESTINA

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POVZETEK

Avtorji poročajo o šestih tujerodnih vrstah indopacifiškega izvora, ki so jih potrdili v vodah ob Gazi (Palestina) na podlagi fotografij in podatkov na namenskih platformah iz obdobja 2016-2023, pridobljenih na podlagi ljubiteljske znanosti (entuziasti in ribiči). Dve vrsti, Cheilinus lunulatus *in* Triacanthus *cf.* biaculeatus*, sta bili v Sredozemskem morju najdeni prvič, štiri vrste* Ambassis *sp.,* Equulites *cf.* elongatus*,* Parupeneus forsskali *in* Heniochus intermedius *pa prvič v palestinskih vodah ob Gazi. Čeprav so podatki in material omejeni, dobljeni rezultati krepijo uporabno podporo ljubiteljske znanosti pri spremljanju vnosa in/ali širjenja tujerodnih vrst v bazenu vzhodnega Sredozemskega morja, ki se sooča z velikim vplivom bioinvazije.*

Ključne besede: Levantsko morje, Palestina, Gaza, tujerodne vrste, lesepska selitev, ljubiteljska znanost

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received: 2023-11-07 DOI 10.19233/ASHN.2024.18

STATUS OF THE EXPLOITED CLAM *RUDITAPES DECUSSATUS* IN THE LITTORAL ZONE OF SFAX, TUNISIA

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ABSTRACT

The natural populations of Ruditapes decussatus *in Tunisia are heavily harvested. The clam harvesting sector is of paramount importance for the local fishing industry. This study was performed to estimate stocks and provide a management plan for natural populations along the Sfax coasts, as the area prepares to resume operations after a 3-year hiatus from exploitation. The results have revealed significant density fluctuation of this bivalve in the study area, which was roughly divided into six sites. The stock density ranged from 0 to 8 ind m^{-2}, and biomass values varied from 0 to 54 g m^{-2}. The total biomass amounted to 115.4 tons, with abundance levels exceeding 22.45 million individuals across an area of 3,867 hectares. The sampled individuals ranged in size from 2 to 59 mm. It was observed that the spread of the species was strongly affected by several abiotic parameters. In order to sustainably exploit this resource, guidelines are necessary to prevent overfishing and restore the stock to sustainable levels.*

Key words: *Ruditapes decussatus*, stock assessment, cartography, population structure, Sfax coasts, Tunisia

STATO DELLO SFRUTTAMENTO DELLA VONGOLA VERACE *RUDITAPES DECUSSATUS* NELLA ZONA LITORALE DI SFAX, TUNISIA

SINTESI

Le popolazioni naturali di Ruditapes decussatus *in Tunisia vengono pesantemente sfruttate. Il settore della raccolta delle vongole è di fondamentale importanza per l'industria della pesca locale. Questo studio è stato condotto per stimare gli stock e fornire un piano di gestione per le popolazioni naturali lungo le coste di Sfax, mentre l'area si prepara a riprendere le attività dopo una pausa di 3 anni dallo sfruttamento. I risultati hanno rivelato una significativa fluttuazione della densità di questo bivalve nell'area di studio, suddivisa approssimativamente in sei siti. La densità dello stock variava da 0 a 8 ind m^{-2} e i valori di biomassa variavano da 0 a 54 g m^{-2}. La biomassa totale ammontava a 115,4 tonnellate, con livelli di abbondanza superiori a 22,45 milioni di individui su un'area di 3.867 ettari. Gli individui campionati avevano dimensioni comprese tra 2 e 59 mm. È stato osservato che la diffusione della specie è fortemente influenzata da diversi parametri abiotici. Per sfruttare in modo sostenibile questa risorsa, sono necessarie linee guida per prevenire la raccolta eccessiva e riportare lo stock a livelli sostenibili.*

Parole chiave: *Ruditapes decussatus*, valutazione dello stock, cartografia, struttura della popolazione, coste di Sfax, Tunisia

INTRODUCTION

The grooved carpet clam *Ruditapes decussatus* (Linnaeus, 1758) is a commercially valuable bivalve mollusk. In Tunisia, only the native populations of this clam have been targeted for shellfish exploitation, representing an important economic resource that is mostly exported to Europe. They are exclusively collected in the southern part of the country. Fishery plays a major socio-economic role in Tunisia. It is fundamental to supporting rural and vulnerable communities, particularly clam collectors, in their struggle for survival. *R. decussatus* has been extensively exploited for two decades, but since 2017, a gradual depletion of the resource has been observed, inducing the cessation of fishing activities in 2021. The main reasons for stock depletion included overexploitation, inappropriate fishing methods, pollution, deterioration of water quality, climate change, and inadequate management of fishing practices (Gharbi *et al.*, 2023). Unfortunately, the most productive coastal areas are characterized by significant industrial activity. To prevent further stock decline and sustain this sector, Tunisian authorities have established a relatively comprehensive institutional and regulatory framework compliant with international standards, as well as overseeing and regularly monitoring the harvest season, and launching several development projects. Accordingly, they resolved that future exploitation should be carefully planned, starting with a proper study on *R. decussatus* in the present study area. But while extensive work has been done on ecotoxicology, reproductive biology, and pollution along the Sfax coasts (Hamza-Chaffai *et al.*, 2003; Smaoui-Damak *et al.*, 2003; Banni *et al.*, 2009; Derbali *et al.*, 2018; Dammak Walha *et al.*, 2021), and although the knowledge of stock assessment is considered essential for a dynamic management and conservation of marine bivalve populations, there has been only one study on the occurrence of the *R. decussatus* clam (Derbali *et al.*, 2017). The overall goal of the present study is therefore to update information and provide new data on the current status of *R. decussatus* along the Sfax coasts focusing on the population structure, geographical distribution, and stock size in relation to the effects of specific abiotic factors.

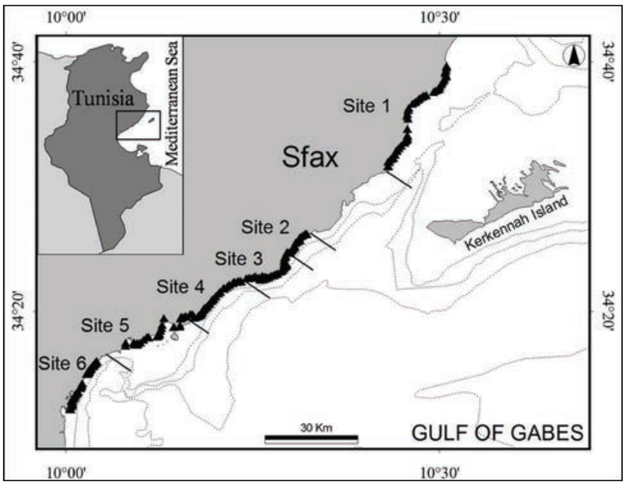

Fig. 1: Map of the study area indicating the locations of sampling transects.
Sl. 1: Zemljevid obravnavanega območja z označenimi lokalitetami vzorčevalnih transektov.

MATERIAL AND METHODS

Study area

The Sfax region, located in the Gulf of Gabes (southern Tunisia), spans 135 km in length (Fig. 1). The seabed is gradually sloping, reaching a depth of 60 m at a distance of 110 km from the coast (Ben Othman, 1973). The predominant substrates in the shellfish production area are muddy sands, with some areas covered by the seagrasses *Cymodocea nodosa* (Ucria) Ascherson and *Nanozostera noltei* (Hornemann) Tomlinson & Posluszny. The local climate is dry due to hot winds (sirocco). The sampling area exhibits the highest tidal ranges in the Mediterranean Sea. The tide is semidiurnal, with the spring tide reaching a high of +1.60 m and a low of +0.30 m (Zaghden *et al.*, 2014). The intertidal zone is an important source of natural resources harvested both by professional and recreational fishers. During spring tides, the expansive intertidal sand and mudflat zone is exploited for clam harvesting, primarily targeting *R. decussatus*.

Field sampling and processing

Field sampling was carried out over a two-year period (2022–2023) along the Sfax coasts (southern Tunisia). The sampling area was roughly divided into six sites based on clam occurrence (Fig. 1). Transects were systematically conducted during low tides. Samples were collected every 50 m along the transect lines extending from the extreme high tide to the extreme low tide. Along each transect, 4–10 replicates were taken in quadrats (0.25 m²) using a shovel. The samples were preserved in a 7% formaldehyde solution and then transferred to the laboratory for processing. During the sampling activities, seawater temperature and salinity were measured near the bottom immediately after sampling, using a multi-parameter kit (Multi 340 i/ SET). To enhance the study on clam distribution, specific interactions between abiotic and biotic factors affecting the spatial distribution of the *R. decussatus* population were investigated by analyzing granulometric characteristics recorded during the sampling activities. Sediment samples were collected from each site to a depth of 5 cm. Samples weighing 300 g each were pooled for each site, treated with an H_2O_2 solution, and then dried at 40 °C. The dried samples were sieved using AFNOR mesh-type sieves ranging from 2 mm to 63 µm. The Shepard (1954) grain size classification was followed.

Data analysis

In the laboratory, shell length (SL, mm; maximum anteroposterior distance considered as reference length), shell height (SH, mm; maximum distance from hinge to ventral margin), and shell width (SW, mm; maximum distance between the closed shell valves) were measured using a digital caliper to the nearest 0.01 mm. Additionally, the specimens were weighed on a top-loading digital balance (with a precision of 0.001 g) to determine total fresh weight (TW). The obtained dataset was registered, and maps were drawn using ArcGIS 10.8 software. Furthermore, the data were pooled at sampling sites to calculate mean densities (ind. m^{-2}) and mean biomass (g. m^{-2}) per site, and assessed across sampling sites using the following equation (Gulland, 1969): $Bi = Ni \times Ai/ai \times 1/Xi$, where Bi represents the total biomass of clams, Ni is the mean abundance of all quadrat samples in each site, Ai is the site area surface, ai is the quadrat swept area, and Xi is the proportion retained.

For statistical analysis, data were tested for homogeneity of variance and normality using Levene's and Kolmorogov–Smirnov tests, respectively. The Kruskal–Wallis median test was used to compare densities, while similarities between sites in terms of abundance and biomass were investigated using cluster analysis (group average method). In addition, the harmonic Spearman correlation coefficient was applied to identify any significant correlations between density and biomass of clams at each site. The results are presented as means ± standard error (SE), and the significance level used for the tests was set at $p < 0.05$.

RESULTS

Environmental parameters

The sediment parameters at all sites predominantly indicated silty-sandy substrates, except for site 5 (Tab. 1). Most of the sampled sites were covered with the seagrassess *C. nodosa* and *N. noltei* (> 50%). During the sampling period, the highest temperature values were recorded in July (31 °C), the lowest in February (14.9 °C). Salinity ranged between 37 in winter and 47 in summer.

Tab. 1: Sediment type recorded in the littoral zone of Sfax (Tunisia).
Tab. 1: Tip sedimenta na obalnem območju Sfaxa (Tunizija).

Sites	%Gravel	%Sand	% Silt/clay
Site 1	1.42	97.21	1.37
Site 2	0	98.50	1.50
Site 3	0.25	94.67	5.08
Site 4	0	95.57	4.43
Site 5	0.30	90.31	9.39
Site 6	0.45	99.26	0.29

Occurrence and distribution

Ruditapes decussatus was found in all sampling zones (sites 1 to 6) at depths between 0 and 1 m. A total of 184 transects were made from the extreme high water tide point to the extreme low water tide point. In total, 796 replicates were collected during sampling, covering a total area of 3,867 ha.

In general, there were significant fluctuations in the distribution of clams across the sites, with densities ranging from 0 to 8 ind. m^{-2} and biomass from 0 to 54 g m^{-2} (Figs. 2–3). Densities did not exhibit normal distribution (Kolmorogov–Smirnov test, $p < 0.05$) and were not homogeneous (Levene's test, $p < 0.05$). Furthermore, pairwise comparisons indicated that abundance and biomass levels obtained for sites (1–6) were significantly different (Kruskal–Wallis median test, $p < 0.05$).

Stock assessment

The total stock of the species under study was estimated at 115.4 ± 32.5 t (total fresh weight), with abundance levels exceeding 22.45 ± 8.4 million individuals. The mean biomasses and densities estimated from all sites were 2.98 ± 0.6 g m^{-2} and 0.58 ± 0.1 ind. m^{-2}, respectively.

Significant variations in mean stock levels were recorded across all sites (Fig. 4). At site 5, the results were significantly higher than those from the remaining sites ($p < 0.05$). On the other hand, no significant variations were found between values from sites 1 and 2 and those from sites 3 and 4 ($p > 0.05$). Regarding abundance, biomasses levels showed significant variations among the surveyed sites, with values at sites 3, 4, and 5 being higher than those from sites 1, 2, and 6 ($p < 0.05$). Similar differences were observed between site 6 and sites 1 and 2. Cluster analysis (group average) applied to assess similarities between the sites identified a core

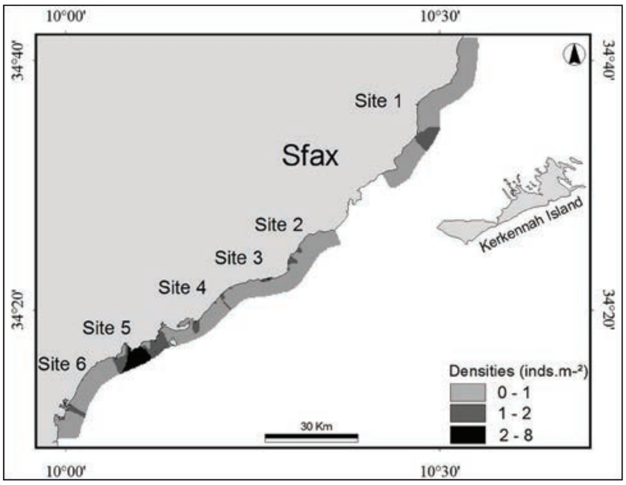

Fig. 2: *Ruditapes decussatus*: ***spatial distribution of densities in the littoral zone of Sfax (Tunisia).***
Sl. 2: *Ruditapes decussatus*: ***prostorska porazdelitev gostot v obrežnem območju Sfaxa (Tunizija).***

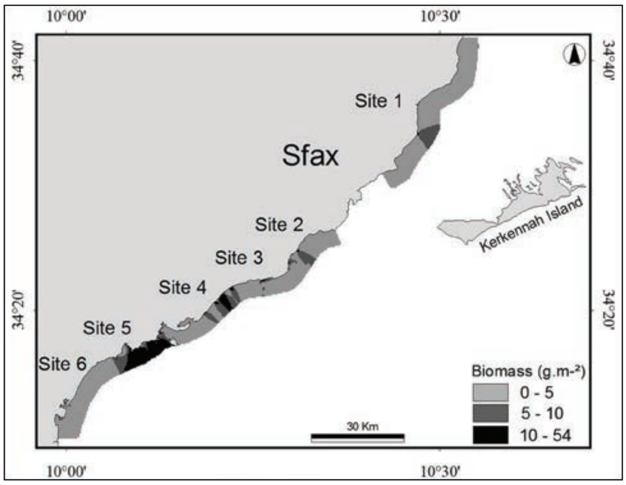

Fig. 3: *Ruditapes decussatus*: ***spatial distribution of biomass in the littoral zone of Sfax (Tunisia).***
Sl. 3: *Ruditapes decussatus*: ***prostorska porazdelitev biomase v obrežnem območju Sfaxa (Tunizija).***

group that spanned all sites (Fig. 5). The analysis of similarity tests revealed significant difference between the aforementioned group and site 5 (global R greater than 0.9; $p < 0.05$). This discrepancy was primarily attributed to *R. decussatus* stocks being most abundant at site 5 compared to the remaining sites.

Population size structure

The size structure analysis combines data from all sites hosting the clam *R. decussatus*. The distribution of clams was analyzed with respect to their sizes, which varied markedly between the sites. The clam population exhibited a non-uniform distribution: while larger specimens displayed a relatively heterogeneous distribution throughout the study area, smaller ones were more geographically restricted to sites 1 and 6. In general, the specimens' sizes ranged from 2 to 59 mm SL. The majority of the population fell into size classes ranging from 2 to 35 mm, representing 83% of all samples. Larger sizes (> 35 mm) only accounted for 17% of the population. In addition, two peaks were observed in size distribution: one at 9 mm and another at 29 mm, possibly indicating the presence of at least two cohorts (Fig. 6).

DISCUSSION

The current study establishes a wide informative baseline of the status of the grooved carpet clam *Ruditapes decussatus* along the Sfax coasts, providing essential groundwork for sustainable stock management as the area prepares to resume operation after more than 3 years of discontinuation. The species was found at depths ranging from 0 to 1 m. Based on our biomass estimates, this area supports a stock of 115.4 ± 32.5 tons of total fresh weight, with density levels exceeding 22 ± 8.4 million individuals. The available information on *R. decussatus* stock levels is deficient. Data about clam stocks are limited to preliminary studies conducted only in the southern part of the Sfax region, where the total biomass was estimated at about 891 tons, with relative abundance levels exceeding 261 million individuals (Derbali *et al.*, 2016). The main factors to have contributed to stock depletion include an increase of fishing activities, climate change, and characteristics of soft bottoms (Gharbi *et al.*, 2023). In fact, *R. decussatus* population stocks

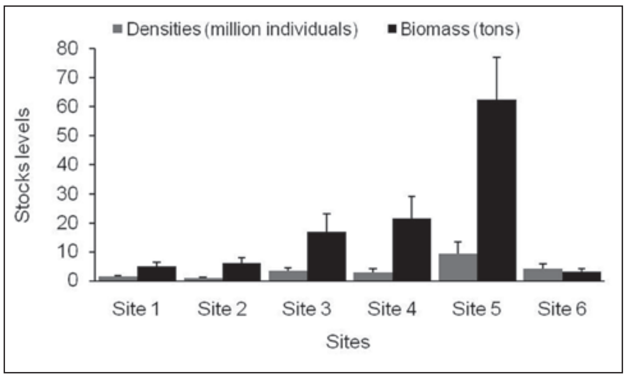

Fig. 4: *Ruditapes decussatus* ***stock levels in the colonized sites and their standard errors (± SE) in the littoral zone of Sfax (Tunisia).***
Sl. 4: Ocena staleža vrste *Ruditapes decussatus* ***v naseljenih lokalitetah in standardna napaka (± SE) v obrežnem območju Sfaxa (Tunizija).***

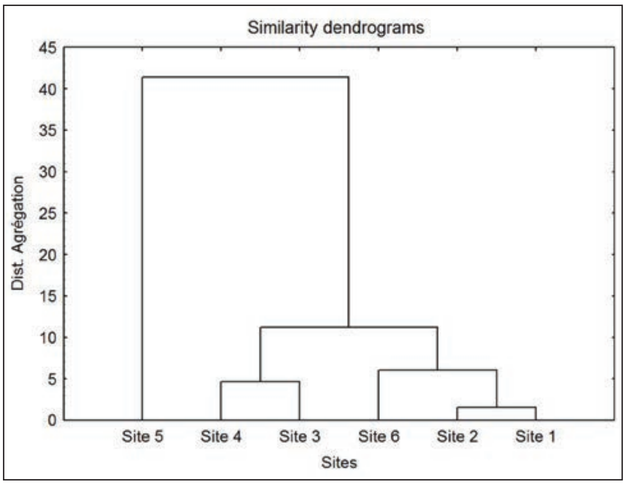

Fig. 5: *Ruditapes decussatus****: similarity dendrograms for the colonized zones (average group) in the littoral zone of Sfax (Tunisia).***
Sl. 5: *Ruditapes decussatus****: podobnostni dendrogrami v naseljenih lokalitetah (povprečne skupine) v obrežnem območju Sfaxa (Tunizija).***

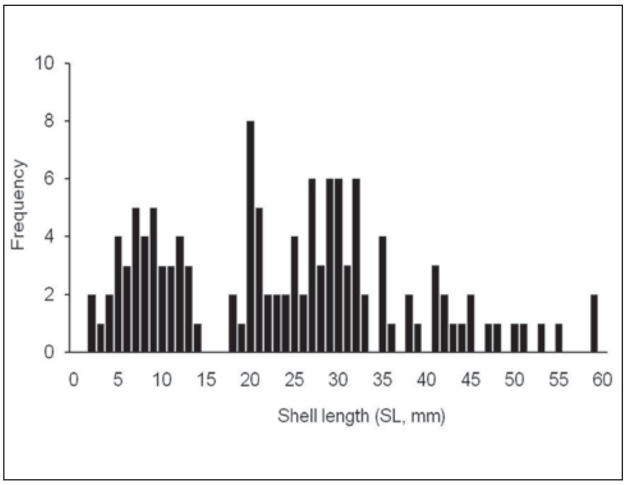

Fig. 6: *Ruditapes decussatus****: length–frequency distribution along the Sfax coastline (Tunisia).***
Sl. 6: *Ruditapes decussatus****: frekvenčna porazdelitev dolžine vzdolž obalne črte Sfaxa (Tunizija).***

varied within and between sampling sites, as well as compared to other geographic areas characterized by diverse seabed characteristics, vegetation cover, and physicochemical factors. The population seems to have been influenced by strong interaction at different levels (e.g., between physicochemical factors and soft bottom features characterizing the study area).

All sampling sites are located in rural zones that are facing several complex challenges, including socio-economic problems (low income from artisanal fishing or fish farming activities, high illiteracy rates), ecological concerns (stock depletion and closure of the clam-fishing season), climate change impacts, and a lack of measures to improve the residents' living conditions. The present investigation revealed variable distribution of *R. decussatus* populations within and among sites despite similar hydrodynamic conditions across the study area. The key factors in structuring bivalve populations include soft bottom and climate change (Derbali & Jarboui, 2021; Derbali *et al.*, 2021). The distribution of clams appears to be inversely correlated with the muddy-sand fraction. There is some evidence suggesting that a high degree of gravel in the seabed may deter clam settling, which, in turn, suggests that muddy-sand seabed may encourage higher densities. However, further studies involving sampling sediments and clams in each quadrat, for instance, are needed to support this hypothesis.

The dramatic decline in stocks could also be attributed to overexploitation in most shellfish production areas. Several incentive mechanisms have been implemented to promote sustainable fisheries management, including limiting fishing efforts, strengthening the legislative and institutional framework, and establishing biological rest periods. The authorities have been supporting this sector by establishing a relatively comprehensive institutional framework, by overseeing and regularly monitoring the harvest season, strengthening control and awareness raising measures, and launching several development projects. Despite all these efforts, clam production has witnessed a severe decline over the past five years, dropping by 95% from 1,825 tons in the 2016 season to just 84 tons in the 2020 season (DGPA, 2020).

R. decussatus appears to have been strongly affected by abiotic factors. During the present study, hydrodynamic conditions were found consistent within the sampling area, suggesting that relative population growth is influenced by other environmental parameters such as sediment type, organic matter content, the clams' burrowing behavior, and their subsequent strategies to counter dislocation and avoid predation. In fact, some interesting connections were detected between environmental conditions and bivalve behavior. The clam population seems to peak in areas sheltered by seagrasses *C. nodosa* and *N. noltei* where these cover more than 50% of the site (i.e., about 1,935 ha in total). The clam distribution was found to be significantly correlated with the abundance of the two seagrasses. This positive correlation could rest on: i) detrital organic source offered by these seagrasses, and/or ii) the fact that the presence of seagrasses reduces bottom scour and allows accumulation of organic matter. Vilela (1950) reported that among the dominant organic sources in the diet of *R. decussatus* is the organic matter from *C. nodosa*. Sarà (2007) reached the same conclusion for cockles in Italy. Additional mechanisms structuring clam populations include soft bottoms, with *R. decussatus* showing a particularly strong association with silty-sandy substrates (site 5).

The grooved carpet clam *R. decussatus* is extensively fished in the study area. The high exploitation rate (E = 0.51) indicates serious overexploitation of the stock. Derbali *et al*. (2024) reported that the fishing mortality (F) of *R. decussatus* (F = 1.02 yr^{-1}) exceeded the natural mortality (M = 0.90 yr^{-1}) in this area. Beck *et al*. (2015) suggested that harvesting activity targeting *R. decussatus* during high tide creates strong disturbances and has a negative effect on clam populations. The depletion of *R. decussatus* stocks can be attributed to direct and indirect mortality (e.g., destruction of tubes, exposure to predators, and loss of specimens due to unstable sediments and water currents) (Munari *et al*., 2006; Carvalho *et al*., 2013). According to Aranguren *et al*. (2014) mortality rates in *R. decussatus*, especially in natural beds, may result from a complex synergy of biotic and abiotic factors. Similarly, Robinson and Richardson (1998) clarified that individuals of *Ensis magnus* (Schumacher, 1817) that were returned to the seabed were slow to re-bury, becoming highly vulnerable to predation by crabs.

Water temperatures and salinities recorded during the sampling period were much higher than those recorded in 2015 (Derbali *et al*., 2016). Several authors have suggested that increased temperature and salinity can have a significant impact on fauna composition and reduce the standing crop (Fishar, 2000; El-Shabrawy, 2001). They have also noted that temperature spikes during summer are associated with adverse effects on marine organisms. It can be inferred that these unfavorable conditions also contribute to the mortality of *R. decussatus* individuals. Furthermore, this mortality rate appears to be correlated with the increase in size of adult individuals. It is likely that clams, as they grow larger, have difficulties in burying themselves in substrates, thereby increasing the chances of mortality. Moreover, our results indicate that the shellfish production area is subject to phytoplankton blooms (diatoms, dinoflagellates, etc.). For years, dinoflagellate blooms have occurred during summer, causing mass mortalities among bivalve species. Among these, *R. decussatus* is particularly negatively impacted by the blooms. The clam disappears from the large central area likely due to anoxia, re-colonizing it in autumn as the temperatures cool down. In our survey, we found that larger individuals almost disappeared in summer. The population structure of this species is also seriously affected by the extensive and continuous removal of seagrasses, as these serve as the main area for larval settlement.

To ensure the sustainable commercial exploitation of *R. decussatus*, it is imperative to implement guidelines that prevent recruitment overfishing. These guidelines should include imposing closed seasons during months of peak spawning activity, monitoring fishing efforts to determine adequate clam fishing technologies, adopting rules to avoid disturbing grass bed, and enforcing limits on clam sizes, as well as regulating catch levels. Implementation of these guidelines could restore the stock to sustainable levels. Further studies are necessary to determine the precise technological requirements for establishing profitable exploitation and long-term farming of this resource.

ACKNOWLEDGEMENTS

The authors thank all the people who contributed to *R. decussatus* sampling. We are grateful to the reviewers for helpful comments on the manuscript.

STANJE KOMERCIALNO IZKORIŠČENE BRAZDASTE VONGOLE *RUDITAPES DECUSSATUS* V LITORALNEM OBMOČJU SFAX, TUNIZIJA

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POVZETEK

*Naravne populacije brazdaste vongole (*Ruditapes decussatus*) so v Tuniziji hudo zdesetkane. Sektor nabiranja školjk je izjemno pomemben za lokalno ribištvo. Namen raziskave je bil oceniti stalež teh školjk in pripraviti načrt upravljanja naravnih populacij vzdolž obale Sfaxa, ko se na območju pripravljajo, da bi po triletnem premoru izkoriščanja spet začeli z delovanjem. Rezultati so obelodanili znatna nihanja v gostoti školjk na obravnavanem območju, ki je bilo v grobem razdeljeno na šest lokalitet. Gostota školjk se je gibala med 0 in 8 osebkov m^{-2}, biomasa pa med 0 in 54 g m^{-2}. Celokupna biomasa je bila 115,4 ton, število školjk pa je na površini 3867 hektarjev presegalo 22,45 milijonov primerkov. Vzorčeni primerki so merili med 2 in 59 mm. Ugotovili so, da je na širjenje vrste vplivalo več abiotskih dejavnikov. Da bi trajnostno izkoriščali ta vir, je potrebno vzpostaviti smernice za preprečevanje prelova in obnovitev staleža na trajnostno raven.*

Ključne besede: *Ruditapes decussatus*, ocean staleža, kartografija, struktura populacije, obale Sfaxa, Tunizija

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received: 2024-04-05 DOI 10.19233/ASHN.2024.19

A PRELIMINARY CHECKLIST OF MARINE HETEROBRANCHS (MOLLUSCA: GASTROPODA: HETEROBRANCHIA) OF SYRIA

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ABSTRACT

The surge in research of marine biodiversity in Syria, particularly with a focus on non-native species, along with the involvement of amateur free-diving enthusiasts, has facilitated the documentation of additional species, including Heterobranchia (Mollusca: Gastropoda). Between 2016 and 2023, several Heterobranchia species were observed by SCUBA divers along the Syrian coast at depths ranging from 2 to 12 meters. Additional specimens were manually collected on rocky shores from 2020 to 2023. In total, 16 species of Heterobranchia were identified in Syrian marine waters. Among them, 6 are non-indigenous, 2 are cryptogenic, and some are invasive. The study also highlights the presence of rare species, such as Fiona pinnata *and* Berthella stellata albocrossata*, recorded in Syria for the first time. The prevalence of the cryptogenic species* Aplysia dactylomela *and the invasive* Elysia grandifolia *is notable across most locations.*

Key words: Nudibranchia, mollusca, new record, rare species, Eastern Mediterranean

LISTA PRELIMINARE DEGLI ETEROBRANCHI MARINI (MOLLUSCA: GASTROPODA: HETEROBRANCHIA) DELLA SIRIA

SINTESI

L'aumento della ricerca sulla biodiversità marina in Siria, con un'attenzione particolare alle specie non autoctone, insieme al coinvolgimento di appassionati di immersione libera amatoriale, ha facilitato la documentazione di ulteriori specie, tra cui gli Heterobranchia (Mollusca: Gastropoda). Tra il 2016 e il 2023, diverse specie di Heterobranchia sono state osservate da subacquei lungo la costa siriana a profondità comprese tra 2 e 12 metri. Altri esemplari sono stati raccolti manualmente sulle coste rocciose dal 2020 al 2023. In totale, sono state identificate 16 specie di Heterobranchia nelle acque marine siriane. Tra queste, 6 sono non indigene, 2 sono criptogenetiche e alcune sono invasive. Lo studio evidenzia anche la presenza di specie rare, come Fiona pinnata e Berthella stellata albocrossata*, segnalate per la prima volta in Siria. La prevalenza della specie criptogenetica* Aplysia dactylomela e *dell'invasiva* Elysia grandifolia è *notevole nella maggior parte delle località*.

Parole chiave: Nudibranchia, molluschi, nuove segnalazioni, specie rare, Mediterraneo orientale

INTRODUCTION

The Syrian coastline, stretching 183 km along the central eastern Mediterranean Sea, is a rich tapestry of environmental habitats, each distinct and delicate. Its seabed features a diverse mosaic of rocky, sandy, gravel, mixed, and coralligenous substrates. These traits create an ideal environment for the proliferation, reproduction, and settlement of a wide array of organisms from varied biogeographic origins. Due to its geographical position and proximity to the Suez Canal, the Syrian coast serves as a gateway for migrants from tropical and subtropical regions, including the Atlantic Ocean, the Red Sea, and the Indo-Pacific Ocean. Consequently, there has been a notable increase in the number of species in recent decades, as highlighted in studies by Ammar (2019; 2023a). Another crucial aspect is the presence of major ports like Latakia, Tartus, and Baniyas on the Syrian coast. Especially the international hubs of Latakia and Tartus, but also Baniyas for oil transportation, could play a crucial role in facilitating the introduction of alien species and potentially altering the ecosystem in the future (Ammar, 2023a).

The Mollusca phylum stands out as the most prominent among invertebrates inhabiting the Syrian sea, with a recorded tally of 404 species up to June 2023 (Ammar, 2024; Arabia, 2011; Ammar, 1995), including 250 gastropod species. Among these, heterobranchs emerge as the least diverse and rather underrepresented group in Syria. However, recent documentation has shed some more light on the sea slugs and sea snails in Syrian waters, some of which were mentioned in earlier works (Katsanevakis *et al.*, 2014; Ammar, 2019), and revealed that their existence had been observed by divers and marine enthusiasts years before formal records were produced.

The subclass Heterobranchia, the focal point of this study, comprises a diverse array of gastropods thriving in marine, brackish, freshwater, and terrestrial habitats. This subclass encompasses six infraclasses, with Opisthobranchia being the most significant. Opisthobranchia sea snails and sea slugs are further categorized into nine orders: lower Heterobranchia, Acteonimorpha, Ringipleura, Umbraculida, Cephalaspidea, Runcinida, Aplysiida, Pteropoda, and Sacoglossa (WoRMS, 2024). Presently, there are 8471 marine species within this subclass, inhabiting both intertidal and sublittoral zones, and exhibiting diverse ecological behaviors such as burrowing in soft substrates, grazing on seagrass, and foraging on rocky shores (Wigham, 2022).

Heterobranchia play a vital environmental role as indicators of water warming, climate change, pollution, and habitat loss (Mehrotra *et al.*, 2020). Moreover, they contribute significantly to the biochemical cycle of nutrients, particularly silicates (Cruz *et al.*, 2013; López-Acosta *et al.*, 2023). Additionally, these mollusks harbor bioactive compounds with medicinal properties, serving as potential sources for analgesic, anti-inflammatory, antiviral, and anticancer drugs (Winters *et al.*, 2018; Eisenbarth *et al.*, 2018).

The growth in research of marine biodiversity in Syria, coupled with the involvement of amateur free-diving enthusiasts looking for alien species and documenting them in social media, has facilitated the recording of newly-observed marine life species, including the captivating and colorful group of mollusks.

The impact of climate change and rising water temperatures in the Eastern Mediterranean, attributed to global warming and heatwaves during the period 2016–2021 (Garrabou *et al.*, 2022), is evidenced by the increase in the number of non-native, tropical sea slug species and their expanding distribution along the southern Syrian coast and beyond. This phenomenon, which is not unique to Syria but extends to other regions of the Eastern Mediterranean, such as Turkey, the Levantine Basin, and the Aegean Sea, has been particularly affecting the Nudibranchia group (Grech *et al.*, 2023). Researchers have underscored the role of climate change and global warming in the proliferation of these species (Rothman *et al.*, 2017; Mioni & Furfaro, 2022). In the broader context of the Mediterranean Sea, approximately 550 species of sea slugs have been recorded, with 270 belonging to Nudibranchia (Trainito & Doneddu, 2014; Furfaro *et al.*, 2020). In the Adriatic Sea, the total number of Opisthobranchia species reaches 233 (Zenetos *et al.*, 2016), with as many as 160 species of Heterobranchia recorded in the Salento Peninsula in Italy alone (Furfaro *et al.*, 2020). Although these numbers may appear modest compared to those of other global seas and oceans, the presence of alien species is notable. The Atlas of Mollusks produced by CIESM records 21 alien Opisthobranchia species (Zenetos *et al.*, 2003), with additional alien species documented in subsequent research across various Mediterranean countries, including Greece, Turkey, Cyprus, Lebanon, and the central Mediterranean region (Crocetta *et al.*, 2013, 2015a,b; Kleitou *et al.*, 2019; Manousis, 2021; Manousis *et al.*, 2020; Riccardi *et al.*, 2022; Lombardo & Marletta, 2023a,b). In comparison, until 2016, a total of seven species, along with one potentially alien species and three cryptogenic species, had been documented from the Adriatic Sea (Zenetos *et al.*, 2016). There has been an observable rise in the number of Nudibranchia in Turkey, the Levantine Basin, and the Aegean Sea which researchers attribute to the effects of climate change and global warming (Rothman *et al.*, 2017; Mioni & Furfaro, 2022; Grech *et al.*, 2023; Garrabou *et al.*, 2022).

Overall, the presence of sea slugs in the Mediterranean remains uncommon (Schubert & Smith, 2020), however, new and rare species continue to be discovered in Syria and other Mediterranean countries, often

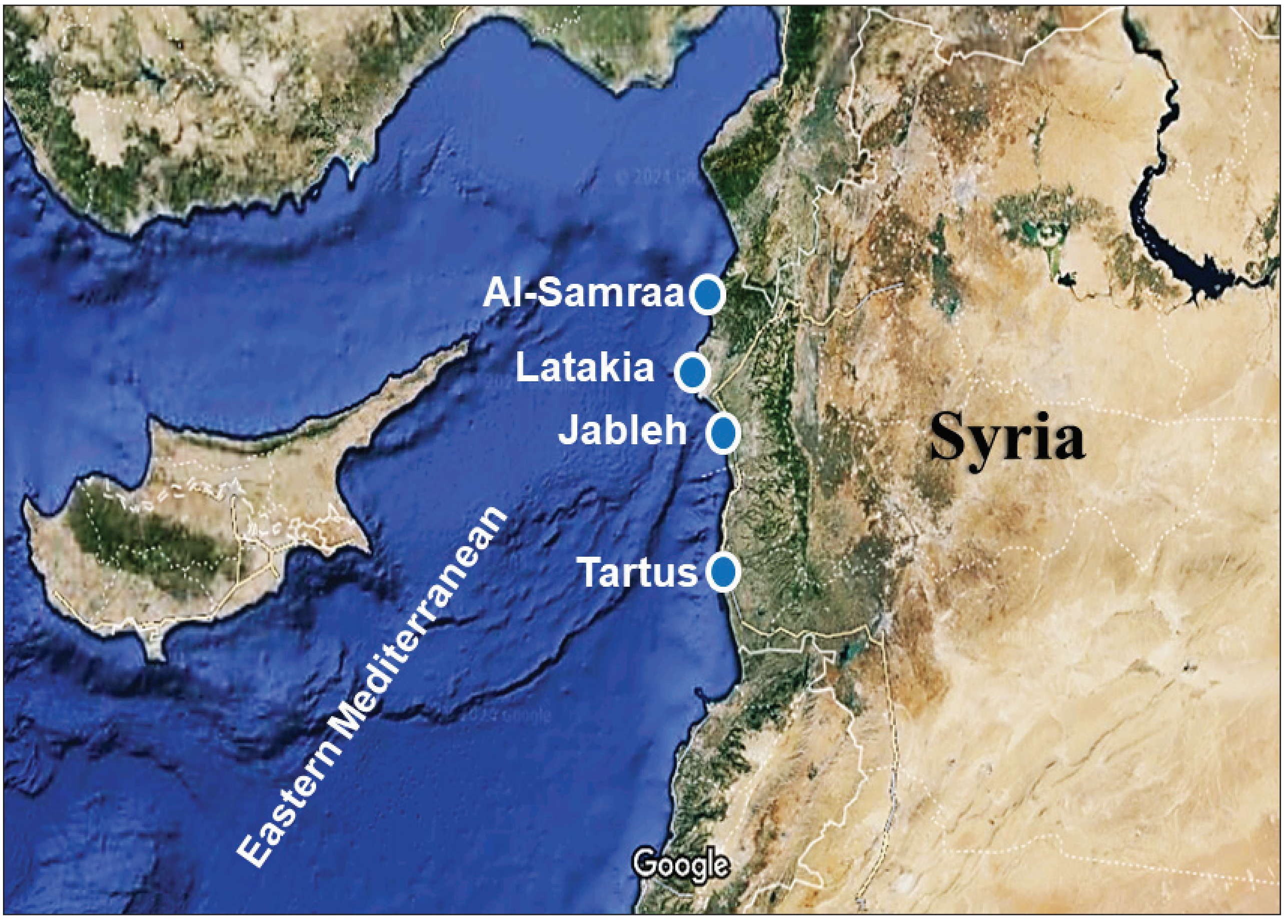

Fig. 1: Study areas in the Syrian coast.
Sl. 1: Zemljevid obravnavanega območja ob sirski obali.

through the efforts of amateur divers (Kleitou *et al.*, 2019; Ammar, 2023c). The primary objective of this study is to compile a preliminary inventory of marine Heterobranchia species in Syria, concurrently documenting new findings for the region.

MATERIAL AND METHODS

The study encompassed various areas along the Syrian coast, specifically Tartus and Latakia (Fig. 1). Most of the sites, ranging in depth from 0 to 12 meters, featured rocky bottoms with patches of sand. Notably, two sites on the northern coast stood out for their coralligenous seabed: the Ibn Hani reserve and Al-Samra.

Benthic organisms inhabiting these areas face numerous challenges and pressures. In addition to the encroachment of alien species, they must contend with the impacts of climate change, warming waters, pollution, and extensive fishing. Over the period from 2020 to 2023, the region experienced a marked increase in water temperatures, with surface seawater temperatures fluctuating between 16.9 °C in winter and 31.4 °C in summer. Similarly, salinity levels varied from 36.4‰ in winter to 39.8‰ in summer. Syrian waters also have low primary production, with chlorophyll (a) concentrations ranging from 0.0 to 6.7 mg/m3 (Ammar & Arraj, 2023; Darwish & Alakash, 2022).

Individuals of Heterobranchia species were observed in shallow waters at the Ibn Hani site (northern Latakia) and the Al-Samraa site from 2016 to 2023, primarily during free diving at depths ranging from 2 to 12 meters. Additionally, specimens were manually collected from the rocky shores of other locations north of Tartus and Jableh between 2020 and 2023, at depths ranging from 0 to 3 meters. Many of these specimens were photographed at the sites by two amateur photographers, Nouh Abbas and Mahmoud Halhal.

Due to technical challenges, genetic analysis could not be conducted. Therefore, species identification of the samples was based on field photographs and observation of external morphological

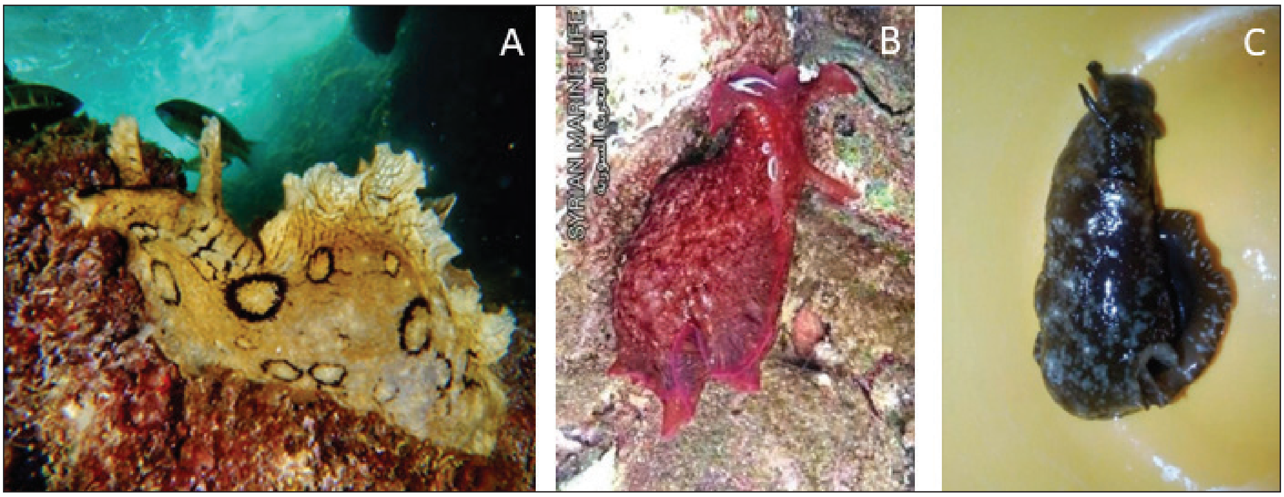

Fig. 2/Sl. 2: (A)** Aplysia dactylomela**, (B)** Aplysia punctata**, (C)** Aplysia fasciata**.

characteristics and coloration, following taxonomic references provided by Zenetos *et al.* (2003), Yonow (2008), Riedl (2011), Trainito & Doneddu (2014), as well as assistance from other experts and sources. The nomenclature adhered to the guidelines of the WoRMS Editorial Board (2024). A few specimens were preserved in formalin for further examination.

RESULTS AND DISCUSSION

The present study confirms the existence of sixteen species of Heterobranchia (Mollusca: Gastropoda) in various locations along the Syrian coast. These species are distributed among four orders and eight families. Notably, six of these species are classified as non-indigenous (NIS), two as cryptogenic, some as invasive, and a few as rare. Most of the specimens were observed and photographed between 2016 and 2023.

Table 1 presents a list of species with their respective taxonomic statuses following Riedl (2011), as well as locations, coordinates, and dates of occurrence and recording.

In the Mediterranean region in general, the Heterobranchia class has historically been regarded as the least diverse and underrepresented. Until 2013, the heterobranchs recorded in Syria were limited to native, Mediterranean species. However, new discoveries have since emerged, such as the cryptogenic *Aplysia dactylomela* Rang, 1828, and *Thecacera pennigera* (Montagu, 1813), calling for a shift in our understanding of their presence (Katsanevakis *et al.*, 2014; Ammar, 2019).

Further exploration of biodiversity, including previously unstudied areas, has led to the identification of four additional non-native species: *Elysia grandifolia* (Kelaart, 1858), *E. ornata* (Swainson, 1840), *Goniobranchus obsoletus* (Rüppell & Leuckart, 1830), and *Hypselodoris infucata* (Rüppell & Leuckart, 1830). These species were observed in a beach pool in Jableh and at the Al-Massab site north of Tartus, southern Syria, where a citizen interested in marine life documented their presence and posted photographs on Facebook. It is worth noting that Al-Massab is a small marina primarily used for docking boats and ships involved in oil transport.

In the southern sector of Tartus, *Elysia grandifolia* has become increasingly common since 2020, with notable sightings in 2022 and 2023. Additionally, *Fiona pinnata* was spotted occasionally on driftwood near the Al-Massab basin.

In the more frequently studied northern sector of the Syrian coast, 12 species were documented between 2016 and 2023. Free diving and underwater photography conducted by local amateur explorers aided in the observations.

The order Aplysiida (Fig. 2) is represented by two local species, *Aplysia punctata* and *Aplysia fasciata*, along with the cryptogenic species *Aplysia dactylomela*. *A. fasciata* has been known in Syria since 1993 and remains widespread, while the occurrence of *A. punctata* was noted only once in Al-Massab in 2021. *A. dactylomela* was first documented in 2013 and continues to be observed in the northern sector, particularly near the Ibn Hani marine protected area.

One Sacoglossa species from the family Plakobranchidae, *Elysia grandifolia* (Kelaart, 1858), was initially sighted in 2016 near the Ibn Hani marine protected area (MPA), a hotspot for nocturnal free diving activities (Fig. 3A). Subsequently, its presence became more frequent, with a significant surge in number during 2023 in various regions of northern and southern Syria. Interestingly, the specimens photographed and collected exhibited some morphological variations, particularly regarding the presence of a white line along the mantle's edge. This difference has caused previous misclassifications, where specimens were erroneously identified as either

Tab. 1: Checklist list of native and non-native sea slugs (Gastropoda, Heterobranchia) from the Syrian coast.
Tab. 1: Seznam domorodnih in tujerodnih vrst polžev zaškrgarjev (Gastropoda, Heterobranchia) ob sirski obali.

Order	Family	Species	Locality	North	East	Year(s)	Depth (m)	Substrate	Reference
Aplysiida	Aplysiidae	*Aplysia dactylomela* Rang, 1828	Latakia (Ibn Hani)	35.5922	35.7422	2013–2023	littoral	rocky	Katsanevakis *et al.* (2014)
			Latakia (Ibn Hani)	35.5930	35.7412	2016	2	rocky	Ammar *et al.*(2023)
			Al-Bassit	35.85077	35.84209	2021	3–4	rock and sand	unpublished data
			Al-Samraa	35.927828	35.915995	2023	2	rocky	This study
		Aplysia fasciata Poiret, 1789	Latakia (Ibn Hani)	35.5922	35.7422	1993–2023	littoral	rocky	Ammar (1995)
			Al-Massab (north of Tartus)	34.9684	35.8750	2021	littoral	rocky	Ammar (2023a)
			Al-Bassit	35.852528	35.821737	2021	2	rocky	unpublished data
		Aplysia punctata (Cuvier, 1803)	Al-Massab (north of Tartus)	34.9684	35.8750	2021	littoral	rocky	Ammar (2023a)
Sacoglossa	Plakobranchidae	*Elysia grandiflora* (Kelaart, 1858)	Jableh (Al-Rmayleh)	35.378485	35.920809	2019, 2020 & 2021	1-2	pond on rocky shore	Ammar *et al.* (2022)
			Tartus (Al Fawwar)	34.850385	35.89326	2020	shoreline	rocky	Ammar *et al.* (2022)
			Latakia (Ibn Hani MPA)	35.592743	35.741689	2017	4	rocky	Ammar *et al.* (2023)
				35.592939	35.750071	2023	4	rocky	This study
Pleurobranchida	Pleurobranchidae	*Berthella stellata albocrossata* Heller & T. E. Thompson, 1983	Latakia (Ibn Hani)	35.593043	35.741230	2022	7	rocky	Ammar (2023c)
			Latakia (Ibn Hani)	35.596254	35.75708	2022	12	artificial reef	unpublished data
		Berthella sp.	Al-Bassit	35. 852528	35.821737	2023	shallow water	rocky	unpublished data
		Pleurobranchus testudinarius Cantraine, 1835	Ibn Hani	35.592939	35.750071	2019	2	rocky beds	Ammar (2023b)
			Al-Samraa	35.927828	35.915995	2019	2	rocky beds	Ammar (2023b)
Nudibranchia	Aeolidiidae	*Spurilla neapolitana* (Delle Chiaje, 1823)	Tartus	34.968416	35.875922	2019–2020	0.5	rocky	Ammar (2023a)
	Fionidae	*Fiona pinnata* (Eschscholtz, 1831)	Tartus (Al-Massab)	34.968416	35.875922	2021	0	floating piece of wood	this study
	Polyceridae	*Plocamopherus ocellatus* Rüppell and Leuckart, 1828	Latakia (Ibn Hani)	35.591589	35.743336	2022	5–6	rocky	Ammar (2023c)
		Thecacera pennigera (Montagu, 1813)	Latakia	35.3559	35. 4444	2013	100	muddy	Ammar (2019)
	Chromodorididae	*Goniobranchus annulatus* (Eliot, 1904)	Tartus	34.87395	35.880702	2018	10	rocky	Ammar (2019)
			Latakia (HIMR)	35.5927	35.74191	2016	2	rocky	Ammar *et al.* (2023)
			Latakia (Ras-Alkhedr)	35.5451	35.7571	2022	5	rocky	this study
		Goniobranchus obsoletus (Rüppell & Leuckart, 1830)	Jableh	35.378494,	35.917967	September 2019	1–2	pond on rocky shore	Ammar *et al.* (2022)
			Tartus (Al-Masab)	34.9684	35.8750	April 2021.	rocky shoreline	small marina	Ammar (2023a)
			Latakia (HIMR)	35.5927	35.74191	2016	2	rocky	Ammar *et al.* (2023)
		Hypselodoris infucata (Rüppell & Leuckart, 1830)	Jableh	35.378494,	35.917967	2020 & 2021	1–2	pond on rocky shore	Ammar *et al.* (2022)
			Tartus (Al-Massab)	34.968416	35.875922	October 2021	rocky shore	small marina	Ammar, (2023a)
			Latakia (HIMR – Ibn Hani)	35.5927	35.74191	2016	4	rocky	Ammar *et al.* (2023)
		Felimare picta (Philippi, 1836)	Al-Samraa (Shatt al-Armen)	35.927828	35.915995	2019	5	rocky beds	Ammar (2023c)
	Dendrodorididae	*Dendrodoris grandiflora* (Rapp, 1827)	Latakia (Ibn Hani)	35.592939	35.750071	2022	approx. 2	rocky beds	Ammar (2023a)

E. grandifolia (Kelaart, 1858) or *E. ornata* (Swainson, 1840) (Ammar *et al.*, 2022).

Due to current limitations in genetic classification within Syrian scientific institutions, experts from abroad were consulted. Their analyses of similar samples from the Lebanese coast confirmed that all individuals, despite their morphological variations, belong to a single species, *Elysia grandifolia* (personal communication). This suggests that *E. ornata* is currently absent from Syria. *E. grandifolia* has emerged as the dominant species in the shallow coastal areas of Syria, with its breeding season occurring in December. The number of observed individuals has been increasing over recent years, reaching approximately 20 individuals per square meter, particularly in sites such as Al Fawwar and the Ibn Hani reserve.

Additionally, three, possibly four, rare Mediterranean species from the Pleurobranchida order were observed and photographed in the northern sector of the Syrian coast (Tab. 1).

Berthella stellata (Risso, 1826), previously misidentified as *Doris verrucosa* Linnaeus, 1758 in a study by Ammar (2023c), belongs to the family of Pleurobranchidae. One individual of *B. stellata* was found under a rock in Ibn Hani (Fig. 3B), and another specimen was later collected from an artificial reef nearby (Fig. 3C). The observed specimens featured a pair of short rhinophores on the head; their yellowish-gray bodies appeared covered with numerous papillae (Fig. 3 B+C).

Establishing a specific and clear classification for the two specimens found in two close but different environments of northern Latakia (natural and artificial) was challenging. Genetic and morphological analyses have revealed *B. stellata* to be a complex species comprising eight different subspecies (Ghanimi *et al.*, 2020). The two Syrian specimens resembled what is known as the subspecies *Berthella stellata albocrossata* Heller & T. E. Thompson, 1983, however, their classification remains uncertain (WoRMS, 2024), due to an ongoing debate regarding the identification of subspecies based on genetic and morphological analyses (Ghanimi *et al.*, 2020).

A very small individual of the *Berthella* genus was discovered attached to stones on a shallow rocky shore near the port of Al-Bassit (35.852528, 35.821737) on September 22, 2023 (Fig. 3D). The sample looked very similar to *Berthella perforata* (Philippi, 1844) (Ghanimi *et al.*, 2020).

B. perforata, known as an Atlantic-Mediterranean species, has been documented along the Turkish coasts of the Mediterranean Sea (Öztürk *et al.*, 2014), in the Sea of Marmara, and in Greece within the Greek Exclusive Economic Zone (Manousis, 2021). Its habitat extends across the South and North Atlantic Oceans, from South Africa as far as Ireland, where it is referred to as *B. plumula* (WoRMS, 2024).

Pleurobranchus testidinarius Cantraine, 1835 (Fig. 3E), belonging to the order Pleurobranchida and the family Pleurobranchidae, is a Mediterranean species documented in various Mediterranean countries, including Turkey, Greece, Italy, France, and Spain, and in the North Atlantic Ocean. Regionally, records of *P. testidinarius* have been reported in Turkey and the Levantine Basin since 1971 (Gökoğlu *et al.*, 2018; Ergüden *et al.*, 2020). In Syria, this rare species was observed for the first time in 2019. Two specimens, each displaying different coloration—yellow and dark red—, were photographed during free diving at a depth of 2 meters over the rocky bottom of Ibn Hani [35.592939, 35.750071] to the north of Latakia, and at Al-Samra [35.927828, 35.915995]. The first official report of *P. testidinarius* in Syria was made in 2023 (Ammar, 2023b).

The order Nudibranchia is represented by nine species belonging to five families (Table 1). In summer 2019, two individuals from the family Aeolidiidae were collected for the first time in Al-Massab, where they were discovered under rocks at a depth of approximately 0.5 meters. They were small, not exceeding 4 cm in length (Fig. 4A). In 2020, another individual was collected from the same site. The morphological characteristics of all three individuals suggest they could be classified as either *Spurilla neapolitana* (Delle Chiaje, 1823) or, possibly, as part of the genus *Aeolidiella* Bergh, 1867. However, precise classification is pending genetic analysis, particularly given the challenges in accurately classifying species within this family based solely on morphology (Carmona *et al.*, 2013). The present constitutes an additional record of this species in the eastern Mediterranean following previous ones from Turkey and Greece (Öztürk *et al.*, 2014; Manousis, 2021).

Fiona pinnata (Eschscholtz, 1831) from the family Fionidae was documented for the first time in Syria during this study. Several individuals were found north of Tartus in 2021, attached to an old piece of driftwood alongside a group of goose barnacles (Lepas) and ascidians (Fig. 4B). While *F. pinnata* is known to have a global distribution, this marks its first documented occurrence in the Levantine Basin and Syria.

Plocamopherus ocellatus Rüppell and Leuckart, 1828 (Fig. 4C+D), and *Thecacera pennigera* (Montagu, 1813) (Fig. 4E) are members of the family Polyceridae. *P. ocellatus*, a Lessepsian migrant originating from the western Indian Ocean, was discovered as a single small individual at the Ibn Hani site in 2022. *T. pennigera*, a cryptogenic species, was collected in deeper waters off Latakia in 2013 and noted as a rare occurrence in the Syrian sea.

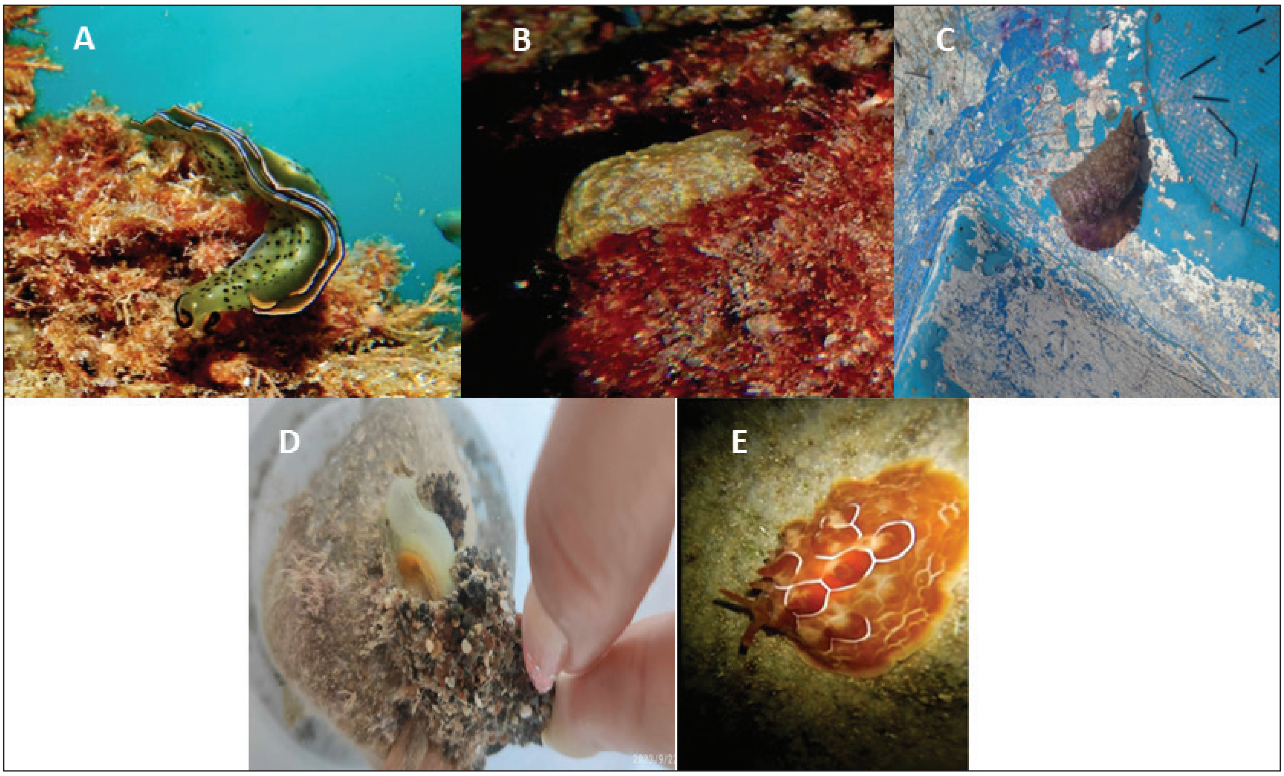

Fig. 3/Sl.3:* (A)** *Elysia grandifolia, (B, C)** *Berthella stellata albocrossata***, (D)** *Berthella* **sp., (E)** *Pleurobranchus testidinarius***.**

The Chromodorididae family is represented in Syria by four species, three of which – *Goniobranchus annulatus* (Eliot, 1904), *G. obsoletus* (Rüppell & Leuckart, 1830), and *Hypselodoris infucata* (Rüppell & Leuckart, 1830) – are non-native. These species have been observed frequently, expanding their distribution range across all studied sites. *G. annulatus* and *G. obsoletus* were first documented in the rocky shore of Latakia (HIMR) in 2016 at a depth of 2–5 meters, with subsequent sightings in the Alsokhneh beach pool north of Jableh in June 2019 and Al-Massab in April 2021 (Fig. 4F, 4G, 4H). Currently, *G. obsoletus* is widespread in all the mentioned sites.

H. infucata, endemic to the Red Sea, occurs in the Mediterranean as a non-indigenous and, in some regions, even invasive species. It was first recorded in 2016 near the Ibn Hani MPA by amateur divers (Fig. 4I), with subsequent sightings in Al-Massab in 2020 and 2021, and in Al Bassit in 2022. Although the species still occurs only in small numbers along the shallow coastal areas of Tartus and Jableh, its invasive potential warrants attention (Ammar *et al.*, 2022).

The Mediterranean slug *Felimare picta* (Philippi, 1836), the only native species of this family found in Syria, was observed once, during a free dive in the far north sector, at Shatt al-Armen, in June 2019 at a depth of 5 meters. The specimen, measuring a notable 18 cm in size, featured continuous parallel yellow lines running along its dark dorsum and extending all the way to the rhinophoral sheaths, complete yellow circles around the edge of the rhinophoral sheath, and several yellow rings on the edges (Fig. 4J).

A single individual of *Dendrodoris grandiflora* (Rapp, 1827) of the family Dendrodorididae, which is typically distributed in the Mediterranean and northeastern Atlantic, was sighted at the Ibn Hani site in September 2022 at a depth of approximately 2 meters. This specimen was 30–40 millimeters long, pale gray with dark brown spots on the dorsum and small brown spots and dark striations on the mantle margin (Fig. 4K). In previous publications (Ammar, 2023c), the species was misclassified as *Tayuva lilacina* (Gould, 1852).

The nocturnality of these species, combined with the challenges of free diving, limited the availability of photographs and specimens necessary for accurate classification, underscoring the rarity and difficulty associated with studying these organisms.

No specific scale is provided for photographs, as the size of the object in the image may vary depending on its proximity or distance, as well as zoom level.

The current study represents the first documented record of *Fiona pinnata* (Eschscholtz, 1831) and *Berthella perforata* (Philippi, 1844) in Syria,

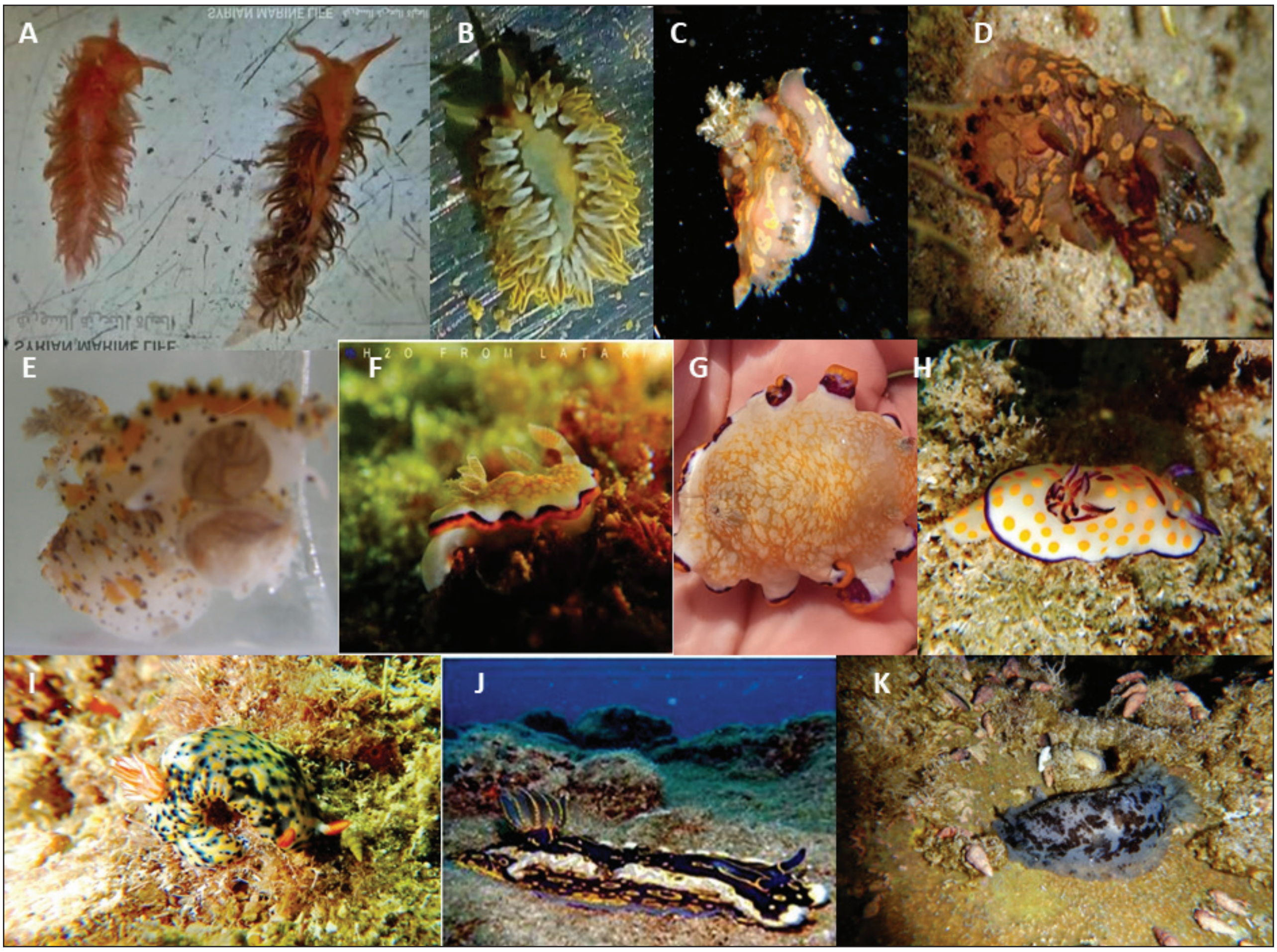

Fig. 4: Underwater photographs of nudibranchs from the Syrian coast: (A)** Spurilla neapolitana**, (B)** Fiona pinnata**, (C & D)** Plocamopherus ocellatus**, (E)** Thecacera pennigera**, (F & G)** Goniobranchus obsoletus**, (H)** Goniobranchus annulatus**, (I)** Hypselodoris infucata**, (J)** Felimare picta**, (K)** Dendrodoris grandiflora**.

Sl. 4: Podvodne fotografije gološkrgarjev iz sirske obale: (A)** Spurilla neapolitana**, (B)** Fiona pinnata**, (C & D)** Plocamopherus ocellatus**, (E)** Thecacera pennigera**, (F & G)** Goniobranchus obsoletus**, (H)** Goniobranchus annulatus**, (I)** Hypselodoris infucata**, (J)** Felimare picta**, (K)** Dendrodoris grandiflora**.

and rectifies previous identifications of *Dendrodoris grandiflora* (Rapp, 1827) and *Berthella stellata albocrossata* Heller & T. E. Thompson, 1983.

Among the species listed, six are non-indigenous species (NIS) originating from the Indian Ocean and the Red Sea: *Goniobranchus annulatus*, *Goniobranchus obsoletus*, *Elysia grandifolia*, *Hypselodoris infucata*, *Plocamopherus ocellatus*, and *Dendrodoris grandiflora*. Two species, *Aplysia dactylomela* and *Thecacera pennigera*, are classified as cryptogenic, *Berthella stellata albocrossata* is yet to be confirmed as a distinct species, while *Spurilla neapolitana* and *Berthella perforata* are identified as native Atlantic-Mediterranean species.

The study has revealed an expanding presence of alien heterobranchs in Syria and a tendency for them to dominate in new environments. Their expansion therefore calls for continued monitoring and management efforts to mitigate the impacts of these invasive species on native ecosystems.

The rise in seawater temperature in the eastern Mediterranean due to global warming has been linked to an increase in the number of alien species of sea slugs, particularly those of tropical origin, in the region. Studies by Rothman *et al*. (2017) and Mioni & Furfaro (2022) have highlighted the impact of climate change on the colonization of these species in the Mediterranean Sea. Prior to 2013, the Mediterranean was home to 30 species of alien Nudibranchia, equaling 6% of the total number of sea slugs in the region (Crocetta *et al.*, 2013).

The discovery of rare species in the Mediterranean has been made easier through various methods, including observations and photography by divers passionate about marine life, as well as contributions from field experts. Online platforms such as the Mediterranean

Slug Site and Sea Slug Forum have proven to be valuable resources for sharing information and images of these rare species (Follett & Strezov, 2015; Yonow, 2015).

The observed increase in the occurrence and distribution of non-native sea slugs along the Syrian coast, in both southern and northern regions, underscores the impact of climate change on marine biodiversity. This trend is supported by the heightened interest and field efforts aimed at documenting and understanding the presence of these species in the region.

CONCLUSIONS

The relatively low number of recorded heterobranchs in Syria up to 2023 can be attributed to several factors, including limited targeted research efforts and reliance on observations by amateur divers. Furthermore, certain species may have been overlooked or not specifically targeted in previous studies, giving the impression that marine gastropods along the Syrian coast are underrepresented.

The emergence and dominance of alien sea slug species, particularly in coralligenous habitats such as the Ibn Hani marine protected area (MPA), bring attention to the possible effects of climate change and global warming on marine biodiversity in Syria and the Eastern Mediterranean. The increasing presence of Atlantic tropical species suggests rapid colonization and adaptation to the Levantine Sea that may alter the local ecosystem dynamics.

The participation of citizen scientists in documenting the presence of rare Mediterranean species is crucial for supplementing local biodiversity records. Their contributions enhance our understanding of marine ecosystems and serve as valuable additions to scientific research efforts. As climate change continues to affect marine environments, collaboration between scientists and citizen scientists in monitoring and conserving coastal biodiversity becomes ever more important.

ACKNOWLEDGMENTS

I would like to thank Dr. Argyro Zenetos from the Hellenic Centre for Marine Research and Dr. Egidio Trainito from the Genoa Marine Center for their invaluable support and insightful comments throughout the research process. I would also like to extend special appreciation to Nouh Abbas and Mahmoud Halhal for their contributions in capturing high-quality field photographs, which have enhanced the documentation of marine biodiversity in the Syrian coast.

PRELIMINARNI SEZNAM MORSKIH POLŽEV ZAŠKRGARJEV (MOLLUSCA: GASTROPODA: HETEROBRANCHIA) SIRIJE

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POVZETEK

Porast raziskav morske biodiverzitete v Siriji s posebnim poudarkom na tujerodne vrste in vključevanje amaterskih ljubiteljskih potapljačev sta omogočila tudi zbiranje podatkov o drugih vrstah, med drugim tudi o polžih zaškrgarjih (Mollusca: Gastropoda). Med letoma 2016 in 2023 so potapljači opazili številne vrste polžev zaškrgarjev v globinskem pasu med 2 in 12 m ob sirski obali. Dodatne primerke so ročno nabrali na skalnati obali med letoma 2020 in 2023. Skupno je bilo v sirskih morskih vodah ugotovljeno 16 vrst polžev zaškrgarjev. Med njimi je 6 vrst tujerodnih, dve sta kriptogeni, nekatere od njih tudi invazivne. Avtor je obelodanil tudi prvo pojavljanje redkih vrst kot sta Fiona pinnata *in* Berthella stellata albocrossata*, v Siriji. Zanimivo je, da sta kriptogena vrsta* Aplysia dactylomela *in invazivna vrsta* Elysia grandifolia *prevladovali na večini lokalitet.*

Ključne besede: Nudibranchia, Mollusca, novi zapis o pojavljanju, redke vrste, vzhodno Sredozemsko morje

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received: 2024-04-05 DOI 10.19233/ASHN.2024.20

FIVE-YEAR MONITORING OF THE ECOLOGICAL STATUS OF THE *CYMODOCEA NODOSA* MEADOW NEAR THE PORT OF KOPER

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ABSTRACT

Seagrass meadows are among the most productive ecosystems in marine environments worldwide and are often considered to symbolise near-pristine conditions on sedimentary bottoms, but their condition is associated to various types of anthropogenic stressors. In the Mediterranean Sea, Cymodocea nodosa *is considered an effective indicator of environmental change, due to its universal distribution, its sensitivity to various natural and anthropogenic pressures, and the measurability of the species' responses to these impacts. The aim of this study is to present the improvement of the ecological status of the* C. nodosa *meadow near the port of Koper over a period of five years and to compare these results with the reference site in the northern Adriatic Sea.*

Key words: *Cymodocea nodosa*, MediSkew index, Port of Koper, status assessment, northern Adriatic Sea

MONITORAGGIO QUINQUENNALE DELLO STATO ECOLOGICO DELLA PRATERIA DI *CYMODOCEA NODOSA* PRESSO IL PORTO DI CAPODISTRIA

SINTESI

Le praterie di fanerogame marine sono tra gli ecosistemi più produttivi negli ambienti marini di tutto il mondo e sono spesso considerate il simbolo di condizioni quasi incontaminate sui fondali sedimentari, ma il loro stato è associato a vari tipi di stress antropico. Nel Mediterraneo, Cymodocea nodosa *è considerata un efficace indicatore del cambiamento ambientale, grazie alle sue: distribuzione universale, sensibilità a varie pressioni naturali e antropiche e misurabilità delle risposte a questi impatti. Lo scopo di questo studio è presentare il miglioramento dello stato ecologico della prateria di* C. nodosa *vicino al porto di Capodistria in un periodo di cinque anni e confrontare questi risultati con il sito di riferimento nell'Adriatico settentrionale.*

Parole chiave: *Cymodocea nodosa*, indice MediSkew, Porto di Capodistria, valutazione dello stato, Adriatico settentrionale

INTRODUCTION

Seagrass meadows are among the most productive ecosystems in marine environments worldwide (Brodersen *et al.*, 2018) and are often considered emblematic of near-pristine conditions on sedimentary bottoms (Sfriso *et al.*, 2021). Seagrass meadows cover large areas of the seabed, and despite their relatively low floral diversity, they support a rich marine fauna (*e.g.* fish and invertebrates) and provide a range of ecosystem services, including habitat provision, biodiversity conservation, food security, sediment stabilization, protection from coastal erosion, carbon sequestration and potentially mitigation of climate change impacts (Cullen-Unsworth & Unsworth, 2013; Espino *et al.*, 2015; Unsworth *et al.*, 2018; Rodil *et al.*, 2022; Traganos *et al.*, 2022). They are listed as priority habitats in several legislations, including the European Habitats Directive (HD, 92/43/EEC).

Seagrass meadows are among the best-studied coastal vegetated habitats due to their worldwide occurrence and relative accessibility in shallow waters. They are more or less the marine counterpart of tropical rainforests, and their condition is linked to various types of anthropogenic stressors. These pressures include shipping routes, vessel traffic, port activities, nutrient loading, siltation, mechanical disturbance (*e.g.* seabed dredging), pollution, aquaculture, introduction of new competitors (like non-indigenous organisms), commercial and recreational activities, runoff from urban and agricultural areas, and increasing climate change and ocean acidification (Marbà et al., 2014; Orlando-Bonaca et al., 2015, 2019; Repolho et al., 2017; Sfriso *et al.,* 2023). These stressors cause physical damage to the seabed (Marbà *et al.*, 2014), limit the light available for photosynthesis and impair nutrient resources (Hemminga & Duarte, 2000). Since the mid-17th century, the global cover of seagrasses has decreased by about 29% (51,000 km^2) and the annual loss of seagrass habitats adds about 300 Tg of carbon per year to the global active carbon pool (Capistrant-Fossa & Dunton, 2024).

In the Mediterranean Sea, *Cymodocea nodosa* (Ucria) Ascherson is considered an effective indicator of environmental change, due to its universal distribution, sensitivity to various natural and anthropogenic pressures, and the measurability of the species' responses to these impacts (Orfanidis *et al.*, 2007, 2010; Orlando-Bonaca *et al.*, 2015; Papathanasiou *et al.*, 2016; Nadzari *et al.*, 2022). Although *C. nodosa* exhibits great phenotypic plasticity and can adapt to various natural and anthropogenic stressors through physiological and morphological adaptations, a strong decline has been reported in coastal areas in recent decades due to direct and indirect effects of multiple stressors (Fabbri *et al.*, 2015; Najdek *et al.*, 2020; Stockbridge *et al.*, 2020).

There is still a lack of long-term data series to support the conservation status of *C. nodosa* meadows in the northern Adriatic Sea*,* while the species is still only protected in spatially restricted Marine Protected Areas (MPAs). The ecological status of *C. nodosa* meadows in the Gulf of Trieste was assessed using the MediSkew index (Orlando-Bonaca *et al.*, 2015; 2016), which was developed in accordance with the requirements of the EU Water Framework Directive (WFD, 2000/60/EC) and the Marine Strategy Framework Directive (MSFD, 2008/56/EC). The ecological status of the *C. nodosa* meadow growing near the Port of Koper was first assessed in 2018 (Orlando-Bonaca *et al.*, 2019), and then monitored annually from 2020 to 2023, as shipping routes and port activities are considered one of the main pressures on the status of *C. nodosa* meadows (Orlando-Bonaca *et al.*, 2015). The aim of this study is to investigate the changes in the ecological status of the *C. nodosa* meadow near the port of Koper during five years of monitoring compared to the reference area for *C. nodosa* in the Gulf of Trieste.

MATERIAL AND METHODS

Study area, fieldwork and laboratory work

The Port of Koper is the only Slovenian port, connecting the markets of Central and South-Eastern Europe with the Mediterranean and the Far East. Today, the marine part of the cargo port consists of three basins, associated jetties, and specialised loading terminals. The main impacts on seabed habitats in the vicinity of the port are caused by high water turbidity due to manoeuvres of large ships (Žagar et al., 2014), dredging and other activities (Luka Koper, 2015, 2020a), which lead to a high sedimentation/resuspension rate.

The investigated *C. nodosa* meadow near the Port of Koper can be considered as part of the biocoenosis of superficial muddy sands in sheltered waters (Orlando-Bonaca *et al.*, 2015, 2022). The meadow was sampled in July 2018, 2020, 2021, 2022 and 2023. Two sites (LuKp1 and LuKp2) were selected (Fig. 1) along the same isobath (3 m). Site LuKp1 (45°34.350'N; 13°44.183'E) is about 500 m away from the water area of the Port of Koper, while site LuKp2 (45°34.551'N; 13°43.861'E) is about 1000 m away from the Port. Within each site, two areas (LuKp1_1, LuKp1_2, and LuKp2_1, LuKp2_2) were selected, approximately 100 m apart. In each area, five metal frames (25 cm x 25 cm) were randomly placed on the bottom by SCUBA divers. These five squares were considered replicates of a sample. All shoots of *C. nodosa* found in each frame were carefully uprooted. The samples were lbelled and individually packed in plastic bags.

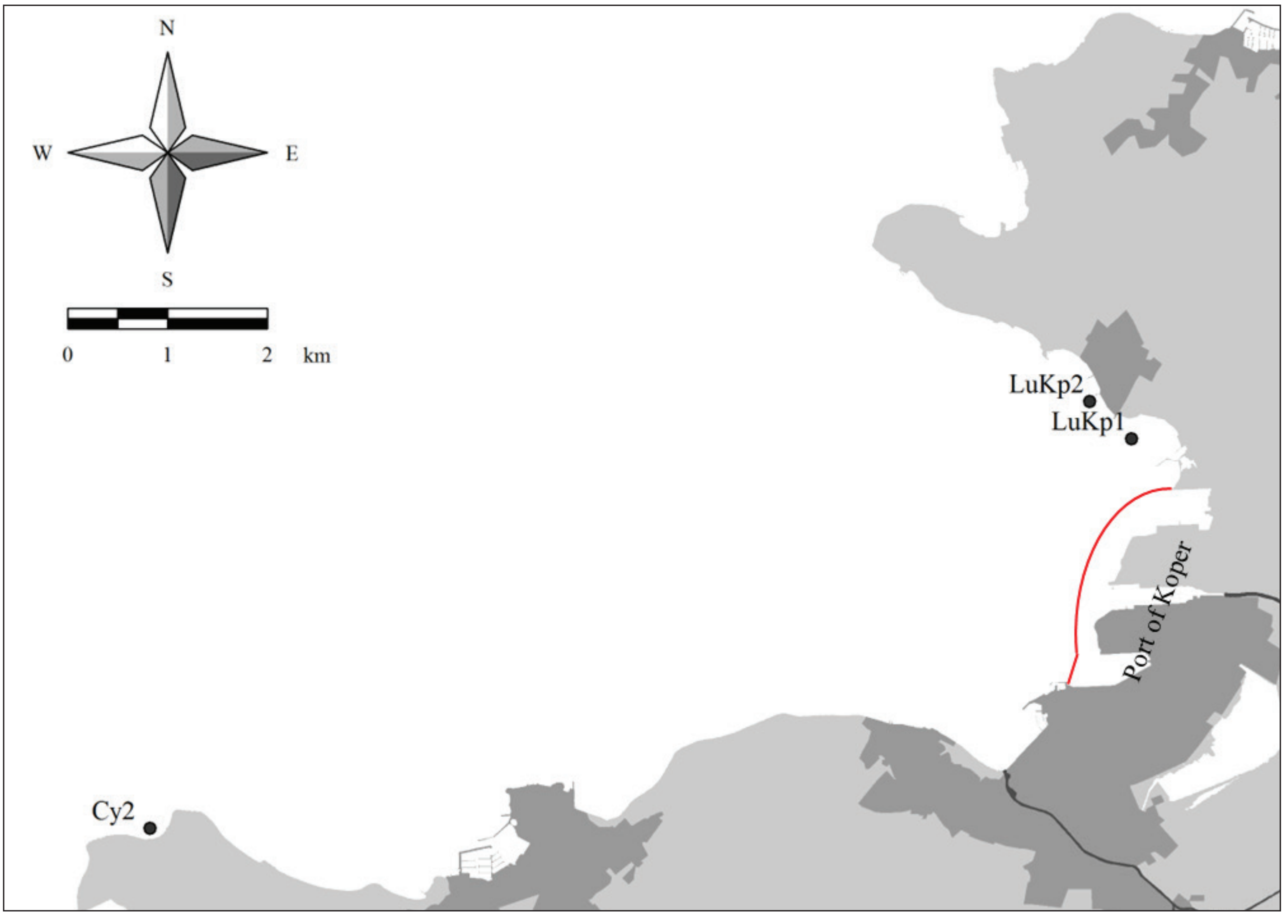

Fig. 1: Map of sampling sites for *Cymodocea nodosa* ***in Slovenian marine waters: near the Port of Koper (LuKp1 and LuKp2) and in the Moon Bay (St. Cross Bay, Cy2), within the Strunjan Nature Reserve. The redline indicate the water area of the Port of Koper.***

Sl. 1: Zemljevid vzorčnih lokalitet kolenčaste cimodoceje v slovenskem morju: ob Luki Koper (LuKp1 in LuKp2) in v Mesečevem zalivu (Zalivu Sv. Križa, Cy2), v Naravnem rezervatu Strunjan. Rdeča črta označuje akvatorij Luke Koper.

In July 2018 and July 2023, samples of *C. nodosa* were also collected in the Strunjan Nature Reserve (sampling site Cy2, areas Cy2_1 and Cy2_2). According to the low value of the Pressure Index for Seagrass Meadows (PISM), the area Cy2_1 was selected as the reference area for *C. nodosa* in the Gulf of Trieste (Orlando-Bonaca *et al.*, 2015).

The samples of *C. nodosa* were stored in a freezer at -20°C in the laboratory of the Marine Biology Station Piran. The day before the analysis, they were slowly defrosted in a refrigerator. The seagrass shoots were then stored in plastic wash basins with seawater. Twenty shoots from each quadrat were randomly selected (Orfanidis *et al.*, 2007). For each leaf (usually 5-6 leaves per shoot), the following parameters were measured to the nearest mm: length of the leaf sheath, length of the photosynthetic part and its width. The age of the leaf was designated as adult state (when the leaf sheath was well-developed), intermediate state (when the leaf sheath was weakly developed at the leaf base), and juvenile state (when the leaf sheath was absent). The above measurements were performed on at least 60 undamaged, photosynthetically active leaves (adult and/or intermediate) from each frame. One sample consisted of five replicates of 60 leaves (300 leaves in total).

Data analysis

Summary statistics were examined for each *C. nodosa* sampling area near the Port of Koper. To quantify changes in the photosynthetic part of the leaf length distribution, the MediSkew index was calculated (for details, see Orlando-Bonaca *et al.*, 2015). The boundaries among the status classes for the MediSkew index were set equidistantly (Tab. 1). Five status classes are sufficient for the assessment of the Ecological Status (ES)

Tab. 1: Boundaries among the status classes for the MediSkew index. Five classes should be used for the assessment of ES according to the WFD. For the assessment of EnS under the MSFD, the classes High and Good indicate a Good EnS, while the classes Moderate, Poor and Bad are considered Not Good EnS (see Orlando-Bonaca et al., 2015).

Tab. 1: Meje med posameznimi razredi stanja za MediSkew indeks. Za opredelitev ekološkega stanja po Evropski vodni direktivi (OVS) smo uporabili 5 razredov. Za opredelitev okoljskega stanja po Okvirni direktivi o morski strategiji (ODMS), razreda Zelo dobro in Dobro označujeta Dobro okoljsko stanje, medtem ko razredi Zmerno, Slabo in Zelo slabo opredeljujejo Slabo okoljsko stanje (po Orlando-Bonaca in sod., 2015).

Status classes	Absolute values of MediSKew
High	0 ≤ MediSKew < 0.2
Good	0.2 ≤ MediSKew < 0.4
Moderate	0.4 ≤ MediSKew < 0.6
Poor	0.6 ≤ MediSKew < 0.8
Bad	0.8 ≤ MediSKew ≤ 1

under the WFD. In addition, the classes High and Good indicate Good Environmental Status (EnS) according to the MSFD, while the classes Moderate, Poor and Bad are considered as Not Good EnS.

RESULTS AND DISCUSSION

The parameters of *C. nodosa* per sampling area are listed in Table 2. The data show that the mean and median leaf lengths at all four sampling areas near the Port of Koper were lower in 2023 than in 2022 and in all previous years for which data are available. At sampling areas LuKp1_1 and LuKp1_2, the maximum leaf length values in 2023 were also lower than in the previous year, while at sampling areas LuKp2_1 and LuKp2_2 they were similar to 2022.

The maximum leaf length, mean and median values at the reference area Cy2_1 were lower in 2023 than in 2018 (Tab. 2), confirming a High ecological status of *C. nodosa*. In both years, the leaves of *C. nodosa* in the areas within the reference site in the Moon Bay (Cy2) were significantly shorter than in the areas near the Port of Koper in all 5 sampling years, as were the median values (Tab. 2). However, there has been a clear trend towards decreasing leaf lengths near the Port of Koper since 2018 (Tab. 2).

All samples of *C. nodosa* near the Port of Koper had fewer damaged leaves in 2023 than in 2020 and 2021 (*pers. obs.*). In particular, at LuKp1_1 *C. nodosa* had so many broken leaves, without apical parts, in 2020 that it was not possible to measure 300 leaves per sampling area (Tab. 3), as stated in the methodology.

The ES (according to WFD) and EnS (according to MSFD) of the sampling areas and sites were assessed according to the boundaries in Table 1. The MediSkew index values for each sampled area near the Port of Koper and for areas Cy2_1 and Cy2_2 at the reference site Cy2 are presented in Table 3. The sampling site LuKp1, which is closest to the Port of Koper, improved the ES from Bad in 2018 to Poor in 2020, then Moderate in 2021 and 2022 to Good in 2023. At the sampling site LuKp2, which is furthest from the Port Basin III, the ES value improved from Poor in 2018 to Good in 2023, with a decrease to Moderate in 2022 (Tab. 3). These data also indicate that the negative impact on the *C. nodosa* meadow decreases with increasing distance from the Port, and that this impact can be observed and monitored within a radius of one kilometer from the port area. It should also be noted that the sampling sites are located away from the Port in the direction of the sea current, which flows counterclockwise in the northern Adriatic (Ogorelec *et al.*, 1991).

The ES of the entire meadow of *C. nodosa* near the Port of Koper was evaluated as Bad in 2018, while it achieved a Good ES in 2021 and 2023 (Tab. 3).

The results obtained from 2018 to 2023 show a significant improvement in the ES of the *C. nodosa* meadow. The Good ES in 2021 and 2023 could be related to the reduction of local anthropogenic pressures, such as construction works within the harbour area, dredging and maritime traffic, which play a key role in the regression of seagrass meadows (Orfanidis *et al.*, 2020; Salinas *et al.*, 2020; Stockbridge *et al.*, 2020). Such pressures lead to increased sediment resuspension, resulting in higher turbidity and consequently less light for the light-limited seagrasses (Touchette & Burkholder, 2000). Marine plants react to low light conditions by increasing the distribution of their biomass on their leaves. By enlarging the leaves, they can capture more light and convert it into photosynthetic production (Greve & Binzer, 2004). Since the construction works for the new RO-RO berth in Basin III were completed in March 2020 (Luka Koper, 2020a) and other construction works interfering with the seabed were not carried out later (Luka Koper, 2023), most of the sediment resuspension is probably due to ship traffic, which mainly occurs when entering and leaving the Port by manoeuvring

Tab. 2: Statistical parameters (minimum, maximum, mean, median) and absolute value of the skewness (|G|) of the ln-transformed lengths of the photosynthetically active parts of the leaves of* Cymodocea nodosa *from the sampling areas near the Port of Koper (LuKp1 and LuKp2) in 2018, 2020–2023, and in the Moon Bay (St. Cross Bay, Cy2, Strunjan Nature Reserve) in 2018 and 2023. The reference median value in 2023 was 10.95 cm.
Tab. 2: Statistični parametri (minimum, maksimum, povprečje, mediana) in absolutna vrednost koeficienta asimetrije (|G|) ln-transformiranih dolžin fotosintetsko aktivnega dela listov kolenčaste cimodoceje na točkah vzorčenja blizu Luke Koper (LuKp1 in LuKp2) v 2018, 2020–2023 ter v Mesečevem zalivu (Zalivu Sv. Križa, Cy2, Naravni rezervat Strunjan) v 2018 in 2023. Referenčna mediana v 2023 je bila 10,95 cm.

Area	Date	Min length (cm)	Max length (cm)	Mean (cm)	Median (cm)	|G|
Cy2_1	12.7.2018	5.4	30.5	14.5	**13.95**	0.261
Cy2_2	12.7.2018	8.1	22.7	13.5	13.20	0.022
LuKp1_1	17.7.2018	5.9	66.2	37.8	41.25	1.423
LuKp1_2	17.7.2018	6.0	57.1	34.7	37.05	1.162
LuKp2_1	17.7.2018	3.7	58.8	30.7	30.45	1.533
LuKp2_2	17.7.2018	6.9	52.2	27.3	28.25	1.130
LuKp1_1	14.7.2020	5.4	62.5	32.0	31.90	1.044
LuKp1_2	14.7.2020	7.4	57.7	29.9	29.25	0.706
LuKp2_1	14.7.2020	5.1	61.3	29.2	28.90	0.979
LuKp2_2	14.7.2020	7.3	55.9	31.4	31.25	0.955
LuKp1_1	1.7.2021	8.7	55.8	27.3	25.90	0.355
LuKp1_2	1.7.2021	7.3	57.1	28.1	27.20	0.442
LuKp2_1	1.7.2021	11.5	47.7	24.7	22.95	0.142
LuKp2_2	1.7.2021	5.7	46.2	24.2	23.15	0.659
LuKp1_1	11.7.2022	9.1	57.1	30.7	30.45	0.762
LuKp1_2	11.7.2022	9.8	42.3	27.1	27.40	0.675
LuKp2_1	11.7.2022	9.0	42.4	26.7	26.80	0.738
LuKp2_2	11.7.2022	6.4	45.1	26.0	24.95	0.461
Cy2_1	12.7.2023	5.1	20.4	11.0	**10.95**	0.347
Cy2_2	12.7.2023	3.5	19.5	11.7	11.80	0.497
LuKp1_1	5.7.2023	6.6	39.8	21.1	20.60	0.397
LuKp1_2	5.7.2023	6.7	38.3	21.9	21.60	0.731
LuKp2_1	5.7.2023	5.2	45.7	21.1	20.15	0.382
LuKp2_2	5.7.2023	8.5	46.4	22.2	21.35	0.391

Tab. 3: MediSkew index values for the sampling areas of* Cymodocea nodosa *in the Port of Koper and assessment of the Ecological Status (according to WFD) and Environmental Status (according to MSFD).
Tab. 3: Vrednosti indeksa MediSkew na točkah vzorčenja s kolenčasto cimodocejo in opredelitev ekološkega stanja (glede na OVS) in okoljskega stanja (glede na ODMS) za travnik ob Luki Koper.

Year	Area	Area's MediSkew	Site's MediSkew	Meadow's MediSkew	Ecolog. Status	Environ. Status	N of leaves	N of adult leaves
2018	Cy2_1	**0.065**	**0.04**		**High**	Good / Achieved	300	112
	Cy2_2	**0.024**					300	123
	LuKp1_1	**1.00**	**0.935**	**0.825**	**Bad**	Not good / Not achieved	300	225
	LuKp1_2	**0.87**					300	204
	LuKp2_1	**0.79**	**0.715**				300	247
	LuKp2_2	**0.64**					300	218
2020	LuKp1_1	**0.71**	**0.635**	**0.640**	**Poor**	Not good / Not achieved	**251**	181
	LuKp1_2	**0.56**					300	223
	LuKp2_1	**0.62**	**0.645**				300	246
	LuKp2_2	**0.67**					300	222
2021	LuKp1_1	**0.39**	**0.415**	**0.37**	**Good**	Good / Achieved	300	238
	LuKp1_2	**0.44**					300	207
	LuKp2_1	**0.26**	**0.325**				300	231
	LuKp2_2	**0.39**					300	212
2022	LuKp1_1	**0.60**	**0.550**	**0.50**	**Moderate**	Not good / Not achieved	300	279
	LuKp1_2	**0.50**					300	286
	LuKp2_1	**0.51**	**0.450**				300	276
	LuKp2_2	**0.39**					300	269
2023	Cy2_1	**0.087**	**0,12**		**High**	Good / Achieved	300	177
	Cy2_2	**0.146**					300	186
	LuKp1_1	**0.34**	**0.395**	**0.37**	**Good**	Good / Achieved	300	232
	LuKp1_2	**0.45**					300	223
	LuKp2_1	**0.33**	**0.342**				300	263
	LuKp2_2	**0.36**					300	272

with tugboats (*pers. obs.*). The data in Table 4 (Luka Koper, 2020b, 2023, 2024) show that the number of ships in the Port of Koper decreased from 1,899 ships in 2018 to 1,433 in 2020 (24.5%) due to the Covid-19 pandemic. The number of ships in the Port then increased until 2022 and then fell slightly in 2023. This means that the number of ships decreased by 13.5% in 2023 compared to 2018. These data hypothesize that the reduction in the number of ships arriving at the Port could have a positive impact on improving the condition of the nearby *C. nodosa* meadow.

In addition, climate change has been a growing concern in recent years, as sea level rise and rising seawater temperatures may further contribute to the decline of seagrass beds (Duarte *et al.*, 2018;

Tab. 4: The number of ships arriving in the Port of Koper for the period 2018 to 2023 (data from Luka Koper, 2020b, 2023, 2024).
Tab. 4: Število ladij, ki so vplule v Luko Koper v obdobju od 2018 do 2023.

Year	Number of ships
2018	1.899
2019	1.664
2020	1.433
2021	1.551
2022	1.659
2023	1.642

Fortes *et al*., 2018; Tsioli *et al*., 2022; Llabrés *et al*., 2023). The Mediterranean Sea is warming three times faster than the oceans (Savva *et al*., 2018) because it is a more enclosed sea. Moreover, the northern Adriatic was hit by a severe heatwave in 2023. The temperature of the surface layers of the sea in the Gulf of Trieste exceeded 30 °C in summer, which has only been measured twice in the past. In addition, the seawater temperature on the seabed exceeded 24 °C, 1 °C higher than at any time in the last 20 years (data from the oceanographic buoy VIDA, https://www.nib.si/mbp/en/oceanographic-data-and-measurements). This places a great pressure on the organisms living on the seabed, which are unable to move. According to Savva *et al.* (2018), *C. nodosa* meadows have a higher tolerance to heat waves than *Posidonia oceanica* meadows, which is probably due to the tropical origin of the genus *Cymodocea*.

Ocean acidification (Repolho et al., 2017) and infections by protists of the genus *Labyrinthula* (Olsen & Duarte, 2015) are also already having a lasting impact on seagrass meadows in other parts of the Mediterranean. Considering all the aforementioned pressures on such ecosystems, the results of a recent study focusing on the dynamics of seagrass meadows along the Slovenian coastline (Ivajnšič *et al.*, 2022) are of great importance. The temporal perspective showed a stable cover of seagrass meadows in the study area (282.4 ha in 2014 and 283.5 ha in 2020). However, the spatial perspective showed a different development of the current extent of seagrass meadows. In some areas, *C. nodosa* meadows has almost completely disappeared (marine area of the Strunjan Landscape Park), while in other areas along the Slovenian coast it has been re-established (Ivajnšič *et al.*, 2022).

The results of the present study indicate a positive trend in the ES of the *C. nodosa* meadow near Koper. Since the Port authority has planned a long-term monitoring programme in the harbour area and its surroundings, we recommend that in addition to the assessment of the ES with the MediSkew index, the distribution of the meadow (in terms of cover) and the detection of possible signs of disease on the leaves of *C. nodosa* should also be evaluated.

ACKNOWLEDGEMENTS

The authors are grateful to the Port of Koper for financially supporting this study. We would also like to thank Lovrenc Lipej, Milijan Šiško, Tihomir Makovec, Borut Mavrič, Leon Lojze Zamuda, Aljoša Gračner, Matej Marinac and Tristan Bartole for their help with the field and laboratory work. Special thanks are due to Milijan Šiško for the preparation of Figure 1.

PETLETNO SPREMLJANJE EKOLOŠKEGA STANJA TRAVNIKA KOLENČASTE CIMODOCEJE (*CYMODOCEA NODOSA*) V BLIŽINI KOPRSKEGA PRISTANIŠČA

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POVZETEK

Morski travniki so med najbolj produktivnimi ekosistemi v morskih okoljih po vsem svetu in pogosto veljajo za simbol skoraj čistih razmer na sedimentnem dnu, vendar je njihovo stanje povezano z različnimi antropogenimi pritiski. V Sredozemskem morju velja kolenčasta cimodoceja (Cymodocea nodosa) *za učinkovit kazalnik okoljskih sprememb zaradi svoje univerzalne razširjenosti, občutljivosti na različne naravne in antropogene pritiske ter merljivosti odzivov vrste na te vplive. Namen te študije je predstaviti izboljšanje ekološkega stanja travnika kolenčaste cimodoceje v bližini koprskega pristanišča v obdobju petih let in te rezultate primerjati z referenčnim območjem v severnem Jadranu.*

Ključne besede: *Cymodocea nodosa,* MediSkew indeks, Luka Koper, ocena stanja, severni Jadran

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IN MEMORIAM

IN MEMORIAM

THOMAS CHARLTON MALONE
(7. september 1943 – 24. februar 2024)

Pretresla nas je novica, da je po padcu na domu nepričakovano umrl Thomas Charlton Malone ("Tom"), zaslužni profesor na Univerzi Maryland v ZDA (University of Maryland, Center for Environmental Sciences – UMCES).

Dodiplomski študij zoologije je opravil na Colorado College, kjer je diplomiral leta 1965, na Havajih (University of Hawaii) pa je leta 1967 magistriral iz oceanografije. Rad se je potapljal, v srednji šoli je blestel v vaterpolu, vendar ga je ljubezen do oceanov pripeljala do kariere oceanografa. Doktorski študij je opravljal na morski postaji stanfordske univerze (Hopkins Marine Station, Monterey, Kalifornija) in se udeležil številnih raziskovalnih križarjenj v vzhodnem delu Tihega oceana. Leta 1971 je doktoriral iz biologije na Univerzi Stanford.

Po doktoratu je nekaj časa raziskoval in predaval na City College, New York, nato je kariero nadaljeval na Univerzi Columbia (Lamont Doherty Geological Observatory and Department of Energy and Environment, Brookhaven National Laboratory). Leta 1982 se je zaposlil v laboratoriju Horn Point Univerze v Marylandu, kjer je kmalu napredoval v rednega profesorja. Izvoljen je bil za predsednika fakultetnega senata Centra za okoljske študije (UMCES) in bil njegov direktor do leta 2001. Kasneje je deloval kot direktor Urada za stalno in integrirano opazovanje oceanov (Interagency Ocean.US Office for Sustained and Integrated Ocean Observations). Predsedoval je mnogim znanstvenim odborom, med drugimi je bil predsednik odbora Združenih narodov za obalne opazovalne sisteme (UN Coastal Ocean Observations Panel) in predsednik združenja za limnologijo in oceanografijo ASLO (Association for the Sciences of Limnology and Oceanography).

Po upokojitvi leta 2010 je Tom nadaljeval z objavljanjem znanstvenih člankov, urejanjem knjig in delom v različnih znanstvenih odborih. Imel je veliko vabljenih predavanj o različnih temah po vsem svetu, od škodljivega cvetenja alg do govora o podnebnih spremembah ter potrebah po znanju in opazovalnih sistemih za morja na 3. svetovni podnebni konferenci v Ženevi.

Tomovi znanstveni interesi so bili široki: od dinamike ekosistemov, ekologije fitoplanktona, obalne evtrofikacije, podnebnih sprememb, sistemov za opazovanje do politike oceanov. Njegove raziskave so bile osredotočene na fitoplankton, fotosintetske organizme, ki sestavljajo osnovo morske prehranjevalne mreže, veliko se je ukvarjal s prekomerno obogatitvijo obalnih morij s hranili in njenimi posledicami ter z morskimi opazovalnimi sistemi.

Z njim sem se spoznala leta 1992, ko je prvič obiskal Slovenijo kot član ameriške delegacije, ki je na njegovo pobudo obiskala tudi Morsko biološko postajo. Na njegov predlog smo z ameriško finančno podporo leta 1995 organizirali konferenco 'Trends in Land-Use, Water Quality and Fisheries: A Comparison of the Northern Adriatic Sea and the Chesapeake Bay', katere rezultat je bila tudi objava knjige *Ecosystems at the Land--Sea Margin* leta 1999. Njegovim prizadevanjem gre pripisati tudi organizacijo nekaj naslednjih delavnic, na katerih smo se srečevali ameriški in

severnojadranski raziskovalci (Trst, oktobra 1998, Rovinj, oktobra 1999, in Gradež, novembra 2001). Ta srečanja so postavila temelje za mnoga večletna vsebinska sodelovanja na področjih raziskav sluzi, želatinastega planktona, mikrobne ekologije, fizikalne oceanografije in razvoja opazovalnih sistemov. Ko se je bližala dvajsetletnica objave knjige *Ecosystems at the Land-Sea Margin*, pa je vzniknila zamisel, da bi ponovno pregledali rezultate raziskav v tem obdobju in objavili knjigo, ki bi predstavila razmere v severnem Jadranu in zalivu Chesapeake dvajset let kasneje. In ponovno je bil Tom motor vseh dejavnosti, te so končno pripeljale do priprave knjige *Coastal Ecosystems in Transition. A Comparative Analysis of the Northern Adriatic and Chesapeake Bay*, ki je leta 2021 izšla pri ugledni založbi Wiley.

Tom je bil eden vodilnih svetovnih znanstvenikov na področju raziskav morja, z njim je naš inštitut (NIB-MBP) sodeloval že od zgodnjih devetdesetih let in ponosna sem na skupno delo, objave, zlasti pa na dve knjigi, ki sta izšli pri odličnih tujih založbah. Vedno sem občudovala njegovo navdušenje in raziskovalno delo, bil je eden tistih znanstvenikov, zaradi katerih je znanost res pomembna. Težko je opisati razsežnosti njegove osebnosti, bil je sanjač in hkrati vernik znanosti, ki mu za doseganje zastavljenih raziskovalnih ciljev ni bilo težko žrtvovati neštetih ur dela. Zagotovo si bomo zapomnili tudi njegovo neomajno pozitivno naravnanost, tudi v težkih časih.

Bil je med redkimi, ki so znali odlično uporabljati znanstveno diplomacijo, kar se je pokazalo zlasti v zadnjem obdobju njegovega delovanja. Gotovo je njegova pomembna zapuščina ustvarjanje mreže ljudi iz različnih držav in okolij, ki je presegala raziskovalne projekte in kratkoročno znanstveno sodelovanje. Vedno se bom spominjala tudi njegovih prijateljskih nasvetov in pozitivnega odnosa do ljudi. In prepričana sem, da ga ne bo zelo pogrešala le njegova družina, temveč tudi mnogi raziskovalci, ki smo se na znanstvenoraziskovalni poti srečali z njim.

Alenka Malej
nekdanja vodja Morske biološke postaje Piran (NIB)

KAZALO K SLIKAM NA OVITKU

SLIKA NA NASLOVNICI: Plamenka (*Pterois miles*) se je pred leti pojavila tudi v Jadranskem morju. Ta tujerodna tropska vrsta, ki velja za eno izmed najbolj invazivnih rib, izvira iz Rdečega morja in se je v Sredozemskem morju prvič pojavila leta 1991. Na fotografiji je njej sorodna vrsta *Pterois volitans*, ki je prav tako invazivna (Foto: B. Mavrič)

Sl. 1: Polži zaškrgarji so pomembni bioindikatorji odzivov, povezanih s segrevanjem vodnih mas, podnebnimi spremembami, onesnaževanjem in izgubo habitatov. Poleg tega so dragocen vir bioaktivnih spojin, uporabnih v medicini. Na sliki vrsta *Diaphorodoris papillata*. (Foto: B. Mavrič)

Sl. 2: Zebrasta babica (*Salaria basilisca*) je ena od večjih in pisanih vrst sredozemskih babic. O tej vrsti z značilnim barvnim vzorcem je razmeroma malo znanega, za Jadransko morje pa ni povsem jasno, ali v njem živi. (Foto: F. Tiralongo)

Sl. 3: Zlati cipelj (*Chelon auratus*) je morska riba, ki pogosto obiskuje sladkovodna in brakična življenjska okolja. Pojavlja se v jatah, ki zaidejo tudi v lagune in estuarije. (Foto: L. Lipej)

Sl. 4: Povezovanje in sodelovanje z rekreativnimi potapljači in podvodnimi fotografi v raziskovanju morja je v zadnjih desetletjih izjemno prispevalo k boljšemu poznavanju polžev zaškrgarjev v Sredozemlju. Na sliki polž vrste *Cratena peregrina*, ki se prehranjuje na kolonijskih trdoživnjakih. (Foto: T. Makovec)

Sl. 5: Veliko morsko šilo (*Syngnathus acus*) je sorodnik morskih konjičkov. Običajno ga najdemo v plitvinah skalnatega dna, pojavlja pa se tudi v morskih travnikih in estuarijih. Za njegovo vrsto je značilno, da samec nosi jajca v zarodni vreči pod repom. (Foto: L. Lipej)

Sl. 6: Nekateri strokovnjaki menijo, da so morski travniki po pomenu enakovredni tropskim deževnim gozdovom in da je zato treba njihovemu ohranjanju posvetiti posebno pozornost. V zadnjem desetletju se s krčenjem morskih travnikov soočamo tudi že v slovenskem delu Jadranskega morja. Na sliki morski travnik pozejdonke (*Posidonia oceanica*). (Foto: T. Makovec)

INDEX TO PICTURES ON THE COVER

FRONT COVER: A few years ago, the lionfish (*Pterois miles*) also appeared in the Adriatic Sea. This non-indigenous tropical fish, considered one of the most invasive fish species and originating from the Red Sea, made its first appearance in the Mediterranean in 1991. The species shown here is its closely related cousin *Pterois volitans*, which is also invasive. (Photo: B. Mavrič)

Fig. 1: Heterobranch gastropods are important bioindicators for assessing ecosystem responses to water mass warming, climate change, pollution, and habitat loss. They also serve as a valuable source of bioactive compounds used in medicine. Here depicted is *Diaphorodoris papillata*. (Photo: B. Mavrič)

Fig. 2: The basilisk blenny (*Salaria basilisca*) is one of the larger and more colourful Mediterranean blennies. Not much is known about this species, which is distinguished by a unique colour pattern, and it is still unclear whether it inhabits the Adriatic Sea. (Photo: F. Tiralongo)

Fig. 3: The golden grey mullet (*Chelon auratus*) is a marine fish species that also frequents freshwaters and brackish environments. It forms schools that enter lagoons and estuaries as well. (Photo: L. Lipej)

Fig. 4: The participation and cooperation of recreational divers in marine research over the past few decades has significantly enhanced our knowledge of heterobranch fauna in the Mediterranean Sea. The image shows a nudibranch grazing on colonial hydroids. (Photo: T. Makovec)

Fig. 5: The greater pipefish (*Syngnathus acus*) is closely related to sea-horses and is typically found in shallow rocky bottoms, although it can also occur in seagrass meadows and estuaries. The male of this pipefish carries the eggs in a brood pouch located under its tail. (Photo: L. Lipej)

Fig. 6: Some experts argue that seagrass meadows are equivalent in significance to tropical rainforests and, as such, deserve special attention for conservation. Over the past decade, we have witnessed the shrinking of seagrass meadows in the Slovenian part of the Adriatic Sea as well. The image depicts a seagrass meadow of *Posidonia oceanica*. (Photo: T. Makovec)

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