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NEW DATA ON THE OCCURRENCE OF TWO LESSEPSIAN MARINE HETEROBRANCHS, *PLOCAMOPHERUS OCELLATUS* (NUDIBRANCHIA: POLYCERIDAE) AND *LAMPROHAMINOEA OVALIS* (CEPHALASPIDEA: HAMINOEIDAE), FROM THE AEGEAN SEA

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ABSTRACT

The authors have recently collected two Lessepsian heterobranchs from Turkey, namely Plocamopherus ocellatus *Rüppell & Leuckart, 1828 and* Lamprohaminoea ovalis *(Pease, 1868), both of which were found significantly out of their known distribution ranges. The single individual of* P. ocellatus *collected at Akbük Cove is a new addition to the Aegean Sea malacofauna, while several individuals of* L. ovalis *observed from the Ayvalık Islands Nature Park and Saros Bay represent the northernmost occurrence limit of the species. Present findings suggest that* P. ocellatus *is currently a casual alien species in the region, while* L. ovalis *has established a breeding population in the northern Aegean Sea.*

Key words: Aegean Sea, Lessepsian species, Heterobranchia

NUOVI DATI SULLA PRESENZA DI DUE ETEROBRANCHI MARINI LESSEPSIANI, *PLOCAMOPHERUS OCELLATUS* (NUDIBRANCHIA: POLYCERIDAE) E *LAMPROHAMINOEA OVALIS* (CEPHALASPIDEA: HAMINOEIDAE) NEL MAR EGEO

SINTESI

Gli autori hanno recentemente raccolto in Turchia due eterobranchi lessepsiani, ovvero Plocamopherus ocellatus *Rüppell & Leuckart, 1828* e Lamprohaminoea ovalis *(Pease, 1868), entrambi trovati significativamente al di fuori dei loro areali di distribuzione noti. Il singolo individuo di* P. ocellatus *trovato ad Akbük Cove è una nuova aggiunta alla malacofauna dell'Egeo, mentre diversi individui di* L. ovalis *osservati nel Parco Naturale delle Isole Ayvalık e nella Baia di Saros rappresentano il limite più settentrionale di presenza della specie. I risultati attuali suggeriscono che* P. ocellatus *sia una specie aliena attualmente casuale nella regione, mentre* L. ovalis *abbia stabilito una popolazione riproduttiva nell'Egeo settentrionale.*

Parole chiave: Egeo, specie lessepsiane, Heterobranchia

INTRODUCTION

Considering the quantitative occurrence of alien species in the Mediterranean Sea, Turkey can be placed in the centre of marine bioinvasions. Alien species diversity has increased almost twofold since 2005, currently reaching well over 500 species, which represents an immense biodiversity change (Çinar *et al.*, 2005; 2021). The Levantine shores of Turkey are typically liable to a heavier invasion impact due to the proximity to the Suez Canal, but a considerable number of thermophilic alien species have also penetrated the Aegean Sea, primarily as a result of the fast warming of surface waters (Katsanevakis *et al.*, 2020). While the number of documented occurrences of alien taxa has increased by 25.2% in the northern Levant over the past decade, the corresponding diversity in the Aegean Sea denotes a drastic rise of 53.3% (from 165 to 253 species) (Çinar *et al.*, 2011; 2021). The prominent evolution of Aegean Sea biota certainly requires an in-depth analysis of the impact of biological invasions and greater research effort, in which close monitoring of new species introductions is of utmost importance.

In this paper, we present novel information on the distribution of two Lessepsian marine heterobranchs from the Aegean coasts of Turkey. One of them, *Plocamopherus ocellatus* Rüppell & Leuckart, 1828, is a nudibranch native to the Red Sea and the Arabian Gulf, which penetrated the Mediterranean Sea by way of the Suez Canal during the late 1970s (Rothman & Galil, 2015). Almost two decades after its first record

Fig. 1. Capture and observation localities of the two Lessepsian heterobranchs from the Aegean Sea. 1) *Plocamopherus ocellatus* ***(Akbük Cove), 2)*** *Lamprohaminoea ovalis* ***(Ayvalık Islands Nature Park), 3)*** *L. ovalis* ***(Saros Bay).***
Sl. 1: Lokalitete, kjer sta bili lesepski vrsti ujeti in opazovani v Egejskem morju. 1) *Plocamopherus ocellatus* ***(zaliv Akbük), 2)*** *Lamprohaminoea ovalis* ***(naravni park v okviru otočja Ayvalık), 3)*** *L. ovalis* ***(zaliv Saros).***

from the Israeli coast (Barash & Danin, 1982), in 1998, the species was encountered by underwater photographers at Kaş (Antalya Bay, Turkey) (Rudman, 2002; Yokeş & Rudman, 2004), with further reports following from Lebanon and Cyprus (Valdés & Templado, 2002; Crocetta *et al*., 2013; Hoeksema & Yonov, 2021) and hereby for the first time from the Aegean Sea. The other species, *Lamprohaminoea ovalis* (Pease, 1868), is a cephalaspid of Indo-West Pacific origin. Its occurrence records from the Mediterranean Sea, dating to the early 2000s (as *Haminoea cyanomarginata*), are based on underwater photographs taken almost synchronously in the Gulf of Corinth (Greece), and in the Çeşme Peninsula and Antalya Bay (Turkey) (Rudman, 2003; Yokeş & Rudman, 2004). During the last two decades, the species has been reported from Cyprus, Croatia, Italy, Malta, Libya, and Spain (Lombardo & Marletta, 2021), and can be currently observed in Ayvalık Islands Nature Park and Saros Bay, showing a significant northern range expansion.

MATERIAL AND METHODS

On 24 October 2021, a single individual of *P. ocellatus* (80 mm in length) was collected from Akbük Cove (37.413782°N, 27.411052°E, Fig. 1, site 1) located along the southern Aegean Sea coast of Turkey. The specimen was found on a small rock over a sandy/muddy bottom, amid patches of *Cymodocea nodosa* (Ucria) Asch. just below the water surface (about 30 cm in depth). It was collected by hand, fixed later in 70% alcohol and preserved in AMBRD Laboratories for further analysis. Identification of the species was made according to descriptions given by Rudman (2002), Zenetos *et al*. (2004) and Rothman & Galil (2015).

During field excursions carried out at the Ayvalık Islands Nature Park (consisting of 19 islands of different dimensions), we were able to collect a total of eight *L. ovalis* during daytime scuba dives from Gunes Island (39.325855°N, 26.543048°E; 3 individuals; 8 April 2021; 4–5 m depth range), Alibey Island (39.386142°N, 26.646606°E; 3 individuals; 9 September 2021; 25–30 m depth range) and Ciplak Island (39.276091°N, 26.581306°E; 2 individuals; 9 December 2021; 5–10 m depth range) (Fig. 1, site 2). *Lamprohaminoea ovalis* was sampled exclusively at rocky substrates mostly covered by filamentous algae. In addition, several underwater photographs of six different *L. ovalis* individuals were taken on 27 October 2019 by a scuba diver in the vicinity of Kömür Harbor located in Saros Bay, northeastern Aegean Sea (40.458241°N, 26.511067°E; Fig. 1, site 3). The photographs were taken at a very shallow depth (1 to 2 m) over algae-covered rocks. Identification of the species was made according to Zenetos *et al*. (2004) and Oskars & Malaquias (2020).

RESULTS AND DISCUSSION

The sampled *P. ocellatus* individual (Fig. 2) had an elongated body, convex dorsum, branched appendages on the oral veil, small and ramified papillae along the mantle edge, lamellate rhinophores, a prominent keel in the posterior dorsal midline, and three pairs of laterodorsal processes, which are characteristic features of the species (Rudman, 2002; Zenetos *et al*., 2004). Body colour was brownish mauve with unevenly spread yellow spots of different sizes and shapes (some bearing dark-coloured flecks in the centre), in accordance with the description by Rothman & Galil (2015). Although previously believed to be a rare species, a total of 23 observations are available from 16 different localities throughout the eastern Levant, with Kaş shores off the Turkish coastline representing the westernmost occurrence limit (Hoeksema & Yonov, 2021). Until now, *P. ocellatus* has not been documented from the Aegean Sea and we report herein a significant northward range expansion of the species by more than 200 nautical miles from Kaş. The source and introduced population of *P. ocellatus* have been reported from a variety of depths (1.5–50 m) and habitat types (shipwrecks, rocks, mud, cave, marina wall, rock pool, etc.) (Hoeksema & Yonov, 2021). The present observation fits well with previous habitat descriptions, whereas the depth appears to be the shallowest hitherto recorded. The sampling site was examined thoroughly but neither an additional individual nor an egg capsule attached to hard substrates was found, so the recent observation indicates *P. ocellatus* to be a casual species in the Aegean Sea.

The Aegean Sea individuals of *Lamprohaminoea ovalis* were characterized by the combination of purple or dark blue-bordered mantle, white body, a large bluish spot separating the narrowly spaced eyes, and deeply bifurcated cephalic shield (Fig. 3), in accordance with Zenetos *et al*. (2004). The observed coloration fits the purple morph definition of Oskars & Malaquias (2020) and some individuals also bear vivid yellow round blotches along the body. In the Mediterranean Sea, the species has been observed both in the daytime and at night, from very shallow depths of 30 cm to as deep as 30 m on rocky surfaces covered by algae (Rudman, 2003; Zenetos *et al*., 2004; Rizgalla *et al*., 2018), which is consistent with our observations. The species is widely recorded in Mediterranean coastal ecosystems as one of the most invasive molluscans known (Lombardo & Marletta, 2021). In Turkey, *L. ovalis* has been intensively collected from all Levantine shores (except Iskenderun Bay) and the whole southern Aegean Sea from Gökova Bay to the Çeşme Peninsula (Yokeş & Rudman, 2004; Yokeş *et al*., 2012). The recent findings from the Ayvalık Islands and Saros Bay considerably extend the distribution of *L. ovalis* northwards, by 50 and 100 nautical miles, respectively. This region was subjected to intense marine bio-

Fig. 2. The sampled individual of *Plocamopherus ocellatus* ***from Akbük Cove, Aegean Sea. (Photo: M. Bilecenoğlu).***
Sl. 2: Vzorčeni primerek vrste *Plocamopherus ocellatus* ***iz zaliva Akbük, Egejsko morje (Foto: M. Bilecenoğlu).***

Fig. 3. *Lamprohaminoea ovalis* ***individuals observed at a depth of 2 m in Saros Bay, northern Aegean Sea, displaying trailing behaviour. (Photo: O. Temizel).***
Sl. 3: Sprevod primerkov vrste *Lamprohaminoea ovalis****, opazovanih na globini 2 m v zalivu Saros, severno Egejsko morje (Foto: O. Temizel).***

diversity research a decade ago (Yokeş *et al*., 2013) and *L. ovalis* was almost certainly absent at the time, thus we may assume that the northern Aegean Sea occurrence of the species is a recent event. *Lamprohaminoea ovalis* displays a common mating ceremony involving unique trailing behaviour (M.B. Yokeş in Rudman, 2003) that we were able to observe both in the Ayvalık Islands and Saros Bay (Fig. 3). Based on this finding, we assume that the recently observed *L. ovalis* has established a breeding population in the northern Aegean Sea, but to determine whether an invasion process is underway at the moment or not, further focused underwater research is required.

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NOVI PODATKI O POJAVLJANJU DVEH LESEPSKIH MORSKIH POLŽEV ZAŠKRGARJEV, *PLOCAMOPHERUS OCELLATUS* (NUDIBRANCHIA: POLYCERIDAE) IN *LAMPROHAMINOEA OVALIS* (CEPHALASPIDEA: HAMINOEIDAE), IZ EGEJSKEGA MORJA

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POVZETEK

Avtorja sta pred kratkim v Turčiji našla dva lesepska polža zaškrgarja, in sicer vrsti Plocamopherus ocellatus *Rüppell & Leuckart, 1828 in* Lamprohaminoea ovalis *(Pease, 1868). Vrsti sta bili najdeni povsem izven njunega znanega areala. Primerek vrste* P. ocellatus*, nabran v zalivu Akbük, predstavlja prvo najdbo za malakofavno Egejskega morja, medtem ko številni primerki vrste* L. ovalis *iz naravnega parka v okviru otočja Ayvalık in v zalivu Saros, predstavljajo najsevernejšo mejo razširjenosti vrste. Na podlagi najdb lahko sklepamo, da je* P. ocellatus *v regiji naključna tujerodna vrsta, medtem ko se vrsta* L. ovalis *v severnem Egejskem morju razmnožuje.*

Ključne besede: Egejsko morje, lesepske selivke, Heterobranchia

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ADDITIONAL CAPTURE OF *HALOSAURUS OVENII* (ACTINOPTERYGII: NOTACANTHIFORMES: HALOSAURIDAE) IN ITALIAN WATERS

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ABSTRACT

A single specimen of Halosaurus ovenii *Johnson, 1864 was collected in 2013 in the Tyrrhenian Sea, western Mediterranean. The finding contributes to the knowledge on the geographical distribution of this rare species in the whole basin. The occurrence of* H. ovenii *is reported for the fifth time in the Mediterranean and for the third in the Italian waters.*

Key words: Halosauridae, rare species, deep waters, Mediterranean Sea

NUOVA CATTURA DI *HALOSAURUS OVENII* (ACTINOPTERYGII: NOTACANTHIFORMES: HALOSAURIDAE) IN ACQUE ITALIANE

SINTESI

Viene segnalato il ritrovamento nel 2013 di un esemplare di Halosaurus ovenii *Johnson, 1864 nelle acque del mar Tirreno, Mediterraneo occidentale, contribuendo alla conoscenza della distribuzione geografica di questa specie rara in tutto il bacino. Si tratta della quinta segnalazione di* H. ovenii *per il Mediterraneo e della terza per le acque italiane.*

Parole chiave: Halosauridae, specie rara, acque profonde, mar Mediterraneo

INTRODUCTION

The family Halosauridae contains 16 species worldwide divided in three genera, *Halosaurus* Johnson, 1863; *Halosauropsis* Collett, 1896 and *Aldrovandia* Goode & Bean, 1896 (Bañón *et al.*, 2016; Froese & Pauly, 2020). Four species in the genus *Halosaurus* occur in the eastern Atlantic: *Halosaurus ovenii* Johnson, 1864, *H. johnsonianus* Vaillant, 1888, *H. guentheri* Goode and Bean, 1896 and *H. attenuatus* Garman, 1899 (Sulak, 1990; Smith, 2016).

Oven's Halosaur (*H. ovenii*) is benthopelagic at depths ranging from 200 to 2800 m, but usually less than 800 m (D'Onghia *et al.*, 2004; Pais *et al.*, 2009; Bañón *et al.*, 2016), and feeds on polychaetes, sipunculids, crustaceans and fish (Froese & Pauly, 2020). This fish occurs on both sides of the Atlantic and in the Mediterranean Sea. In the eastern Atlantic it occurs in the south of Ireland, Gulf of Biscay, Spain, Portugal, Madeira, Azores, and Canary Islands and the western African coast from Morocco to South Africa; in the western Atlantic it is present from New York to Colombia, including the Gulf of Mexico, the Caribbean Sea and the Antilles (Bañón *et al.*, 2016).

The Oven's Halosaur was recorded in the ichthyofauna of the deep Mediterranean waters in 1960, when the first specimen was reported off the Habibas Islands (Algeria) (Dieuzeide, 1963; Tortonese, 1964; Fredj & Maurin, 1987). Successively, other three specimens of *H. ovenii* have been collected, all in the western part of the basin: off Capo Teulada (Sardinia, Italy), in March 1980 (Cau & Deiana, 1979), off the Balearic Islands (Spain), in June 2001 (D'Onghia *et al.*, 2004) and 1.5 miles off the port of Arbatax (Sardinia, Italy), in April 2007 (Pais *et al.*, 2009), in the north Tyrrhenian Sea, following the subdivisions of the Italian seas proposed by Bianchi (2004).

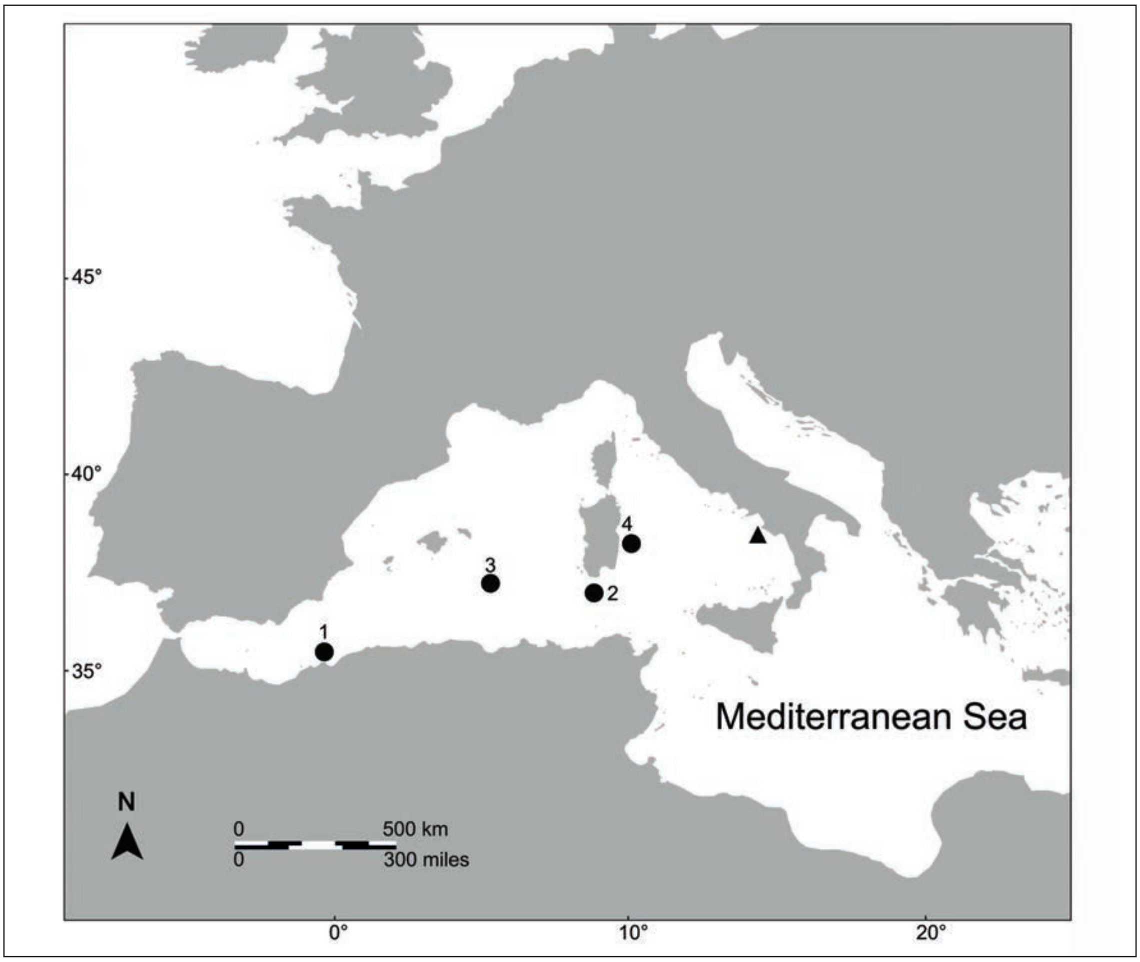

Fig. 1: Records of** Halosaurus ovenii **in the Mediterranean Sea (● Previous records. 1: Dieuzeide (1963); 2: Cau & Deiana (1979); 3: D'Onghia et al. (2004); 4: Pais et al. (2009); ▲ Present study).

Sl. 1: Zapisi o pojavljanju vrste** Halosaurus ovenii **v Sredozemskem morju (● prejšnji zapisi. 1: Dieuzeide (1963); 2: Cau & Deiana (1979); 3: D'Onghia et al. (2004); 4: Pais et al. (2009); ▲ Pričujoča raziskava).

Fig. 2: *Holosaurus ovenii* ***from Punta Licosa, Castellabate (Salerno, Italy), 475 mm total length (A), and detail of head (B: lateral view, C: ventral view). (Photo: Aniello Amato).***
Sl. 2: Primerek vrste *Halosaurus ovenii* ***iz lokalitete Punta Licosa, Castellabate (Salerno, Italija), 475 mm celotne dolžine (A), in detajl glave (B: pogled z boka, C: spodnja stran). (Foto: Aniello Amato).***

Tab. 1: Measurements (mm), main proportions (as % of gnathoproctal length, GPL), meristics and weight (g) of the *Halosaurus ovenii* ***specimen from the south Tyrrhenian Sea.***

Tab. 1: Meritve (mm), glavna razmerja (kot % gnatoproktalne dolžine, GPL), meristika in teža (g) primerka vrste *Halosaurus ovenii* ***iz južnega Tirenskega morja.***

Morphometric measurements	**mm**	**% GPL**
Total length	475	
Gnathoproctal length	234.3	
Body height	37.7	16.1
Head length	63.9	27.3
Snout length	23.7	10.1
Predorsal length	156	66.6
Preanal length	245.8	
Eye diameter length	10.1	4.3
Eye diameter height	7.1-7.5	
Interorbital width	5.7	2.4
Meristic counts		
Dorsal fin rays	I+10	
Anal fin rays	>140	
Pectoral fin rays	I+12	
Ventral fin rays	I+8	
Scales above lateral line	14	
Gill rakers 1st arch	12 (9+3)	
Total weight (g)	142	

In the present study, the finding of a specimen from the south Tyrrhenian Sea is described, contributing to improve knowledge on the geographical distribution of this deepwater fish rarely captured in the Mediterranean.

MATERIAL AND METHODS

A specimen of *H. ovenii* was caught on 7 June 2013 with a bottom trawler off Punta Licosa, Castellabate (Salerno, Italy), southeast Tyrrhenian Sea (40°13′54.04″N, 14°32′40.15″E), at 600 m of depth (Fig. 1). It is preserved in liquid at the Museo Civico di Storia Naturale di Comiso, Ragusa (Italy) with the Catalogue number MSNC 4874.

Meristic characters were counted and the main biometric measurements were taken according to McDowell (1973) and Paulin & Moreland (1979), using a caliper (accuracy 0.1 mm).

RESULTS AND DISCUSSION

The specimen was identified as *H. ovenii* following McDowell (1973), Sulak (1986), Smith (2016) and Bañón *et al.* (2016). The specimen which measured 475 mm in total length and weighed 142 g, presented the following features (Fig. 2): body elongate and attenuated to the caudal peduncle; tail slender and attenuate, anus slightly before mid length. Cycloid scales covering all the body, including top and sides of head anterior to tip of lower jaw and opercle (Fig. 2A, B). Lateral line well developed, runs along lower side of body. Snout extending in front of mouth, over the lower jaw, and provided by a large and thin rostrum-like (Fig. 2). Snout contained 2.7 times in head length. Head elongate, its length contained 3.8 times in preanal length. Mouth inferior, overhung by snout; teeth small (Fig. 2C). Dorsal fin short-based, on midtrunk, slightly closer to anus than to tip of snout, all rays segmented, anal-fin base long, extending from just behind anus to tip of tail; pectoral fin above lateral midline; pelvic fins located abdominally just in front of dorsal fin; caudal fin absent. Color: silvery rose, darker dorsally; mouth dark on the roof and in front of the tongue, pale in the remaining areas; gill cavity dark (Fig. 2C); lateral line scales unpigmented. The proportions of main measurements and meristic counts (Tab. 1) were in agreement with Pais *et al.* (2009) and Bañón *et al.* (2016).

The species *H. ovenii* reaches 600 mm in total length and 260 mm in preanal length (Froese & Pauly, 2020). Our sample from the southeastern Tyrrhenian Sea was an adult similarly to the specimens collected in the southern and the eastern Sardinian waters (Cau & Deiana, 1979; Pais *et al.*, 2009). It was caught at a depth included in the range reported for the species (Froese & Pauly, 2020) and similar to the depth of 550 m observed for the capture in Algerian waters (Dieuzeide, 1963) and of 620 m reported from the south of Sardinia, Italy (Cau & Deiana, 1979), while the shallowest and deepest records for this fish were respectively 200 m from the Sardinian waters (Pais *et al.*, 2009) and 2800 m from off the Balearic Islands (D'Onghia *et al.*, 2004). Up to date, the finding described in the present study represents the easternmost record of the species in the Mediterranean Sea (Fig. 1).

The Oven's Halosaur *H. ovenii* has been previously considered by some authors a non-indigenous species of Atlantic origin that reached the Mediterranean basin via the Gibraltar Strait (Relini & Lantieri, 2010; Zenetos *et al.*, 2010; Occhipinti-Ambrogi *et al.*, 2011; Psomadakis *et al.*, 2012; Golani *et al.*, 2013; Grimes *et al.*, 2018). Nevertheless, a number of species having displayed a natural range expansion from the Atlantic toward the Mediterranean through the Strait of Gibraltar were removed by many authors from the inventories of non-indigenous species, including *H. ovenii* (Zenetos *et al.*, 2012; Servello *et al.*, 2019). Taking into account that it is a species widely distributed in the eastern Atlantic, it has been recently suggested to consider *H. ovenii* as a cryptogenic species for the Mediterranean (Evans *et al.*, 2020). Undoubtedly, being a deepwater fish recorded few times in the basin, it could be defined a “very rare” species, following Bello *et al.* (2014).

Probably, a fraction of the deep-sea Mediterranean biodiversity is still unknown, although intensification of research investigations and the use of new technologies are enriching its knowledge (Danovaro *et al.* 2010; IUCN, 2019; Lombarte *et al.*, 2021). The finding of *H. ovenii* here reported is the second for the Tyrrhenian Sea after the record described by Pais *et al.* (2009), and the first for its southern sector, a basin that revealed a high fish diversity of 447 species, 65.4 % of the whole Mediterranean ichthyofauna (Psomadakis *et al.*, 2012).

ACKNOWLEDGEMENTS

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NOVI ULOV VRSTE *HALOSAURUS OVENII* (ACTINOPTERYGII: NOTACANTHIFORMES: HALOSAURIDAE) V ITALIJANSKIH VODAH

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POVZETEK

V Tirenskem morju (zahodno Sredozemsko morje) so leta 2013 ujeli primerek vrste Halosaurus ovenii *Johnson, 1864. Najdba je obogatila poznavanje razširjenosti te redke vrste v celotnem bazenu. To je peti primer pojavljanja vrste* H. ovenii *v Sredozemskem morju in tretji za italijanske vode.*

Ključne besede: Halosauridae, redke vrste, globoko morje, Sredozemsko morje

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FIRST RECORD OF MARBLED STINGRAY, *DASYATIS MARMORATA* (CHONDRICHTHYES: DASYATIDAE) FROM THE ALGERIAN COAST (SOUTHWESTERN MEDITERRANEAN SEA)

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ABSTRACT

The authors report for the first time the capture of a specimen of marbled stingray Dasyatis marmorata *(Steindachner, 1892) from the coast of Algeria. The specimen was an adult male measuring 340 mm in disc width, 310 mm in disc length, 450 mm in total length, and probably weighing 3 kg. Its occurrence in the region was probably due to migration from other southern areas such as the Tunisian coast, where the species is captured in relative abundance. These migrations are mainly due to the warming of the Mediterranean waters but also to competition pressure between members of the Dasyatidae inhabiting the same area. Additionally, the present capture constitutes the southwesternnmost limit of the species' extension range in the Mediterranean Sea.*

Key words: Dasyatidae, first record, migration**,** extension range, distribution, Algerian coast

PRIMA SEGNALAZIONE DI *DASYATIS MARMORATA* (CHONDRICHTHYES: DASYATIDAE) LUNGO LA COSTA ALGERINA (MEDITERRANEO SUDOCCIDENTALE)

SINTESI

Gli autori riportano la prima cattura di un esemplare di Dasyatis marmorata *(Steindachner, 1892) lungo le coste dell'Algeria. L'esemplare era un maschio adulto che misurava 340 mm di larghezza del disco, 310 mm di lunghezza del disco, 450 mm di lunghezza totale e pesava circa 3 kg. La sua presenza nella regione è probabilmente dovuta alla migrazione da altre aree meridionali, come la costa tunisina, dove la specie viene catturata in relativa abbondanza. Queste migrazioni sono dovute principalmente al riscaldamento delle acque del Mediterraneo, ma anche alla pressione competitiva tra i membri dei Dasyatidae che condividono la stessa area. L'attuale cattura costituisce inoltre il limite sud-occidentale dell'areale di estensione della specie nel Mediterraneo.*

Parole chiave: Dasyatidae, prima segnalazione, migrazione, estensione dell'areale, distribuzione, costa algerina

INTRODUCTION

The marbled stingray, *Dasyatis marmorata* (Steindachner, 1982) is a species known off the eastern Atlantic coast south of the Strait of Gibraltar (Capapé, 1989). It has been recorded in the Mauritanian coast, where it appears to be abundantly captured and from where some traits of its reproductive biology were reported by Valadou *et al.* (2006). Capapé *et al.* (1995) provided biological observations, and Diaby *et al.* (2022) studied the food and feeding habits of the specimens from the area. Southwards, *D. marmorata* is reported from the Gulf of Guinea (Fowler, 1936) to Angola (Krefft, 1968) and southern African waters (Cowley & Compagno, 1993).

In the Mediterranean Sea, *D. marmorata* was previously only reported from southern Tunisian waters, the Gulf of Gabès, and a close brackish area, the Bahiret el Bibane (Maurin & Bonnet, 1970; Capapé, 1989; Capapé *et al.*, 2004). Captures of specimens from these areas have allowed us to study the diet and feeding habits and the reproductive biology of the species (Capapé & Zaouali, 1992, 1995). After migrating to northern Tunisian areas the species was caught in the brackish Lagoon of Bizerte (El Kamel *et al.,* 2009).

However, records of the species are not restricted to Tunisian waters, *D. marmorata* also occurred eastward of the Turkish coast (Ergüden *et al.*, 2014; Özgür Özbek *et al.*, 2015; Yeldan & Gündogdu, 2018) and in Greece, in the central Aegean Sea (Chatzispyrou *et al.*, 2020). The species was additionally reported from the Levant Basin by Golani & Capapé (2004) and Bariche & Fricke (2020).

Routine monitoring conducted throughout the Algerian coast for two decades at least, together with the assistance of experienced fishermen, have allowed us to locate in the fish market of Algiers a specimen of *D. marmorata* captured in the area. The present paper provides a short description of the specimen, including main morphometric characters and some comments about the real status of the species in this area and in the wider Mediterranean Sea.

MATERIAL AND METHODS

A specimen of *D. marmorata* was captured on 16 March 2016, off Annaba, 37°10′ N, 7°15′ E, on sandy-rocky bottoms partially covered by seagrass at a depth of 100–150 m (Fig. 1). Carefully observed, identified and photographed, it was then sold as part of a catch of bony fishes and other elasmobranch species.

RESULTS AND DISCUSSION

The present specimen was identified as *D. marmorata via* the combination of the following morphological characters: disc rhomboid with anterior margins slightly convex at level of eyes while the posterior margins straight anteriorly and convex posteriorly, snout pointed, pelvic fins quadrangular and with rounded outer corner, dorsal and ventral surface of the tail with fold posterior to the sting but not extending to the end of the tail, dorsal surface brownish along the margin of the pectoral fin and toward the snout, pelvic fins also brownish, slightly darker between along the centre of the body and the length of the tail, grey to slate blue blotches, irregularly shaped, some interconnected, bordered by a thin dark, flint grey margin that spreads along the central part of the back, from between the eyes to just before the beginning of the tail, ventral surface uniformly whitish to beige with margin grey to slightly brownish at tip of snout (Fig. 2). The description of the specimen was in agreement with Cowley & Compagno (1993), Golani & Capapé

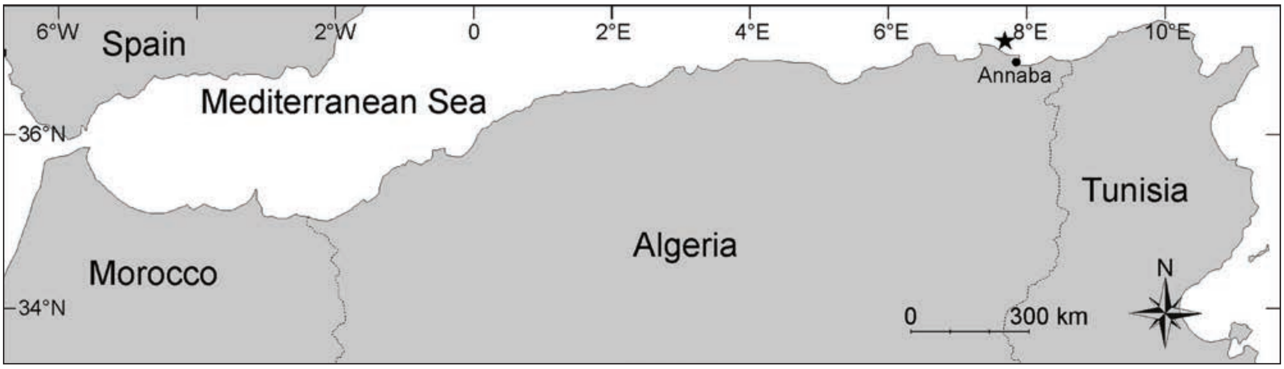

Fig. 1: Map the Algerian coast indicating the capture site of *Dasyatis marmorata****, off Annaba (black star).***
Sl. 1: Zemljevid alžirske obale z označeno lokaliteto v bližini Annabe (črna zvezdica), kjer je bil ujet primerek vrste *Dasyatis marmorata****.***

Fig. 2: The *Dasyatis marmorata* ***captured from the Algerian coast, scale bar = 100 mm.***
Sl. 2: Primerek vrste *Dasyatis marmorata****, ujet ob alžirski obali, merilo = 100 mm.***

(2004), El Kamel *et al.* (2009) and Ergüden *et al.* (2014) and allowed the inclusion of *D. marmorata*, with this first record, in the list of Algerian ichthyofauna. Additionally, this capture constitutes the southwesternmost limit of the species' extension range in the Mediterranean Sea.

The specimen measured 340 mm in disc width (DW), 310 mm in disc length, and 450 mm in total length, and according to the fishermen it weighed 3 kg. It was an adult, exhibiting well-developed, stout, rigid and calcified claspers, larger than pelvic fins. These parameters confirm previous observations made by Capapé and Zaouali (1995), who noted that size at first sexual maturity in males occurred at 300 mm DW. The Algerian specimen was smaller than those collected from the Tunisian coast, which measured 400 mm and 440 mm DW, as maximal size for males and females, respectively (Capapé and Zaouali, 1995). Conversely, it was larger than the specimens observed in some other marine areas, such as Mauritania (Valadou *et al.*, 2006) and the Levant Basin (Ergüden *et al.*, 2014).

When first reported from the Mediterranean Sea by Maurin & Bonnet (1970), from the Gulf of Gabès, southern Tunisia, *D. marmorata* was confused with its close relative species, the common stingray *D. pastinaca* (Linneaus, 1758) and misidentified as *D. pastinaca* var. *marmorata*. The two species differ in the DW *vs.* disc length ratio, and in the snout to vent length *vs.* DW (Cowley & Compagno, 1993; Ergüden *et al.*, 2014). According to Golani & Capapé (2004), the dorsal fold of tail is higher than the ventral fold in *D. marmorata* and lower in *D. pastinaca*. Additionally, the dorsal surfaces display different colorations and patterns, yellowish to slate blue blotches in *D. marmorata* and solid dark brown to olive in *D. pastinaca*.

Such patterns explained why the species was not already recorded in the study area. But information recorded from Algerian fishermen shows that the latter are unable to distinguish among the different sting ray species landed in local fish markets. These are globally included among skates and rays in fishery statistics (Hemida, 2005). However, taxonomical papers have shown that the two species can in fact be differentiated by morphological characters. Chatzispyrou *et al.* (2020) noted that DNA barcoding was used to confirm *D. marmorata* as a valid species, adding that the combination of these two methods allowed a confirmation of the species' occurrence in Greek waters.

D. marmorata used to be considered rather abundant in southern Tunisian waters (Capapé & Zaouali, 2005), but lately it has been under fishing pressure and interspecific competition pressure from other sympatric species (Capapé, 1989). This could explain why the species first took refuge in Bahiret el Bibane (Capapé *et al.*, 2004) and then migrated toward northern areas as far as the Lagoon of Bizerte (El Kamel *et al.*, 2009). Such migration is spurred by global warming, which has been affecting Mediterranean waters for several decades (Francour *et al.*, 1994) and could explain this new occurrence of *D. marmorata* in Algerian waters as possible migration from Tunisian waters. Are Tunisian waters the core of *D. marmorata* in the Mediterranean Sea? Migrations from this region towards western and eastern areas of the Mediterranean remain a suitable hypothesis that does require further investigation but cannot be totally ruled out either.

PRVI ZAPIS O POJAVLJANJU MARMORIRANEGA MORSKEGA BIČA, *DASYATIS MARMORATA* (CHONDRICHTHYES: DASYATIDAE) IZ ALŽIRSKE OBALE (JUGOZAHODNO SREDOZEMSKO MORJE)

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POVZETEK

Avtorji poročajo o prvem ulovu marmoriranega morskega biča Dasyatis marmorata *(Steindachner, 1892) ob obali Alžirije. Bil je odrasel samec, ki je meril 340 mm v premeru diska in 450 mm celotne dolžine, tehtal pa naj bi 3 kg. Pojavljanje te vrste na obravnavanem območju je potrebno verjetno povezati s selitvijo iz drugih južnih predelov kot je na primer tunizijska obala, kjer ga lovijo v zmernem številu. Te selitve pripisujejo segrevanju Sredozemskega morja in kompeticiji med vrstami iz družine Dasyatidae, ki s to vrsto sobivajo. Pričujoči ulov predstavlja skrajno jugozahodno mejo razširjenosti te vrste v Sredozemskem morju.*

Ključne besede: Dasyatidae, prvi zapis o pojavljanju, selitev, širjenje areala, razširjenost, alžirska obala

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SECOND OCCURRENCE OF *SIGANUS JAVUS* (SIGANIDAE) IN THE MEDITERRANEAN WATERS

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ABSTRACT

A single specimen of Siganus javus *(Linnaeus, 1766) was captured in December 2021 in the waters off Alexandria, Egypt. This Indo-Pacific species is reported for the second time in the Mediterranean Sea and its occurrence in the basin is briefly discussed.*

Key words: Non-Indigenous species, Siganidae, Mediterranean Egyptian waters, introduction pathway, citizen science

SECONDA SEGNALAZIONE DI *SIGANUS JAVUS* (SIGANIDAE) NEL MEDITERRANEO

SINTESI

Un esemplare di Siganus javus *(Linnaeus, 1766) è stato catturato nelle acque al largo di Alessandria, Egitto, nel dicembre 2021. Si tratta della seconda segnalazione di questa specie di origine Indo-Pacifica nel mar Mediterraneo e la sua presenza nel bacino viene brevemente discussa.*

Parole chiave: Specie non-indigene, Siganidae, acque egiziane del Mediterraneo, percorso di introduzione, citizen science

INTRODUCTION

Six non-indigenous species (NIS) belonging to the Indo-Pacific family Siganidae have been recorded in the Mediterranean Sea: *Siganus rivulatus* Forsskål & Niebuhr, 1775 and *Siganus luridus* (Rüppel, 1829) (Golani *et al.*, 2021), *Siganus javus* (Linnaeus, 1766) (Ibrahim *et al.*, 2010), *Siganus virgatus* (Valenciennes, 1835) (Ahnelt, 2016), *Siganus fuscescens* (Houttuyn, 1782) (Azzurro & Tiralongo, 2020) and *Siganus argenteus* (Quoy & Gaimard, 1825) (Abdelghani *et al.,* 2021). The rabbitfish *S. rivulatus* and *S. luridus* are well established in the basin for a long time, while to date the occurrence of the remaining species is still based on single records. The records of *S. javus* and *S. virgatus* are considered questionable, the first because it was reported in a not peer reviewed abstract of a CIESM Congress (Zenetos *et al.*, 2011, 2022) and also it does not occur in the Red Sea (Golani *et al.*, 2021), the second because it occurs only off eastern India and the labelling of the specimen from the Adriatic Sea deposited at the National History Museum of Vienna may be incorrect (Golani *et al.*, 2021). Considering the above listed *Siganus* NIS, the Red Sea is currently included in the native range of *S. rivulatus*, *S. luridus*, *S. argenteus* (Woodland, 2001; Golani & Fricke, 2018), and *S. javus* (Debelius, 2011).

The first occurrence of the Streaked spinefoot *S. javus* in the Mediterranean waters of Egypt is hereby documented, adding a third siganid species to *S. luridus* and *S. rivulatus* previously recorded in the same area (Halim & Rizkalla, 2011; Akel & Karachle, 2017) and a second record of the species for the whole basin, after its first finding in Syrian waters (Ibrahim *et al.*, 2010).

MATERIAL AND METHODS

On 5 December 2021 a fisherman caught a fish not familiar to him, at Miami Beach, Alexandria, Egypt (31.27234° N, 29.99065° E), with a fishing rod (shrimp as bait), at around 12 m of depth on a rocky area. Video and photo of the freshly captured sample were soon posted to a Facebook group https://m.facebook.com/groups/AlexandrianFisherman/permalink/445710968440 7264/?paipv=0&eav=AfYgASY0_i967sRjLs_B1dnj03c-No0S3Vz-MSIDWRqxg7xHf2cj8IxctV_6rBPZIFlg&_rdr. The fisherman identified the fish by its known local generic name (سمكة البطاطا أو السيجان سبحان الخالق, "batata", in English potato fish), but he underlined that he had never seen such a "batata" fish, in particular for the shape of the body and the strange wavy lines on the body sides. The sample was not retained.

RESULTS AND DISCUSSION

The fish was identified as *S. javus* following Woodland (2001), on the basis of the characters observed in Fig. 1 and the available video: body deep and compressed; dorsal fin with XIII strong spines and 10 soft rays, anal fin with VII strong spines and 9 soft rays; mouth small, terminal; dorsal profile of head slightly concave above orbit; snout short and blunt; preopercular angle approximately 80°; caudal fin emarginate; scales minute. Colour: bronze on back and sides to paler below; bluish spots on head and upper sides, smaller and regular on head, larger and irregular in the upper back, extending to the upper caudal peduncle; silvery bluish undulating lines on mid- and lower sides, vanishing on ventral side; spines and rays of dorsal, anal, and pelvic fins golden, membranes golden (particularly in the inner part of anal fin), dusky distally; pectoral fins hyaline in the distal portion, dusky in the proximal; caudal fin dusky; cheek shiny golden greenish. The main measurements of the specimen, obtained from Fig. 1 (the sides of squares in the newspaper having a known length of 4.5 mm), were approximately: total length 260 mm, standard length 201 mm, head length 45 mm, body depth 91 mm (2.2 times in SL), and caudal peduncle depth 15 mm. The diameter of bony orbit is approximately two times the shortest distance between bony orbit and upper lip. Following the identification keys of Woodland (2001), there are more than 29 scale rows between lateral line and base of second to fourth dorsal-fin spines. This count was not possible from the available photos and video. Nevertheless, the comparison of body morphology and colour of our freshly caught fish (Fig. 1) with all the *Siganus* species described and showed in Woodland (2001), Burhanuddin *et al.* (2014), Woodland & Anderson (2014) and Froese & Pauly (2022) led to ascertain its identification as *S. javus*, excluding eventual confusion with other siganid species.

The Streaked spinefoot *S. javus* has a wide range of distribution from the Persian Gulf through the Indo-Malayan Archipelago to Vanuatu and New Caledonia (Froese & Pauly, 2022). This rabbitfish, commonly up to 30 cm in total length, dwells in shallow coastal waters, rocky or coral reefs, brackish lagoons, in mangroves, estuaries and estuarine lakes, feeding primarily on algae attached to the substrate and on floating algal fragments (Woodland, 2001; Borsa *et al.*, 2007; Perpetua *et al.*, 2013), but also on zooplankton (Okamoto *et al.*, 2016). The first occurrence of this Indo-Pacific herbivorous fish in the Mediterranean Sea was observed near the port of Lattakia, Syria, in 2009 (Ibrahim *et al.*, 2010). The second finding of *S. javus* described hereby for the Mediterranean, confirms the presence of this NIS fish in the basin, after twelve years since its first sighting in Syrian waters. While there is no certainties regarding the pathway of introduction of *S. javus* in the Mediterranean, the geographical position of our finding off Alexandria, suggests arrival via the Suez Canal (Lessepsian migration) as the most probable pathway (Ibrahim *et al.*, 2010). On the other hand, a ship-mediated introduction cannot be excluded, considering the intense maritime traffic of the large port of Alexandria (cf. Azzurro &

Fig. 1: The specimen of *Siganus javus* ***(approximate total length 260 mm) caught off Alexandria, Egypt (photo credit: Yassine Mahmoud Gaber).***
Sl. 1: Primerek vrste *Siganus javus* ***(približna dolžina 260 mm), ujet blizu Aleksandrije, Egipt (Foto: Yassine Mahmoud Gaber).***

Tiralongo, 2020). It is possible that *S. javus* was able to adapt and establish in the new ecosystem and expanded an apparently limited population along the Levantine coasts, escaping nevertheless further intermediate detections since its first sighting. Competition with the native herbivorous fishes as well as with the established Lessepsian migrants *S. luridus* and *S. rivulatus* may have prevented the diffusion and increase in abundance of *S. javus*. The Marbled spinefoot *S. rivulatus* is, for example, one of the most important commercial species in the artisanal coastal fishery of the understudied area, around Alexandria (Bakhoum, 2018; Rizkalla & Heneish, 2021). It is also plausible that the species has failed the first attempts of adaptation presenting a new and more recent introduction.

The streaked spinefoot *S. javus* enjoys swimming and therefore it is suitable for large aquarium displays, but not for home aquariums (https://reefapp.net/en/encyclopedia/siganus-javus). Some species of siganids are used in aquaculture, while others, including *S. javus*, are promising candidates for this purpose (Duray, 1998).

The Mediterranean Sea, in particular its eastern basin, is one of the regions of the world most affected by biological invasions (Katsanevakis *et al.*, 2020; Occhipinti-Ambrogi, 2021). The Mediterranean Egyptian waters are heavily impacted by NIS, in particular fish of Indo-Pacific/Red Sea origin that migrate into the basin via the Suez Canal corridor (Halim & Rizkalla, 2011). The finding of *S. javus*, although casual for the moment, increases to at least 72 the number of fish species of Indo-Pacific origin recorded in the Mediterranean waters of Egypt (Adel *et al.*, 2021; Al Mabruk *et al.*, 2021; Mehanna & Osman, 2022; Nour *et al.*, 2022a, b). Further field research may substantiate an eventual successful establishment of this NIS in this eastern Mediterranean region.

The finding of *S. javus* from Egypt undoubtedly substantiate the significant support of citizen scientists and sensitized fishers in increasing data on occurrence and spreading of NIS, through the use of new technologies and platforms, particularly in areas where scientific research and monitoring projects are limited, as in the North African countries (Al Mabruk *et al.*, 2021a; Nour *et al.*, 2022a). Among the above mentioned 72 NIS fishes of Indo-Pacific/Red Sea origin reported from the Mediterranean Egyptian waters, at least ten species have been recently recorded due to the input of citizen science and social media (Al Mabruk *et al.*, 2020, 2021b, c; Adel *et al.*, 2022; Nour *et al.*, 2022a).

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DRUGI ZAPIS O POJAVLJANJU PROGASTEGA MORSKEGA KUNCA, *SIGANUS JAVUS* (SIGANIDAE), V SREDOZEMSKIH VODAH

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POVZETEK

Avtorji poročajo o primerku progastega morskega kunca, Siganus javus *(Linnaeus, 1766), ujetega v decembru 2021 v vodah blizu Aleksandrije v Egiptu. To je drugi zapis o tej indo-pacifiški vrsti v Sredozemskem morju. Avtorji razpravljajo na kratko o njenem pojavljanju v bazenu.*

Ključne besede: tujerodne vrste, Siganidae, Sredozemlje, egiptovske vode, način vnosa, ljubiteljska znanost

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COLONISATION OF EXOTIC FISH SPECIES OF THE GENERA *PSEUDOTROPHEUS* AND *AULONOCARA* (PERCIFORMES: CICHLIDAE) AND THE DECLINE OF NATIVE ICHTHYOFAUNA IN NAHAL AMAL, ISRAEL

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ABSTRACT

In the present study, the ichthyofauna of Nahal Amal, a small river in Israel, was sampled annually from 1998 to 2021. The local ichthyofauna was found to have 27 taxa of which ten are native species and 17 are exotic. Until 2010 the dominant species was the indigenous cichlid Astatotilapia flaviijosephi *(Lortet, 1883) which was first replaced for two years by cichlid specimens belonging to the genus* Pseudotropheus. *These were later replaced by specimens of another cichlid genus* Aulonocara *which presently dominates the site. It is suggested that the exotic species entered the site as escapees or following release from the hatchery located on the river's bank or by aquarium hobbyists.*

Key words: colonisation, cichlids, freshwater, Nahal Amal, Israel

COLONIZZAZIONE DI SPECIE ITTICHE ESOTICHE DEI GENERI *PSEUDOTROPHEUS* E *AULONOCARA* (PERCIFORMES: CICHLIDAE) E DECLINO DELL'ITTIOFAUNA AUTOCTONA A NAHAL AMAL, ISRAELE

SINTESI

Nel presente studio l'ittiofauna del Nahal Amal, un piccolo fiume in Israele, è stata campionata annualmente dal 1998 al 2021. L'ittiofauna locale è risultata composta da 27 taxa, di cui dieci specie autoctone e 17 esotiche. Fino al 2010 la specie dominante era il ciclide indigeno Astatotilapia flaviijosephi *(Lortet, 1883), sostituito per due anni da esemplari appartenenti al genere* Pseudotropheus. *Questi ultimi sono stati poi sostituiti da esemplari di un altro genere di ciclidi,* Aulonocara, *che attualmente domina il sito. Si ipotizza che le specie esotiche siano entrate nel sito in seguito a fughe o al rilascio dall'incubatoio situato sulla riva del fiume, o da parte di acquariofili.*

Parole chiave: colonizzazione, ciclidi, acqua dolce, Nahal Amal, Israele

INTRODUCTION

The invasion and establishment of exotic species in new environments is a major global issue. In aquatic environments, they are a significant cause of biodiversity loss. The main concern is that non-native species will outcompete native species and alter the ecosystem, damaging the habitat, hybridizing with local species and/or introducing new parasites and diseases. They may adversely affect the local commercial fishery as well as tourism. In freshwater habitats, the colonisation of non-indigenous fish presents an even greater potential risk than in marine environments, since freshwater fish often have small and isolated populations with a high rate of endemism which renders them particularly prone to extinction (Moyel & García-Berthou, 2011). In the present paper, a long-term study of the ichthyofauna of a small river, Nahal Amal, in the Beit-She'an Valley (Emek Hama'ayanot), Israel, was carried out. The stream was sampled annually in order to study the long-term dynamics and changes caused by anthropogenic activity.

MATERIAL AND METHODS

Study site

The study site, Nahal Amal, locally known as Nahal Assi, is a small river located at 32^{0}30′0.5.82˝N 35^{0}27′38.97˝E, 1650 m downstream from its source at Ein Amal. At the study site the width of Nahal Amal is 30 m. (Fig. 1).

Its discharge ranges from 1700 to 2700 m^2/hour with an average of 1800 m^2/hour. The water temperature is consistently high, 24-26 ˚C, throughout the year, with a salinity of ca. 1100 mg/liter (~ 2 psu) (Rozenberg & Mendel, 1977; Nir, 1989; Kabara-Leykin & Romem, 2020). The northern bank is covered with thick continuous vegetation, mainly Bulrush reed, (*Typha domingensis* (Persoon, 1807)) while the southern bank has spaces between vegetation, allowing access to the stream (Fig. 1). The water depth is 50-70 cm. Until 2010-2011 the substrate was covered with Soft Hornwort (*Ceratophyllum submersum* L., 1763) which was later removed (Y. Lahav, *pers. comm.*), leaving only some debris of large branches on a very deep muddy substrate.

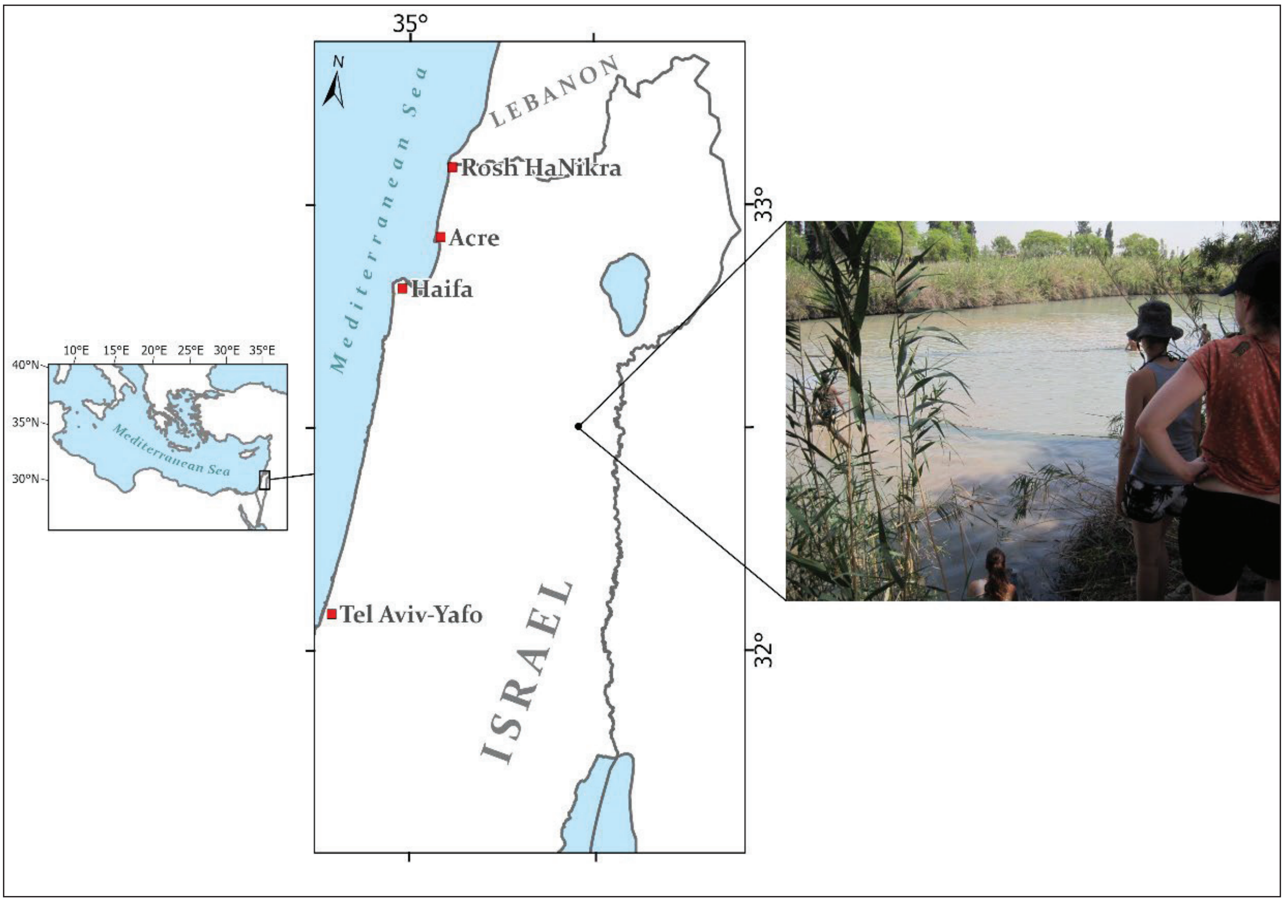

Fig. 1: Maps and photo of study site Nahal Amal.
Sl. 1: Zemljevid in fotografija obravnavanega območja Nahal Amal.

Sampling

The samples were collected with a 30 m long beach seine net, with decreasing mesh size from 40 mm, knot to knot, to 2 mm at the center (Fig. 2).

Each sampling consisted of three sequential hauls, covering ca. 2,000 m^2. Fish from all three hauls were combined. Species were identified to the lowest possible taxa and counted. Due to taxonomic complexity and a high rate of hybridization (Joyce *et al.*, 2011; Genner & Turner, 2012) all specimens of the genera *Pseudotropheus* (Regan, 1922) and *Aulonocara* (Regan, 1922) were identified only to the generic level. We distinguished between these two genera by the following characteristics: *Pseudotropheus* have numerous small, deeply embedded scales on the breast region (Schraml, 1998) while *Aulonocara* are characterized by an enlargement of the sensory canal on the head (Snoeks, 2004) and very large sensory pores in the enlarged infraorbital bones (Konings, 2016). During the years 1998-2010 and 2018-2019, sampling was conducted annually during the months April-June, while during 2011-2017 two samples were collected each year during the same months. Several specimens from each species were saved and deposited in the Fish Collection of the Hebrew University (HUJ).

RESULTS

A total of 27 fish taxa were collected in the present study, in addition to two species, the Black Carp (*Mylopharyngodon piceus*, (Richardson, 1846)) and the Red Drum (*Sciaenops ocellatus*, (Linnaeus, 1766)), that were observed and photographed but were not collected (Tab. 1).

Of the species that were collected, ten are indigenous species and 17 are exotic, of which one was the hybrid of the Striped Bass (*Morone saxatilis* (Walbaum, 1792)) and the White Bass (*M. chrysops* (Rafinesque, 1820)), a likely aquaculture escapee. Another such species was the golden strain of the Blue Tilapia (*Oreochromis aureus*). Five additional species were found: The common carp - *Cyprinus carpio,* Blue Tilapia - *Oreochromis aureus,* Nile tilapia - *O. niloticus,* Thinlip grey mullet - *Chelon ramada* and the Flathead grey mullet - *Mugil cephalus*; these are non-native species that are known to be cultured in local aquaculture and are thus likely escapees. An additional species, the Mosquito fish (*Gambusia affinis*), was introduced to Israel in the 1920's for the purpose of malaria control and is currently present in almost all freshwater bodies in Israel (Goren & Ortal, 1999; Golani & Mires, 2000). Six of the collected species are popular in the aquarium trade in Israel: Vermiculated sailfin catfish - *Pterygopichthys dijunctivus,* Amazon sailfin catfish - *P. pardalis,* Yucatan molly - *Poecilia velifera,* Green swordtail - *Xiphophorus helleri,* Convict cichlid - *Amatitilapia nigrofasciata* and the Malawi eyebiter *Dimidichromis comptessiceceps* and the genera *Aulonocara* and *Pseudotropheus*. Figure 3 reveals a clear shift of the river's ichthyofauna composition; until 2009 the indigenous cichlid *Astatotilapia flavijosephi* was the dominant species, but then in 2010 began to decline sharply. During the following two years (2011-2012), specimens of the exotic geneus *Pseudotropheus* displayed an increase and were most common, but by 2013 specimens of another exotic genus, *Aulonocara* increased and since has dominated the stream fish assemblage until the end of this study.

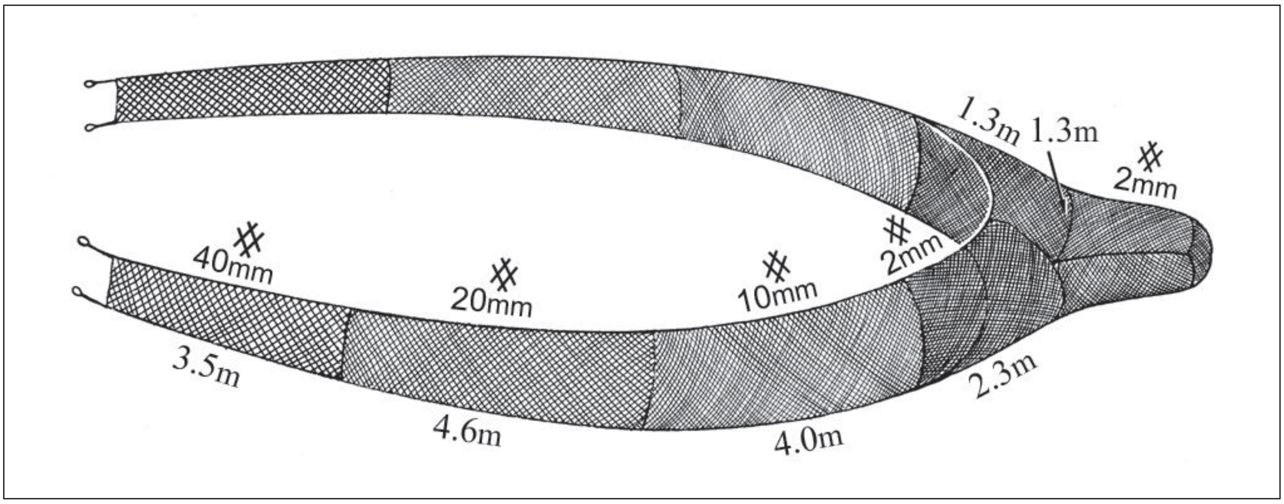

Fig. 2: Experimental beach seine used in the present study.
Sl. 2: Poskusna povlečna mreža, uporabljena v pričujoči študiji.

Tab: 1: List of species sampled in Nahal Amal in the present study. I - indigenous spp., E – exotic spp., O – species observed, photographed, but not collected.
Tab: 1: Seznam vrst rib v reki Nahal Amal v pričujoči raziskavi. I – domorodne vrste, E – eksotične vrste, O – vrste, ki so bile opažene in fotografirane, vendar niso bile ulovljene.

Family	**Species**	
CYPRINIDAE	*Acanthobrama lissneri* Tortonese, 1952	**I**
	Barbus longiceps Valenciennes, 1842	**I**
	Caracobarbus canis (Valenciennes, 1842)	**I**
	Cyprinus carpio Linnaeus, 1758	**E**
	Hemigrammocapoeta nana (Heckel, 1843)	**I**
	Garra rufa (Heckel, 1843)	**I**
CLARIDAE	*Clarias gariepinus* (Burchell, 1822)	**I**
LORICARIIDEA	*Pterygoplichthys disjunctivus* (Weber, 1991)	**E**
	Pterygoplichthys pardalis (Castelnau, 1855)	**E**
CYPRINODONTIDAE	*Aphanius mento* (Heckel, 1843)	**I**
POECILIDAE	*Gambusia affinis* (Baird & Girard, 1853)	**E**
	Poecilia velifera (Regan, 1914)	**E**
	Xiphophorus helleri Heckel, 1848	**E**
MORONEIDAE	*Morone saxatilis X Morone chrysops*	**E**
CICHLIDAE	*Amatitilapia nigrofasciata* (Günther, 1867)	**E**
	Astatotilapia flaviijosephi (Lortet, 1883)	**I**
	Aulonocara sp. Regan 1922	**E**
	Coptodon, zillii (Gervais, 1848)	**I**
	Dimidichromis compressiceceps (Boulenger, 1908)	**E**
	Labidochromis caeruleus Fryer, 1956	**E**
	Oreochromis aureus (Steidachner, 1864)	**E**
	Oreochromis aureus- orange morph	**E**
	Oreochromis niloticus (Linnaeus, 1758)	**E**
	Pseudotropheus spp. Regan, 1922	**E**
	Sarotherodon galilaeus (Linnaeus, 1758)	**I**
MUGILIDAE	*Chelon ramada* (Risso, 1827)	**E**
	Mugil cephalus Linnaeus, 1758	**E**
CYPRINIDAE	*Mylopharyngodon piceus* (Richardson, 1846)	**O**
SCIAENIDAE	*Sciaenops ocellatus* (Linnaeus, 1766)	**O**

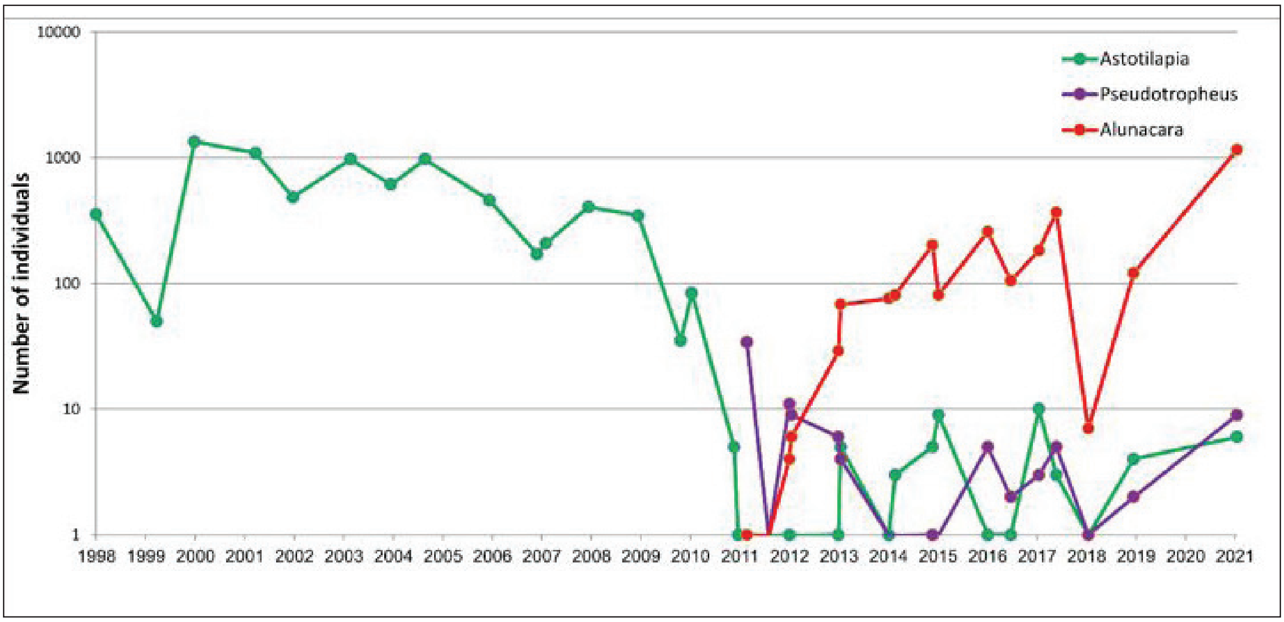

Fig. 3: Number of specimens of the three main taxa in each sample in Nahal Amal. Green – *Astatotilapia flaviijosephi*, ***Purple –*** *Pseudotropheus* ***spp., Red –*** *Aulonocara* ***spp.***

Sl. 3: Število primerkov treh glavnih taksonov v posameznem vzorcu v reki Nahal. Zeleno – *Astatotilapia flaviijosephi*, ***vijolično –*** *Pseudotropheus* ***spp., rdeče –*** *Aulonocara* ***spp.***

DISCUSSION

Fish introduction to the freshwater system of Israel has been studied by several ichthyologists (Ben-Tuvia, 1981; Goren & Ortal, 1999; Golani & Mires, 2000). The families and lower taxa that were excluded from these studies were Loriacarridae with *Pterygoplychthys disjunctivus* and *P. pardalis* which were included in a later study (Golani & Snovsky, 2013) and Cichlidae with *Amatitilapia nigrofasciata, Dimidichromis compressiceceps, Labidochromis caeruleus* and the genera *Aulonocara* and *Pseudotropheus*.

The main finding of this study is a clear shift in the ichthyofauna of Nahal Amal. Until the year 2009 Nahal Amal ichthyofauna was heavily dominated by the native cichlid *Astatotilapia flaviijosephi* (171-1340 specimens per sample), followed by a sharp decrease of 35-85 specimens per sample during 2010. In the following years 2011-2020, this species was represented by only a few individuals (1-10 individuals per sample). During the years 2011-2012 specimens belonging to the exotic genus *Pseudotropheus* were the most abundant in sampling and a few specimens of another exotic genus, *Aulonocara,* first appeared in the samples. From 2013 until the end of the study, *Aulonocara* gradually became the dominant species in Nahal Amal, reaching 1060 specimens per sample in 2021.

Two scenarios are possible regarding the observed ichthyofauna changes. One scenario is that the removal of the Soft Hornwort in 2010-2011 led to a rapid decline of the indigenous *Astatotilapia flaviijosephi* population, leaving the ecosystem vacant or underutilised, thus enabling exotic species to exploit and dominate the Nahal Amal ecosystem. Alternatively, it is possible that individuals of the exotic species were already present in the river in 2010 and 2011 but were overlooked in sampling and they succeeded to outcompete native species.

Golani & Snovsky (2013) assumed that the probable origin of the exotic fish in Nahal Amal was due to escapees from a fish hatchery that was located on the bank of Nahal Amal. According to E. Lahav (*pers. comm.*), this hatchery ceased operating in 2006 but when active, it was concerned only with amelioration and husbandry of aquaculture species, mainly of the family of Cichlidae (*Oreochromis niloticus, O. mossambicus* (Peters, 1852), and *O. urolepis* (Norman, 1922), known also as *O. hornorum*). However, it is highly likely that during the hatchery's operation prior to its demolition, additional species were held in the facility, including the Malawi cichlids (*pers. obs.*). Therefore, the origin of *Pseudotropheus* and *Aulonocara* in Nahal Amal could have resulted from spillover from the hatchery, as well as release or escapees from aquarium hobbyists.

Both genera *Pseudotropheus* and *Aulonocara* are endemic to Lake Malawi. Species belonging to these genera are thermophilic, omnivorous, maternal mouth brooders and inhabit habitats similar to that of Nahal Amal. According to Barlow (2002), maternal mouth brooders have an advantage in colonising new habitats. Member of the genus *Pseudotropheus* have been recorded as exotic species in the United States, in Nevada and Hawaii (Nico, 2019). Indeed, Malawi cichlids are popular worldwide in the aquarium trade, including in Israel.

It is interesting to note that five indigenous species (Lissner's bleak - *Acanthobrama lissneri,* Longhead barbel - *Barbus longiceps, Hemigrammocapoeta nana, Garra rufa* and *Aphanius mento*) were not collected in this study site after the removal of the Soft Hornwort in 2010-2011. Three indigenous species, *Carasobarbus canis, Coptodon zillii* and *Sarotherodon galilaeus*, were sampled in similar numbers (2-26 per sample) throughout the study, both as juveniles and adults, thus indicating that they are spawning in Nahal Amal.

The probability that the exotic fishes of Nahal Amal will unintentionally spread to other locations of the freshwater ecosystem of Israel is highly unlikely. The winter temperature in regional fish ponds plummets to 10^0C, which is below the tolerance limit of these thermophilic exotic Lake Malawi-originated fish. Indeed, about 200 m east of the study site, Nahal Amal water is collected and used following dilution with water from other near-by springs, for irrigation and filing aquaculture fish pond.

CONCLUSIONS

The present study of colonisation of exotic species in Nahal Amal is a long term case study demonstrating the phenomenon which may represent grave risk to native fish species and their competitive exclusion by exotic species, a risk that is particularly keen in freshwater systems. It is incumbent upon fresh water management to monitor, control, and as much as possible, prevent the entry of invasive species, to preserve the wellbeing of native species and ensure the conservation of the local ecosystems.

NASELJEVANJE EKSOTIČNIH VRST RIB IZ RODOV *PSEUDOTROPHEUS* IN *AULONOCARA* (PERCIFORMES: CICHLIDAE) IN UPAD DOMORODNE RIBJE FAVNE V REKI NAHAL AMAL, IZRAEL

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POVZETEK

Avtorji so v pričujoči raziskavi vzorčili ihtiofavno v Nahal Amalu, manjši reki v Izraelu v letih od 1998 do 2021. Lokalno ihtiofavno tvori 27 taksonov, od katerih je 10 domorodnih vrst in 17 eksotičnih vrst. Do leta 2010 je prevladovala domorodna vrsta ostrižnika Astatotilapia flaviijosephi *(Lortet, 1883), ki sta jo najprej nadomestili dve drugi vrsti ostrižnikov iz rodu* Pseudotropheus. *Te pa so kasneje zamenjale vrste iz še enega rodu ostrižnikov* Aulonocara*, ki danes prevladujejo na lokaliteti. Najverjetneje so se tujerodne vrste na lokaliteti pojavile zaradi pobega ali namernega izpusta iz vzrejnega centra na rečnem bregu ali zaradi akvaristov.*

Ključne besede: naseljevanje**,** ostrižniki, sladke vode, Nahal Amal, Izrael

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ON THE OCCURRENCE OF *VELOLAMBRUS EXPANSUS* (BRACHYURA, PARTHENOPIDAE) IN HELLENIC WATERS

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ABSTRACT

The finding in 2022 of the parthenopid Velolambrus expansus *(Miers, 1879) in the Hellenic waters of the Aegean Sea is reported. This crab is considered rare in the Mediterranean Sea and the distribution of its records in the basin is updated and briefly discussed.*

Key words: Crustacea Decapoda, rare species, Mediterranean Sea, distribution

SULLA PRESENZA DI *VELOLAMBRUS EXPANSUS* (BRACHYURA, PARTHENOPIDAE) IN ACQUE ELLENICHE

SINTESI

Viene segnalato il ritrovamento nel 2022 del partenopide Velolambrus expansus *(Miers, 1879) nelle acque elleniche del mar Egeo. Questo granchio è considerato raro nel Mediterraneo e la distribuzione delle sue segnalazioni nel bacino viene aggiornata e brevemente discussa.*

Parole chiave: Crostacei Decapodi, specie rare, Mar Mediterraneo, distribuzione

INTRODUCTION

The crab *Velolambrus expansus* (Miers, 1879) is an Atlanto-Mediterranean species (Manning & Holthuis 1981) rarely collected in the Mediterranean Sea (García-Raso, 1989; Christodoulou *et al*., 2009). The species was described for the first time by Miers (1879) as *Lambrus (Parthenopoides) expansus*. This parthenopid lives between 30 m and 190 m of depth on a variety of substrates such as gravel, sand, broken shell, coral, mixed rocky-sandy bottoms, calcareous algae (e.g., maërl), volcanic detritus (Pastore, 1975; Manning & Holthuis, 1981; García-Raso, 1989; d'Udekem d'Acoz, 1999; Spanò, 2002).

In the Mediterranean Sea, *V. expansus* was first recorded in 1893 at northwest of Crete Island, Greece (Adensamer, 1898). In the Hellenic waters, after this old record, the species was collected only a second time, in the Aegean Sea (Koukouras *et al*., 1992, 1993).

The recent finding of two specimens of *V. expansus* in the Saronikos Gulf, Greece, is described, ascertaining its current occurrence in the Aegean Sea after more than 65 years and updating knowledge on its distribution in the whole Mediterranean basin.

MATERIAL AND METHODS

On 19 June 2022 two crabs of similar features were collected off the island of Fleves, Saronikos Gulf, southwestern Aegean Sea (37.7344°N, 23.7692°E) (Fig. 1), as by-catch of trammel net at 120 m of depth on a muddy sand and maërl bottom. The above fishing gear, named μπαρμπουνοδίχτια (barbounodichtia) is commonly used in the Hellenic small scale fishery and targets prevalently red mullet *Mullus* spp. but also other species (Adamidou, 2007). The discarded crab specimens, currently stored by one of the authors (P.O.), were identified following Manning & Holthuis (1981), Falciai & Minervini (1992) and Tan & Ng (2007). Measurements (CW, carapace width, CL, carapace length) of both specimens were taken with a caliper to the nearest 0.1 mm.

RESULTS AND DISCUSSION

The specimens (Fig. 2) were identified as *V. expansus*, according to the above mentioned literature. Both crabs were males, the largest, specimen A, with CW 5.43 mm and CL 4.22 mm, the smallest, specimen B, with CW 3.0 mm and CL 2.98 mm.

The following main characteristics were observed (Fig. 2): carapace triangular in outline, slightly broader than long in specimen A, same CW and CL in specimen B. Front prominent forming a straight line with sides of carapace; in specimen A, the front terminates with five tubercles, the central more pronounced; in specimen B, the front appears rounded, slightly sunken in the center. In the posterior half of both specimens the lateral margin is slightly widened, showing 3 shallow teeth just before posterolateral angle. Posterior margin of carapace slightly convex, with inconspicuous tuber-

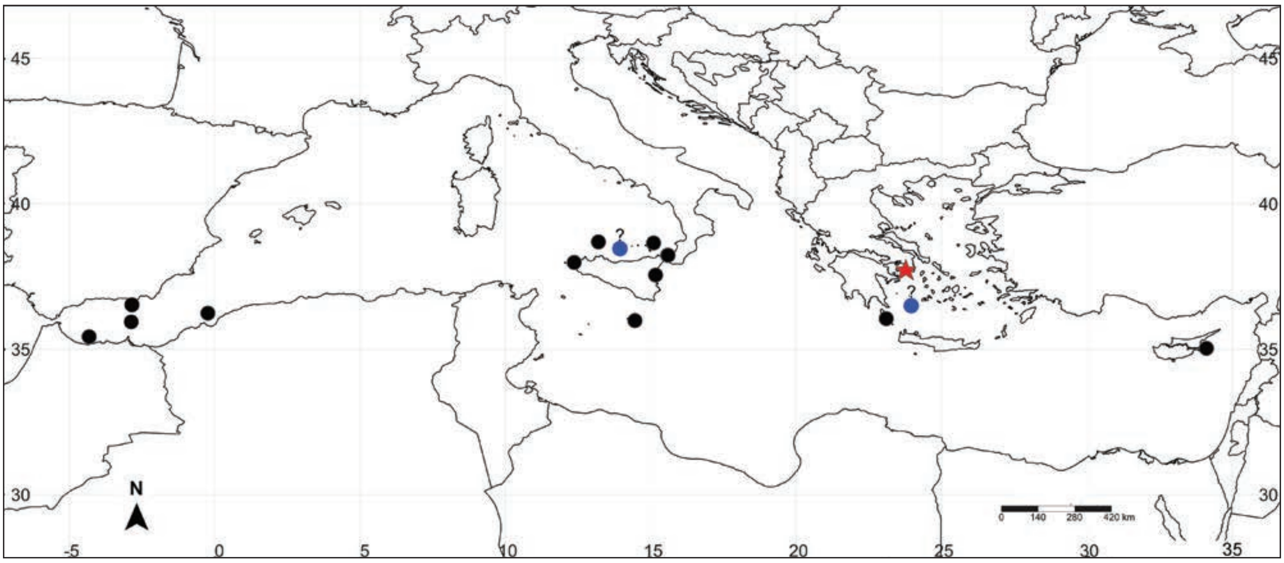

Fig. 1: Distribution of records of *Velolambrus expansus* **in the Mediterranean Sea. Black circles: published records with specified or approximate coordinates; blue circles, published records with unspecified site of collection (south Tyrrhenian Sea and Aegean Sea); red star, present record. Detail in Tab. 1.**

Sl. 1: Razširjenost vrste *Velolambrus expansus* **v Sredozemskem morju na podlagi zapisov o pojavljanju. Črni krogci: objavljeni zapisi z natančnimi ali približnimi koordinatami; modri krogci, objavljeni zapisi z neoznačeno lokaliteto najdbe (južno Tirensko morje in Egejsko morje); rdeča zvezdica, pričujoči zapis o pojavljanju. Detajli v Tab. 1.**

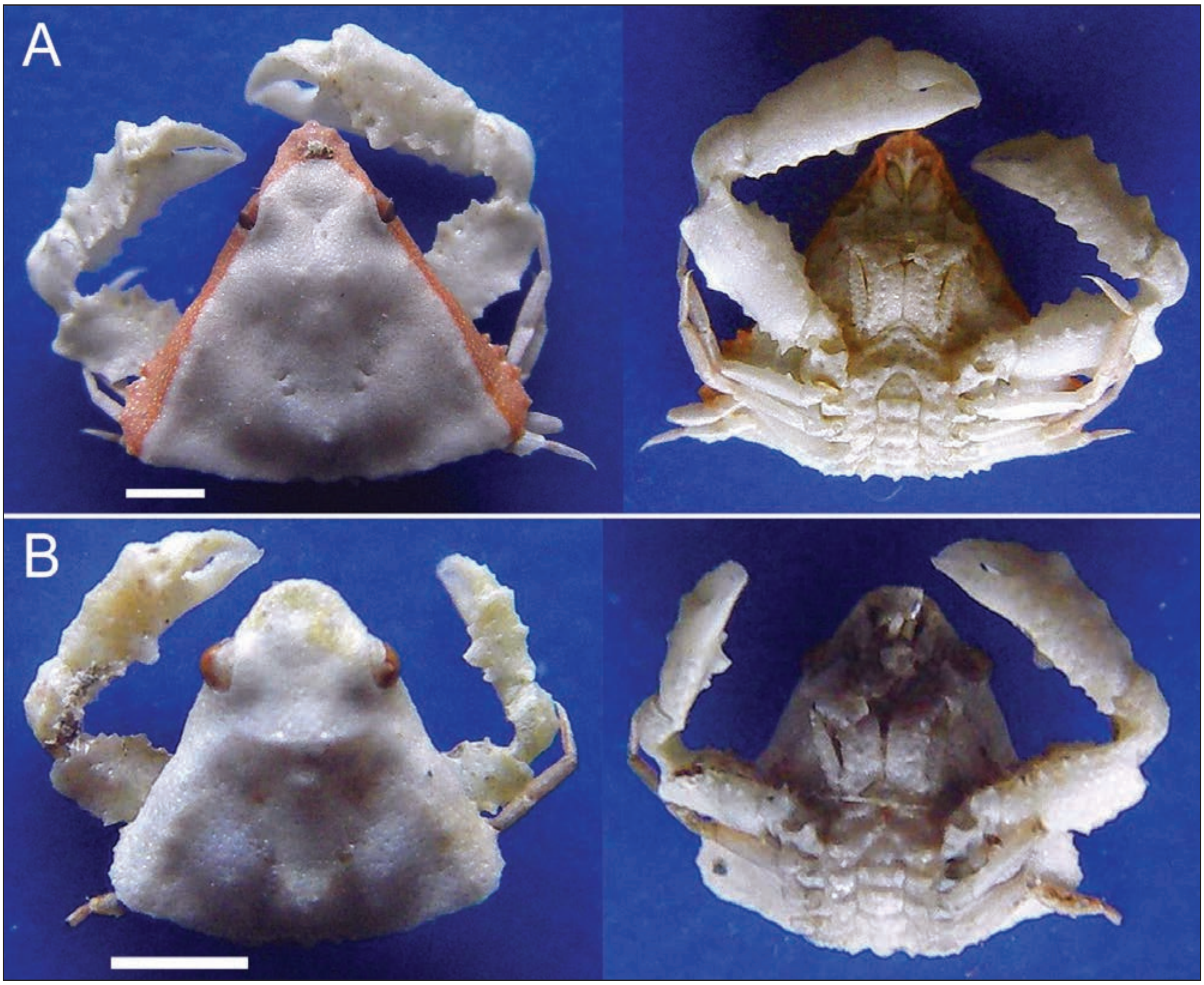

Fig. 2: Dorsal and ventral view of the two male specimens of *Velolambrus expansus* ***from the Saronikos Gulf, Greece. Scale bars: 1 mm (photo: P. Ovalis).***

Sl. 2: Pogled s hrbtne in trebušne strani na dva samca vrste *Velolambrus expansus* ***iz zaliva Saronikos v Grčiji. Merilo: 1 mm (foto: P. Ovalis).***

cles. The expanded lateral margins and the posterior margin of carapace partially cover the ambulatory legs. Carapace grossly smooth but evenly minutely pitted. Gastric region with three prominences. Posterior part of carapace bearing one median and two submedian elevations, median with a tubercle. Oblique, smooth ridge present over each branchial region ending in posterolateral angle and running parallel to lateral margin of carapace. Chelipeds different, heaviest the right in specimen A, the left in specimen B. Upper surface of palm slightly smooth; outer margin bearing ridge with three large blunt teeth, more pronounced in smaller than in larger cheliped. Inner margin of the upper surface of palm bearing about five blunt teeth, middle largest. Merus short and wide, inner margin bearing distinct larger and smaller teeth, on outer margin teeth less conspicuous. Lower margin of merus with longitudinal row of large tubercles, inner surface bearing some scattered tubercles, outer surface almost smooth. In specimen A, antennal article IV same length of antennal article III; in specimen B, antennae were damaged. Telson triangular, broader than long.

Color. Specimen A: front and lateral margins of carapace rose, all the remaining surface of carapace and legs whitish; specimen B: uniformly whitish (Fig. 2).

The size of specimen B was small and not included in the known size range of carapace, CW 5-12 mm and CL 4-10 mm, reported by Manning & Holthuis (1981); it was also smaller than the size of specimens collected in the last forty years in the Mediterranean and listed in Tab. 1. Comparing our specimens with those reported

Tab. 1: References and detail of the records of* Velolambrus expansus *in the Mediterranean Sea (n: number of specimens; CW: carapace width, mm; CL: carapace length, mm).
Tab. 1: Objavljeni zapisi in detajli o pojavljanju vrste* Velolambrus expansus *v Sredozemskem morju (n: število primerkov; CW: širina karapaksa, mm; CL: dolžina karapaksa, mm).

Country	Date	Location	Depth (m)	Coordinates	Bottom	n	Sex	CW	CL	References
Greece	1893	Aegean Sea, NW Crete	160	36.05°N, 23.1°E	Nullipores & coarse sand	1	♂			Adensamer (1896); Holthuis & Gottlieb (1958); Manning & Holthuis (1981)
	1955	Aegean Sea								Koukouras *et al.* (1992, 1993); d'Udekem d'Acoz (1999)
	2022	Aegean Sea, Saronikos Gulf	120	37.7344°N, 23.7692°E	Maërl & muddy sand	2	♂	5.4	4.2	Present study
							♂	3.0	3.0	
Italy	1972	West Ionian Sea, north to the Gulf of Catania	50-60	37.55°N, 15.1667°E	Detritus & organic remains	2	♂			Pastore (1975)
	1983	Ustica Isl.	50-200	~38.6880°N, 13.2025°E		2				Covazzi Harriague *et al.* (2008)
		Panarea Isl.	50-100	~38.6522°N, 15.0982°E		1				
		Levanzo Isl.	50-100	~37.9812°N, 12.3671°E		1				
	1995	Strait of Messina	47	38.2322°N, 15.5831°E	Coralligenous	4	♂	9.9	8.7	Spanò (1998a, 2002); Pipitone & Arculeo (2003); Froglia (2010); Spanò & De Domenico (2017)
			55	38.2353°N, 15.585°E	Coralligenous		♂	10.4	9.5	
			60	38.2317°N, 15.5839°E	Coralligenous		♂	8.4	7.3	
			190	38.2281°N, 15.5942°E	Hard		♀ ovig.	11.9	9.8	
	1992-1996	South Tyrrhenian Sea								Spanò (1998b); Pipitone & Arculeo (2003); Froglia (2010)
Cyprus	2004		68	35.0307°N, 34.1106°E	Maërl	1	♂		9.7	Christodoulou *et al.* (2009)
Malta	1996	Off Qawra,Ghallis	60-100	35.9822°N, 14.4578°E	Maërl	1				Sciberras *et al.* (2009); Mifsud (2017); Hall-Spencer *et al.* (2018)
		Off St Paul's Islands		36.0015°N, 14.4307°E		1				
Spain	1985	Alboran Sea	70-100	36.5267°N, 2.8433°W	Red coral	1	♂	10.4	7.8	García-Raso (1989); Marco-Herrero *et al.* (2015)
	2011-2012		40-150	~35.9372°N, 3.03648°W	Gravel					García-Raso (2012); García-Raso *et al.* (2014)
Morocco	1984	Alboran Sea	170	35.4283°N, 4.3133°W	Shell remains	6	♂	Largest 10		García-Raso (1996)
							♀	Largest 7.5		
								Smallest ovig. 6.8		
Algeria		Western Algeria (Mostaganem-Ghazaouet		~ 36.2369°N, 0.2301°W		Larvae				Seridji R., 1989; Grimes *et al.* (2016); Bakalem A. pers. comm. (2022)

in the literature (Pastore, 1975; García-Raso, 1989; Tan & Ng, 2007; Christodoulou *et al.*, 2009), some morphological characters appear variable, such as the expansions of the lateral margins in the posterior half of carapace and the presence or absence of tubercles in the front and in the lateral ridges. Color polymorphism is observed in this small species: uniform white-grey (Pastore, 1975) as in specimen B, creamy with reddish brown irregular spots as in specimens observed in Madeira (Wirtz, 2020, citing Araújo & Wirtz, 2015), whitish with reddish lateral and frontal margins as the specimen of *V.* cf *expansus* photographed within the Tagoro Volcano complex, Canary Islands, Spain (Sotomayor-García *et al.*, 2019), this last similar to the color of our specimen A.

In the Eastern Atlantic, *V. expansus* has been recorded from Madeira, the Azores, the Canary Islands, and West Africa from Mauritania to the islands of Cape Verde to São Tomé and Annobon islands in the Gulf of Guinea (d'Udekem d'Acoz, 1999). Although the occurrence of this crab is documented from all across the Mediterranean, to date the records of this species in the basin appear scattered, prevalently concentrated in the Alboran Sea and around Sicily (Tab. 1 and Fig. 1).

It is rarely detected likely for its small size and no commercial value and consequent discard during fishing operations, but also for the relatively high depths where it lives and for the mimetic color patterns, as happens in other marine crabs (Tan & Richer de Forges, 1993; Bedini, 2002; Stevens, 2016; Price *et al*., 2019), which render difficult its observation. The species *V. expansus* may be more abundant than expected and palatable for other organisms like fishes. In fact, Chartosia *et al*. (2021) recently documented that the species is a component of the diet of the non-indigenous tetraodontid *Torquigener flavimaculosus* Hardy and Randall, 1983, in Cyprus.

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O POJAVLJANJU RAKOVICE VRSTE *VELOLAMBRUS EXPANSUS* (BRACHYURA, PARTHENOPIDAE) V GRŠKIH VODAH

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POVZETEK

Avtorja poročata o najdbi vrste rakovice Velolambrus expansus *(Miers, 1879) iz družine Parthenopidae v grških vodah Egejskega morja. Gre za redko vrsto v Sredozemskem morju. Avtorja na kratko razpravljata o razširjenosti in podajata listo do zdaj objavljenih zapisov o pojavljanju.*

Ključne besede: Crustacea Decapoda, redke vrste, Sredozemsko morje, razširjenost

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FIRST RECORD OF THE LONG-JAWED SQUIRRELFISH *HOLOCENTRUS ADSCENSIONIS* (OSBECK, 1765) IN THE ADRIATIC SEA

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ABSTRACT

A specimen of Holocentrus adscensionis *(Osbeck, 1765) was observed, photographed and filmed for several days in August 2022 in the shallow rocky zone of the WWF Miramare marine protected area near Trieste (Gulf of Trieste, northern Adriatic). This is the first record of this species in the Gulf of Trieste and in the Adriatic Sea, and the second in the Mediterranean Sea.*

Key words: *Holocentrus adscensionis*, Holocentridae, Atlantic influx, Gulf of Trieste, Mediterranean Sea

PRIMA SEGNALAZIONE DEL PESCE SCOIATTOLO *HOLOCENTRUS ADSCENSIONIS* NEL MARE ADRIATICO

SINTESI

Un esemplare di Holocentrus adscensionis *(Osbeck, 1765) è stato osservato, fotografato e filmato per diversi giorni nell'agosto del 2022 nella zona rocciosa poco profonda dell'area marina protetta WWF Miramare, vicino a Trieste (Golfo di Trieste, Adriatico settentrionale). Si tratta del primo avvistamento di questa specie nel Golfo di Trieste e nell'Adriatico, e del secondo nel Mediterraneo.*

Parole chiave: *Holocentrus adscensionis*, Holocentridae, afflusso atlantico, Golfo di Trieste, Mediterraneo

INTRODUCTION

The ongoing process of biotic globalisation evidenced by the arrival of new species to the Mediterranean Sea is affecting its marine biodiversity at an alarmingly high rate. The number of alien fish species in the Mediterranean has substantially increased after year 2000 with approximately 40% of the total number of fish species arrivals reported after the beginning of the 21st century (Zenetos *et al.*, 2017). Many fish species came to the Mediterranean Sea through the Suez Canal, some through the Strait of Gibraltar, some unaided by human activities (Zenetos *et al.*, 2012), others by following towed oil platforms (Dragičević *et al.*, 2012; Paiuelo *et al.*, 2016). The northernmost portion of the Adriatic Sea is also affected by the invasion of alien fish species from the Red Sea, known as Lessepsian migration (Lipej & Dulčić, 2004).

This paper presents the first record of *Holocentrus adscensionis* (Osbeck, 1765) in Italian and Adriatic waters and proffers a possible explanation for it.

MATERIAL AND METHODS

The shoreline of the Miramare Marine Protected Area (MPA) near Trieste is mainly characterised by structured rocky limestone bottom with many different habitat types, and sediment-bottom areas. On August 14, during a night dive, one of the divers visiting the Miramare MPA (Gulf of Trieste, northern Adriatic Sea), spotted a fish with a distinctive red livery. Alerted at the end of the dive, MPA researchers began an immediate search for the individual, and after two days and more than 300 minutes of diving, on August 16, the team located the specimen hiding among the rocks below the south wall of Miramare Castle at a depth of about 3.5 m (Fig. 1).

The sighting area appears to be a rocky landslide composed of medium-sized limestone boulders covered by turf and colonised mainly by organ pipe sponges (*Aplysina aerophoba*) and black sponges of the genus *Sarcotragus*. The area is characterised by a high density of fish fauna. During the first day of sighting, the researchers focused on taking photographs and video material suitable for identifica-

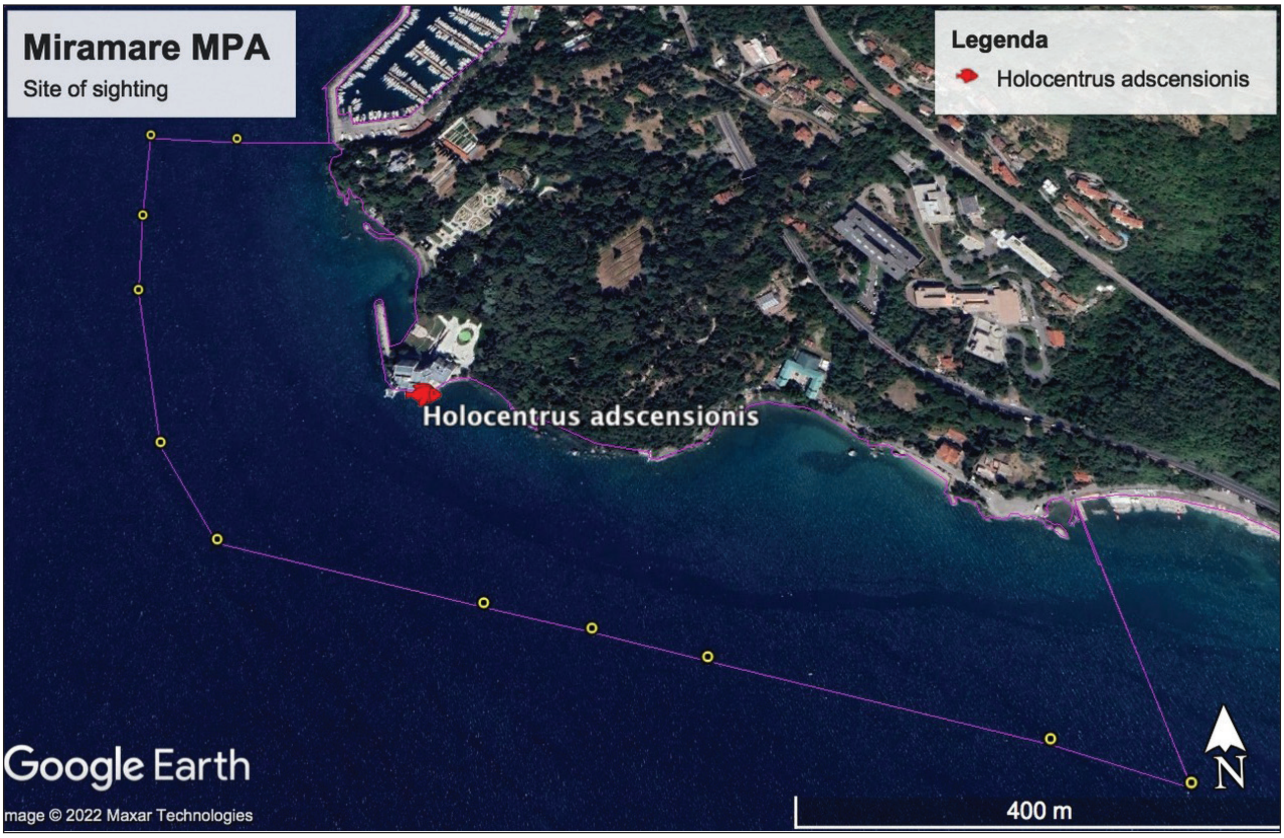

Fig. 1: Map of the study area indicating the locality where the specimen of* Holocentrus adscensionis *was photographed and filmed.
***Sl. 1: Zemljevid obravnavanega območja z lokaliteto, kjer je bil fotografiran in posnet primerek vrste* Holocentrus adscensionis.**

Fig. 2: A specimen of long-jawed squirrelfish** Holocentrus adscensionis**, photographed in the marine protected area of WWF Miramare near Trieste on August 16, 2022.
Sl. 2: Primerek vrste veveričjaka** Holocentrus adscensionis**, fotografiran 16. avgusta 2022 v zavarovanem območju WWF Miramare.

tion. On the following day, they tried to capture the specimen with a hand net. Unfortunately, the specimen eluded capture and the next day, despite intense effort, the researchers were no longer able to spot it.

RESULTS AND DISCUSSION

Based on direct observations, digital photographs and videos, the specimen was identified as a *Holocentrus adscensionis* (Osbeck, 1765) (Fig. 2). The main distinguishing features were the two rather long spines on the head, with the preopercular spine distinctly larger than the opercular one (Fig. 3) (Fischer *et al.*, 1981). In addition, the posterior margin of upper jaw reached the posterior margin of pupil (Uyeno *et al.*, 1983). The anterior part of the dorsal fin with 11 spines was, as usual in this species, yellowish. The anterior part of the soft dorsal fin rays and the upper caudal lobe were distinctly elongate. The dorsal fin was without the evident white spots behind the tip of each spine (Greenfield, 2003) that are typical of a related species, *H. rufus*. The specimen was characterised by a long and oblong body with slender caudal peduncle. The body had a faint pattern of alternating red and white transverse stripes. The breast and belly were white. The front part of the head was dark red with the white streak on the cheek clearly visible.

The specimen was hiding in a small cavity, making rare excursions out of its shelter. During the few exits outside its shelter in the rock crevices it was immediately attacked by different seabream species (genus *Diplodus*).

The long-jawed squirrelfish inhabits the waters of the western Atlantic coast from North Carolina (USA) to Brazil, including the Gulf of Mexico and the Caribbean (Woods & Greenfield, 1978), and of the eastern Atlantic coast from Gabon to Ascension Island (Ben-Tuvia, 1990). The long-jawed squirrelfish feeds on meroplankton, including crab and shrimp larvae, as well as juvenile fish, and mainly during the night (Beets, 1997). During the day it generally hides in the crevices within coral colonies (Greenfield, 1981). The long-jawed squirrelfish prefers structurally more complex habitats, as they offer more shelter place (Ferreira *et al.*, 2004). This was also the case in the Miramare MPA. Since *H.*

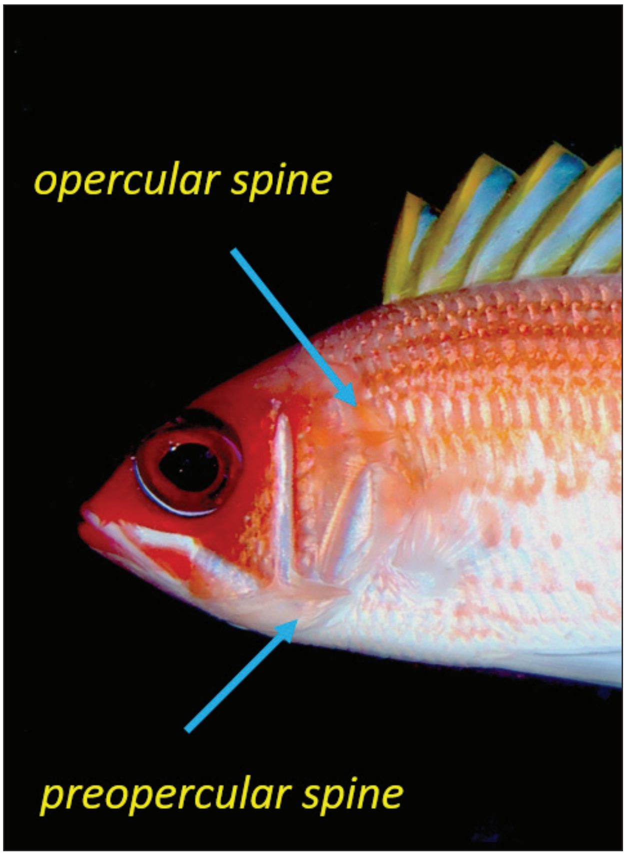

Fig. 3: Head detail of the specimen of** Holocentrus adscensionis **showing opercular and preopercular spines.
Sl. 3: Detajl glave primerka vrste** Holocentrus adscensionis**, na katerem sta vidna operkularni in preoperkularni trn.

Tab. 1: Non-native fish species recorded in the Gulf of Trieste. Legend: AT – species arrived through the Gibraltar Strait (Atlantic influx), AQ – released aquarium fish, LM – Lessepsian migration, M – month, n - number of specimens, I –introduction, Y – year, IT – Italy, and SI – Slovenia.

Tab. 1: Tujerodne in druge vrste, opažene v Tržaškem zalivu. Legenda: AT – vrste, ki so prišle skozi gibraltarsko ožino (atlantski vtok), AQ – ribe, izpuščene iz akvarija, LM – lesepska selitev, M – mesec, n – število primerkov, I – vnos ali prihod, Y – leto, IT – Italija, in SI – Slovenija.

species	locus	Y	M	n	I	source
Plectorhinchus mediterraneus	Miramare (IT)	1993	Aug	1	AT	Lipej *et al.,* 1996
Plectorhinchus mediterraneus	Piran (SI)	1993	Dec	1	AT	Lipej *et al.,* 1996
Epinephelus coioides	Gulf of Trieste (IT)	1998	May	1	LM	Parenti & Bressi, 1998
Terapon theraps	Gulf of Piran (SI)	2007	Aug	1	LM	Lipej *et al.*, 2007
Siganus luridus	Miramare (IT)	2010	Aug	1	LM	Poloniato *et al.,* 2010
Stephanolepis diaspros	Gulf of Piran (SI)	2013	Sep	1	LM	Lipej *et al.,* 2014a
Chrysiptera cyanea	Portorož (SI)	2014	Aug	3	AR	Lipej *et al.,* 2014b
Oplegnathus fasciatus	Trieste (IT)	2015	Sep	1	AT	Ciriaco & Lipej, 2015
Abudefduf saxatilis	Muggia (SI)	2021	Aug	1	AT	Lipej *et al.,* 2021
Holocentrus adscensionis	Miramare (IT)	2022	Aug	1	AT	This work

adscensionis is a nocturnal species, it may have been previously overlooked in Mediterranean waters, as already pointed by Vella *et al*. (2016).

According to Kovačić *et al*. (2020), 444 fish species were confirmed in the Adriatic Sea through an evidence based approach. Their checklist did not include the squirrelfish, so the finding of *H. adscensionis* in the Gulf of Trieste represents an additional species to be added to the Adriatic checklist and the first record in Italian seas. It also represents the second record of this squirrelfish species in the Mediterranean after it was recorded by Vella *et al*. (2016) in Maltese waters. The family Holocentridae comprises about 83 species, which are mostly found in waters below 100 m of depth (Nelson *et al*., 2016). Some of them are important in commercial and recreational fisheries.

Until recently, the redcoat squirrelfish, *Sargocentron rubrum* (Forsskal, 1775) was the only squirrelfish species reported in the Mediterranean basin. It was recorded as early as 1947 by Haas & Steinitz (1947) in Israeli waters and later on the north African coast in Libya (Štirn, 1970). Nowadays, this species is reported to be established (Golani & Ben Tuvia, 1985) and relatively common along the Mediterranean coast of Egypt (*sensu* Farrag *et al*., 2018). The second reported species, as previously mentioned, was the *H. adscensionis* recorded in the Maltese waters of the Mediterranean Sea by Vella *et al*. (2016). Over the past two years another three squirrelfish species have been discovered in Mediterranean for the very first time. In 2021, *Sargocentron spinosissimum* (Temminck & Schlegel, 1843) and *Sargocentron tiereoides* (Bleeker, 1853) were found in the Mediterranean waters of Egypt (Deef, 2021), while in 2022 the first Mediterranean record of silverspot squirrelfish *Sargocentron caudimaculatum* (Rüppell, 1838) was reported from Tunisian waters (Ghanem *et al*., 2022).

Despite their northernmost position, the Gulf of Trieste and the adjacent northern Adriatic Sea have witnessed many alien fish species. Their introductions are well documented, but their number is much lower compared to other Mediterranean areas. The very first alien species documented in the northern Adriatic was the silver pomfret *Pampus argenteus*, which was caught in the waters off Rijeka (Fiume) in 1896 (Dulčić *et al*., 2004). Further new arrivals to the study area (Gulf of Trieste) were not reported until 1993, when a specimen of rubberlip grunt *Plectorchinchus mediterraneus* (Guichenot, 1850) was caught in the waters off Miramare and another in the Bay of Piran (Lipej *et al*., 1996), and in 1998, when an orange-spotted grouper (*Epinephelus coioides*) was captured alive and kept in the Trieste aquarium (Parenti & Bressi, 1998).

Later other alien fish species were reported as well, such as the large-scaled terapon *Terapon theraps* Cuvier, 1829 in the waters off Piran in 2007 (Slovenia) (Lipej *et al.*, 2008), *Siganus luridus* (Rüppell, 1829) at Miramare (Trieste) (Poloniato *et al.*, 2010), the reticulated leatherjacket *Stephanolepis diaspros* (Fraser-Brunner, 1940) in the Bay of Piran (Lipej *et al.*, 2014a), the barred knifejaw *Oplegnathus fasciatus* (Temminck & Schlegel, 1843) in the waters off Muggia (Ciriaco & Lipej, 2015), and the sergeant major *Abudefduf saxatilis* (Linaneus, 1758) at Punta Sottile, Muggia (Lipej *et al.*, 2020). There was also a case of an intentional release of three specimens of blue devil *Chrysiptera cyanea* (Quoy & Gaimard, 1825) from aquaria in the waters off Piran (Lipej *et al.*, 2014b). One of these, which was collected by divers, was kept in the aquarium tank of the Marine Biology Station Piran for many months until it died. Since the majority of alien species were sighted or caught only as single specimens, it is rather difficult to speculate about the means of their arrival to the Gulf of Trieste.

After the first record of *S. luridus* in the Adriatic Sea, obtained through observations, photographs, and videos of a single specimen at Bagno Ducale (Miramare MPA, Trieste) (Poloniato *et al.,* 2010), the species was subsequently also recorded in other parts of the Adriatic Sea (Dulčić *et al.*, 2011). The same occurred with some other mentioned aliens: *T. theraps* was later confirmed in Greek waters, *O. fasciatus* was captured some months after the first record in the waters off Rijeka (Dulčić *et al.*, 2016), and *A. cf. saxatilis/vaigiensis/troschelii* was confirmed in the Adriatic, also by Dragičević *et al.* (2021).

Although a captured specimen that was properly prepared, and stored in a registered museum collection, thus enabling the acquisition of basic biometric and meristic data as well as material for genetic research, would be more appreciated by ichthyologists, high-quality evidence testifying to the occurrence of the species, such as photographs and film recordings, is sufficient to confirm the presence of a species in a certain environment (*sensu* Kovačić *et al.*, 2020). This is especially true with regard to tropical species, which often stand out for their colourful patterns. The photographed records of rare or endangered species are very important and may even constitute the only evidence of the presence of certain species (Lipej *et al.*, 2005). Regular monitoring of alien fish species in the Gulf of Trieste and elsewhere in the Adriatic Sea and in the Mediterranean is an important prerequisite for understanding the impact of newcomers on the native biota. This is also important in the case of squirrelfish species, since some of them (such as *S. rubrum*) have already established viable populations in the eastern Mediterranean Sea. According to some authors, *H. adscensionis,* the long-jawed squirrelfish, is a potentially successful invader since it demonstrates great resilience, being able to survive for many days inside traps and in polluted areas (Wyatt, 1983).

This record of the long-jawed squirrelfish is further evidence of how effective a tool citizen science can be in the monitoring of alien species in the Mediterranean Sea (Crocetta *et al.*, 2017; Tiralongo *et al.*, 2019).

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PRVI ZAPIS O POJAVLJANJU VRSTE VEVERIČJAKA *HOLOCENTRUS ADSCENSIONIS* (OSBECK, 1765) V JADRANSKEM MORJU

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POVZETEK

Na plitvi skalnati brežini znotraj zavarovanega območja WWF Miramare pri Trstu (Tržaški zaliv, severni jadran) so v več avgustovskih dneh opazovali, fotografirali in posneli primerek vrste Holocentrus adscensionis *(Osbeck, 1765). Gre za prvi primer opazovanja te vrste v Tržaškem zalivu in Jadranskem morju ter drugi v Sredozemskem morju.*

Ključne besede: *Holocentrus adscensionis*, Holocentridae, atlantski vtok, Tržaški zaliv, Sredozemsko morje

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FIRST RECORD OF MOONTAIL BULLSEYE *PRIACANTHUS HAMRUR* (OSTEICHTHYES, PRIACANTHIDAE) FROM THE SYRIAN COAST (EASTERN MEDITERRANEAN SEA)

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ABSTRACT

On 18 February 2022, a specimen of moontail bullseye Priacanthus hamrur *(Forsskål, 1775) was caught in a demersal fixed net, at a depth of about 120 m, on muddy bottom. The capture site was at Albassiiah, south of the city of Baniyas, 2 km offshore. This paper reports the first record of* P. hamrur *from the Syrian coast and probably the second record from the Mediterranean Sea.*

Key words: *Priacanthus hamrur,* Priacanthidae, measurements, counts, Levant Basin

PRIMO RITROVAMENTO DEL PESCE OCCHIO GROSSO *PRIACANTHUS HAMRUR* (OSTEICHTHYES, PRIACANTHIDAE) LUNGO LA COSTA SIRIANA (MEDITERRANEO ORIENTALE)

SINTESI

Il 18 febbraio 2022, un esemplare di Priacanthus hamrur *(Forsskål, 1775) è stato catturato in una rete demersale fissa, a una profondità di circa 120 m, su un fondo fangoso. Il luogo di cattura era Albassiiah, a sud della città di Baniyas, 2 km al largo. Questo lavoro riporta il primo ritrovamento di* P. hamrur *lungo la costa siriana e probabilmente il secondo per il Mediterraneo.*

Parole chiave: *Priacanthus hamrur*, Priacanthidae, misure, conteggi, Bacino del Levante

INTRODUCTION

Four priacanthid species have been recorded to date in the Mediterranean Sea, all belonging to the genus *Priacanthus* Oken, 1817: *Priacantus arenatus* Cuvier, 1829, *P. hamrur* (Forsskål, 1775), *P. prolixus* Starnes, 1988 and *P. sagittarius* Starnes, 1988 (Golani *et al.*, 2021).

Among these species, *P. hamrur* displays the widest distribution range. It has been reported from the Pacific, i.e., from French Polynesia to southern Australia and Japan (Fricke, 1999), from the Indian Ocean, specifically, the Red Sea (Golani *et al.*, 2021), and from the Mediterranean Sea.

The first specimen in the Mediterranean Sea to be identified as *P. hamrur* was collected off Mahdia, central Tunisian coast (Abdelmoleh, 1981), and a second one from Turkish waters (Ergüden *et al.*, 2018).

This study aims to report the first occurrence of *P. hamrur* in the Syrian coast and a new record for the Mediterranean Sea.

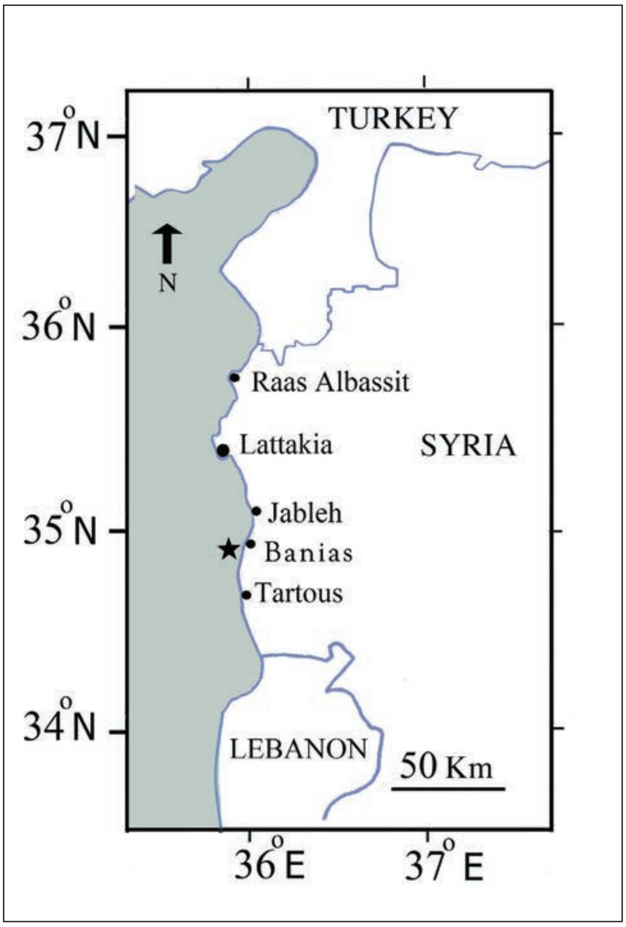

Fig. 1: Map of the Syrian coast with black star indicating the capture site of *Priacanthus hamrur.*
Sl. 1: Zemljevid sirske obale z označeno lokaliteto ulova (črna zvezdica) primerka vrste *Priacanthus hamrur.*

Tab. 1: Morphometric measurements in mm and as percentages of total length (%TL), meristic counts and weight in gram recorded in the specimen of *Priacanthus hamrur* ***captured off the Syrian coast.***
Tab. 1: Morfometrične meritve izražene v mm in kot delež celotne dolžine (%TL), meristična štetja ter teža v gramih primerka vrste *Priacanthus hamrur,* ***ujetega ob sirski obali.***

Reference	**32-2022**	
Morphometric measurements	**mm**	**%TL**
Total length	198	100.0
Standard length	164	82.8
Body depth	60	30.3
Head length	62	31.3
Eye diameter	22	11.1
Snout length	13	6.6
Upper jaw length	23	11.6
Lower jaw length	25	12.6
Dorsal fin length	92	46.5
Pectoral fin length	34	17.2
Pelvic fin length	56	28.3
Anal fin length	64	32.3
Caudal fin length	42	21.2
Pre-dorsal length	54	27.3
Pre-pectoral length	56	28.3
Pre-pelvic length	45	22.7
Pre-anal length	89	44.9
Meristic counts		
Dorsal fin	X + 14	
Pectoral fin	17	
Pelvic fin	I + 5	
Anal fin	III + 15	
Caudal fin	19	
Scales on the lateral line	80	
Vertical scale rows	48	
Gill rakers on the first gill arch	25	
Total body weight (gram)	137	

Fig. 2: *P. hamrur* ***captured in the Syrian coast, scale bar = 20 mm.***
Sl. 2: Primerek vrste *P. hamrur,* ***ujet ob obali Sirije (merilo = 20 mm).***

MATERIAL AND METHODS

On 18 February 2022 a specimen of moontail bullseye, *P. hamrur*, (Forsskål, 1775) was caught by a professional fisherman using a demersal gill net, at a depth of about 120 m, on muddy bottom. The capture site was located at Albassiiah, south of the city of Baniyas, 2 km offshore: 35°09¢ N; 35°53¢ E (Fig. 1). Morphometric measurements were recorded to the nearest millimetre and presented as percentages of total length (% TL), and included in Table 1 together with meristic counts. The specimen was preserved in 10% buffered formalin, and deposited in the Ichthyological Collection of Environmental Research Higher Institute, Tishreen University, under catalogue number 32-2022.

RESULTS AND DISCUSSION

The specimen of moontail bullseye, *P. hamrur*, measured 198 mm in total length (TL) and weighed 137 g (Fig. 2). It was a mature female and its stomach contained several unidentifiable remains of squid. The specimen was identified *via* the following features (see Ergüden *et al.*, 2018): body ovate, its depth 2.7 times in standard length, mouth oblique with projecting lower jaw, its extremity above level of midline of body, scale rows between dorsal fin and lateral line at highest point 11, pelvic fins less than head length, soft dorsal fin moderately long,

Tab. 2: Number of gill rakers recorded in *P. hamrur* ***and*** *P. sagittarius* ***specimens captured in different areas, including the Syrian specimen.***
Tab. 2: Število škržnih listov pri primerkih vrst *P. hamrur* ***in*** *P. sagittarius****, ujetih v različnih predelih, upoštevaje tudi sirski primerek.***

Species	**Number of gill rakers**	**Ocean of region**	**Authors**
Priacanthus hamrur (?)	18	Tunisia	Abdelmoleh (1981)
P. hamrur	24-26	Indo-Pacific	Starnes (1988)
P. hamrur	24-26	Indian Ocean	Philipp (1994)
P. hamrur	26	Levant Basin	Ergüden *et al.* (2018)
P. hamrur	25	Levant Basin	This study
P. sagittarius	19-22	Indo-Pacific	Starnes (1988)
P. sagittarius	19-21	Indian Ocean	Ramachandran & Varghese (2009)
P. sagittarius	18	Levant Basin	Goren *et al.* (2010)
P. sagittarius	18	Levant Basin	Golani *et al.* (2011)
P. sagittarius	22	Egypt	Farrag *et al.* (2016)
P. sagittarius	19	Levant Basin	Gürlek *et al.* (2021)

pelvic fin membranes with single dark basal blotch, caudal fin margin concave or lunate, outer rays slightly longer than remainder of rays; body pink to reddish with some red bands and some small dark spots along the lateral line, fins red to light pink, pelvic fins red with a black spot at the fin base.

The morphology, morphometric measurements, meristic counts and colour are in total accordance with previous descriptions of *P. hamrur* by Starnes (1988), Ramachandran & Varghese (2009), Ergüden *et al.* (2018) and Golani *et al.* (2021). Therefore, this is the first substantiated record of *P. hamrur* from the Syrian coast, warranting the inclusion of the species in the list of local ichthyofauna. *P. hamrur* was first considered to be a casual species (Zenetos *et al.*, 2005), but its status was later amended to questionable in the central and eastern Mediterranean (Zenetos *et al.*, 2010). The change was related to a specimen originally identified as *P. hamrur* collected off Mahdia, Tunisia (Abdelmoleh, 1981). Starnes (1988) and Golani (2002) noted that the description and the photograph provided by Abdelmoleh (1981) were not sufficient to conclusively establish the identity of the specimen, which should have been confirmed through agreement with Goren *et al.* (2010).

Starnes (1988) noted that the number of gill rakers on the first gill arch plays a major role in distinguishing between the species of the genus *Priacanthus*. As evidenced by Table 2, the number of gill rakers is higher in *P. hamrur* than in *P. sagittarius*. Based on these results, Abdelmoleh's finding (1981) was not a specimen of *P. hamrur* and should be reassigned to *P. sagittarius*. It follows that the first Mediterranean record of *P. hamrur* was reported by Ergüden *et al.* (2018), and the second one in this note. Nevertheless, Abdelmoleh's finding still constitutes the first confirmed report of an alien member of the Priacanthidae from the Mediterranean Sea. Such hypothesis is further corroborated by the fact that *P. sagittarius* was described by Starnes (1988) posteriorly to Abdelmoleh's finding (1981).

All Priacanthid species inhabit similar biotopes at similar depths and do not differ much in their food and feeding habits (Starnes, 1988). Interspecific competition pressure among them cannot be totally ruled out, and it appears that nowadays *P. sagittarius* is the species most successfully established in the area of the Mediterranean. The occurrence of *P. hamrur* is based on two specimens only, and the status of the species in the Mediterranean Sea pending possible captures of other specimens incoming from the Red Sea through the Suez Canal remains obscure.

PRVI ZAPIS O POJAVLJANJU LUNASTOREPEGA VELIKOOKEGA OSTRIŽA *PRIACANTHUS HAMRUR* (OSTEICHTHYES, PRIACANTHIDAE) S SIRSKE OBALE (VZHODNO SREDOZEMSKO MORJE)

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POVZETEK

Osemnajstega februarja 2022 so v pridneno ribiško mrežo ujeli primerek lunastorepega velikookega ostriža Priacanthus hamrur *(Forsskål, 1775) na globini okoli 120 m na muljastem dnu. Ulovili so ga blizu lokalitete Albassiiah, južno od mesta Baniyas, 2 km od obale. Ta prispevek poroča o prvem zapisu za vrsto* P. hamrur *s sirske obale in verjetno o šele drugem primeru najdbe te vrste v Sredozemskem morju.*

Ključne besede: *Priacanthus hamrur,* Priacanthidae, meritve, štetja, levantski bazen

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SREDOZEMSKI MORSKI PSI

SQUALI MEDITERRANEI

MEDITERRANEAN SHARKS

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DISTRIBUTION AND STATUS OF THE GREAT WHITE SHARK, *CARCHARODON CARCHARIAS*, IN TURKISH WATERS: A REVIEW AND NEW RECORDS

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ABSTRACT

The occurrence of Carcharodon carcharias *in Turkish waters has been reported since the end of the 19th century. A total of 77 records of great white shark have been compiled from 1881 to 2020. The available data suggest that the species occurs in Turkish waters throughout the year. The occurrences of adult specimens have shown a remarkable decrease during this period, nevertheless, the species has not been extirpated from the region. The present study demonstrates that the distribution of* C. carcharias *in Turkish waters has seen a significant regional shift over time, with the current distribution of young-of-the-year and juveniles extending from the central to northern Aegean Sea and concentrating in the Bay of Edremit.* C. carcharias *has been recently declared as a species under protection in Turkish waters, but the next steps towards providing better protection for the species in the region are urgently required.*

Key words: nursery, management, conservation, eastern Mediterranean, Lamnidae, coastal fishery

DISTRIBUZIONE E STATUS DEL GRANDE SQUALO BIANCO, *CARCHARODON CARCHARIAS*, NELLE ACQUE TURCHE: RASSEGNA E NUOVE SEGNALAZIONI

SINTESI

La presenza di Carcharodon carcharias *nelle acque turche è stata segnalata dalla fine del XIX secolo. Dal 1881 al 2020 sono state raccolte 77 registrazioni di squali bianchi. I dati disponibili suggeriscono che la specie è presente nelle acque turche durante tutto l'anno. La presenza di esemplari adulti ha mostrato una notevole diminuzione durante questo periodo, tuttavia la specie non è stata estirpata dalla regione. Il presente studio dimostra che la distribuzione di* C. carcharias *nelle acque turche ha subito un significativo spostamento regionale nel corso del tempo, con l'attuale distribuzione dei giovani dell'anno e del novellame che si estende dall'Egeo centrale a quello settentrionale e si concentra nella Baia di Edremit. Lo squalo bianco è stato recentemente dichiarato specie sotto protezione nelle acque turche, ma i prossimi passi per fornire una migliore protezione alla specie nella regione sono urgenti.*

Parole chiave: nursery, gestione, conservazione, Mediterraneo orientale, Lamnidae, pesca costiera

INTRODUCTION

The great white shark, *Carcharodon carcharias* (Linnaeus, 1758) (Lamniformes: Lamnidae), has been the focus of both naturalists and scientists since the Middle Ages (De Maddalena & Heim, 2012). For example, in the book entitled *De aquatilibus*, the 16th century French naturalist Petrus Bellonius gave brief information about the great white shark (referred to as *Canis carcharias*), which is considered one of the earliest descriptions of *C. carcharias* (Bellonius, 1553). Another 16th century French naturalist, Guillaume Rondelet, narrated of the discovery of an armoured knight following the evisceration of an enormous great white shark caught off the coast of Marseilles and noted one of the earliest observations on the predatory behaviour of *C. carcharias* (Steel, 1985). Due to significant popular and scientific intrest that it arouses, *C. carcharias* is today considered a "flagship species" in all aspects of shark research and conservation efforts, and in public perception it has changed from a sea monster into a charismatic member of marine megafauna (Mazzoldi *et al.*, 2019).

According to Compagno (2002), *C. carcharias* is a huge and formidable shark, inhabiting both coastal and offshore waters over continental and insular shelves in temperate seas. It is circumglobal, commonly occurring in most temperate seas, including the Mediterranean Sea, and less common in tropical regions (Ebert & Stehmann, 2013). *C. carcharias* is a very active, nomadic and social lamnid shark, whose regional occurrence is remarkably effected by migration (e.g., bluefin tuna, *Thunnus thynnus*) or coastal communities (e.g. pinnipeds) of its prey species. Although the seasonal occurrence of the great white shark in coastal or insular waters in certain localities worldwide is clearly associated with the presence of coastal populations of pinnipeds (e.g., South African [Cape] fur seal, *Arctocephalus pusillus pusillus*, or California sea lion, *Zalophus californianus*; Kelly & Klimley, 2003; Martin *et al.*, 2005; Johnson *et al.*, 2009), its occurrence in the Mediterranean Sea is closely associated with the migrations of *T. thynnus* (De Maddalena, 2000; Kabasakal, 2016; Barrull & Mate, 2001; Soldo & Jardas, 2002; Galaz & De Maddalena, 2004; De Maddalena & Heim, 2012; Morey *et al.*, 2003).

Publications on several aspects of the life history of the great white shark in the Mediterranean Sea, where currently 779 confirmed cases have been recorded (Moro *et al.*, 2020; Jambura *et al.*, 2021), include regional occurrence records of single or few individuals (e.g, Celona, 2002; Galaz & De Maddalena, 2004; Soldo & Dulčić, 2005; Celona *et al.*, 2001; Maliet *et al.*, 2013; Tiralongo *et al.*, 2020; Jambura *et al.*, 2021), reviews of regional abundance and distribution (e.g,. De Maddalena, 2000; Barrull & Mate, 2001; Soldo & Jardas, 2002; Morey *et al.*, 2003; Maliet *et al.*, 2013), and assessments of Mediterranean population as a whole (e.g, Fergusson, 1996; Gubili *et al.*, 2010; De Maddalena & Heim, 2012; Boldrocchi *et al.*, 2017; Moro *et al.*, 2020).

Although the first records of *C. carcharias* in Turkish waters were reported from the Bosphorus Strait, the far northern extension of the Mediterranean ecosystem, as early as the end of the 19th century (Fergusson, 1996), the occurrence of the great white shark in the region has been mentioned in only a few 20th century ichtyhological inventories (Deveciyan, 1926; Ayaşlı, 1937; Akyüz, 1957; Akşıray, 1987). Apart from occasional reports on the capture of this megashark in the urban waters of Istanbul city, which is also known as Bosphorus, accompanied with catchy photograps, appearing in newspapers up to the early 1970s (Kabasakal, 2003), an inexplicable paucity of *C. carcharias* specific studies characterised the entire 20th century. However, with the beginning of the 2000s this situation changed and the number of studies and publications specifically devoted to great white sharks occurring in Turkish waters has steadily increased (Kabasakal 2003, 2008, 2011, 2014, 2016, 2020a,b,c,d; Kabasakal & Gedikoğlu, 2008; Kabasakal & Bayrı, 2020, 2021; Kabasakal *et al.*, 2009, 2018). The present article provides a review of the existing literature and new records on the occurrence, distribution, and status of the great white shark in Turkish waters. More specifically, this article reviews (1) spatial and seasonal distribution of *C. carcharias* in Turkish waters, (2) seasonal and spatial distribution of length groups, (3) potential nursery areas, and (4) fishery and human interaction in the study region.

MATERIAL AND METHODS

Study area

Turkey is a peninsular country, surrounded by the Black, Aegean and Levantine Seas and the Turkish Straits system, which stretches along the Dardanelles Strait, the Sea of Marmara and the Bosphorus Strait (Fig. 1). Generally speaking, the most prominent oceanographical pecularities of the seas around Turkey are as follows: the high hydrogen sulphide concentration prevailing below 150 to 200 m in the Black Sea is an important factor preventing the dispersal of fishes in the deep zones. The TSS plays a significant if not decisive ecological role in the dispersal of living organisms between the Mediterranean and Black Seas, since it constitutes a barrier, a corridor, or an acclimatisation zone for marine species. The Aegean Sea is topographically divided by (approximately) the 38° parallel into two basins, i.e., the North and South Aegean, where the North Aegean Sea is an area characterised by cold-water fauna, and the South Aegean Sea by warm-water fauna, including Lessepsian migrants. Finally, with the opening of the Suez Canal in 1869 and the general warming of the world oceans, the Mediterranean Sea has been impacted by the phenomenon known as "tropicalisation", which causes the retreating of temperate species towards colder areas of the basin. Recent studies have revealed the occurrence of 38 shark species in Turkish waters (Kabasakal, 2021; Turan *et al.*, 2021).

Data sources and collection

Data on the great white sharks were collected from the following sources: (a) articles published in peer-reviewed journals, (b) specimens recorded in old historical inventories (Deveciyan, 1926; Ayaşlı, 1937; Akyüz, 1957; Akşıray, 1987), (c) news reports on the capture of great white sharks in Turkish waters published in old newspapers between the late 19th and the late 20th centuries, (d) social media posts reporting on the capture of great white sharks shared on Facebook, Instagram, and YouTube, collated as digital sources, and (e) unpublished records, which mostly consist of observations by citizen scientists. For each of the records, the following data were collected, if available: date, locality of capture, total length (TL), total weight (TW), sex, type of data source (scientific reference, old ichthyological record, old newspaper record, online source or citizen science observation data), and remarks (e.g. stomach contents, presence of human remains, type of fishing gear, presence of birth mark, and the outcome after landing the shark). Unless otherwise stated, all sizes are TL, in the measurement of which the shark is held belly down with its dorsal caudal-fin lobe depressed into line with its body axis and the TL is measured as a point to point distance (not over the curve of the body) from the snout tip to the tip of the dorsal caudal-fin lobe (Compagno, 2002). Collated data are presented in the Turkish Great White Shark Data Archive (TGWSDA, Appendix 1). To allow the identification and mapping of the approximate locality of a possible nursery ground of *Carcharodon carcharias* in Turkish waters, data on the pregnant females, newborns and juveniles were treated as high priority. A newborn shark is defined as a specimen with an open or healing birth mark (or umbilical scar) between the pectoral fins on the belly (De Maddalena & Heim, 2012). To provide a visual guideline for a quick crosscheck, historical and contemporary photographs of the respective great white shark were shown side by side, as proposed by Kabasakal & Bayrı (2021).

The age classification of great white sharks was based on the following four length categories (Boldrocchi *et al.*, 2017): young-of-the-year (YOY) (≤175 cm TL), juveniles (>175-300 cm TL), subadults (>300–360 cm TL, males; >300–450 cm TL, females), and adults (>360 cm TL, males; >450 cm TL, females). When sex was not recorded, a threshold of maturity was set at >450 cm TL, which would include adult males and most maturing females (Boldrocchi *et al.*, 2017).

Data analysis

The great white shark records listed in the TGWSDA (Appendix 1) were analysed for spatial and temporal distribution in Turkish waters and by shark size to identify possible spatial patterns in the subregions of Turkish seas. The subregional and temporal distribution of *C. carcharias* in Turkish waters by shark size was investigated using the Wilcoxon test (α=0.05). An ANOVA test was used to investigate the seasonal occurrence of great white sharks across subregions and the influence of type of fishing gear on the TL of captured fish (p=0.05). The chi-square test was used to investigate the differences between subregions (p=0.05). Statistical analyses were performed using the Analysis ToolPak Excel software.

RESULTS

Spatial distribution of the great white shark in Turkish waters

Between 1881 and 2020, 77 records of *Carcharodon carcharias* were collected. Most of them originated from the Aegean Sea (n=32, 41.5%), followed by the Sea of Marmara (n=23, 29.8%) and the Bosphorus Strait (n=20, 25.9%). The Dardanelles Strait and the Bay of İskenderun are each represented by 1 record (1.3%). All records of *C. carcharias* from the Bosphorus Strait and the Sea of Marmara consisted of historical or old captures of the great white shark, while the majority of the Aegean Sea records were recent captures dating from the early 2000s (n=28, 36.3% of all records). Related data and remarks concerning these records are listed in the TGWSDA (Appendix 1).

Records of *C. carcharias* from both the Bosphorus Strait and the Bay of Edremit are of special importance due to their proximity to urban areas (Fig. 1). The Bosphorus Strait records in particular contain reports of very large great white sharks which were in some cases caught just a few hundred meters off the coast of a metropolitan centre (Istanbul). A similar metropolitan affinity can be observed in records of *C. carcharias* in the Sea of Marmara, where most of

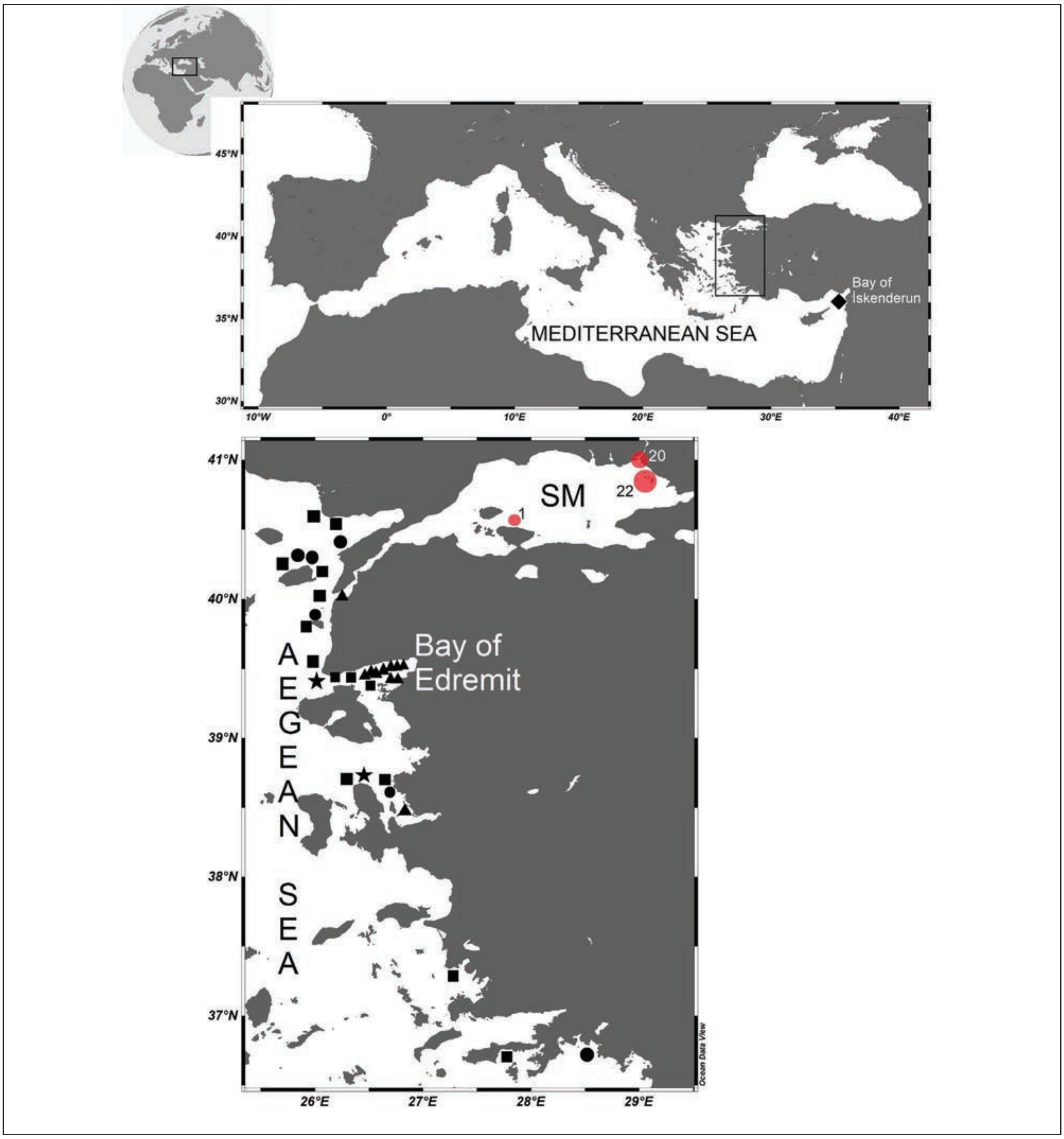

Fig. 1: Spatial distribution of great white sharks (n=77) in Turkish waters. On the map of the Mediterranean Sea, the sign (♦) indicates the specimen reported by Akyüz (1957; sp. no. 21 in Appendix 1); on the map below, the solid red circles indicate localities of historical records of C. carcharias in the waters of the Bosphorus Strait (total n=20) and the Prince Islands (total n=22), and the single specimen sighted off Kapıdağ Peninsula in 1985 (sp. no. 44 in Appendix 1); the (▲), (■) and (●) symbols indicate YOY, juvenile, and adult specimens of Carcharodon carcharias recorded in Turkish Aegean waters, respectively.

Sl. 1: Razširjenost belega morskega volka (n=77) v turških vodah. Na zemljevidu Sredozemskega morja diamant (♦) označuje primerek, o katerem poroča Akyüz (1957; primerek št. 21 v Prilogi 1); polni rdeči krogci na spodnji mapi Bosporske ožine in Prinčevih otokov označujejo lokalitete, kjer so v preteklosti poročali o belih morskih volkovih (skupno število = 22) in o primerku, opaženem ob polotoku Kapıdağ Peninsula leta 1985 (primerek št. 44 v Prilogi 1). Ostali znaki: enoletni (▲), mladostni (■) in odrasli primerki (●) belega morskega volka v turških egejskih vodah.

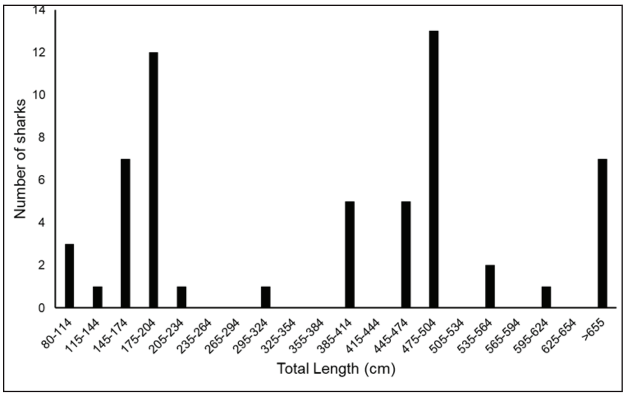

Fig. 2: Length-frequency distribution of the great white shark in Turkish waters for both sexes combined (n=58).
Sl. 2: Velikostna porazdelitev dolžin belega morskega volka v turških vodah za oba spola (n=58).

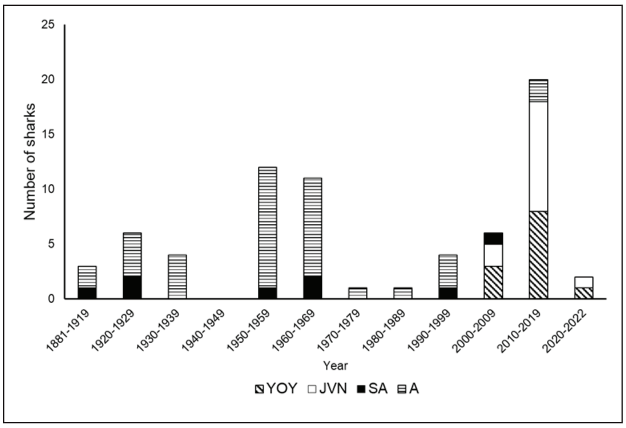

Fig. 3: Distribution of age classes of the great white shark in Turkish waters from 1881 to 2022 (n=70). YOY: young-of-the-year; JVN: juvenile; SA: subadult; A: Adult.
Sl. 3: Porazdelitev starostnih skupin belega morskega volka v turških vodah v obdobju 1881-2022 (n=70). YOY: enoletni; JVN: mladostni; SA: pododrasli; A: odrasli primerki.

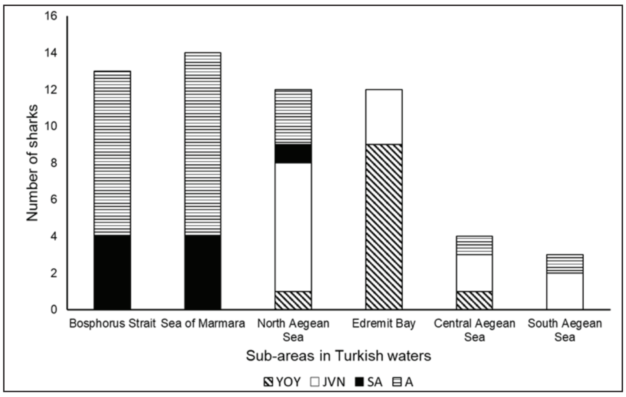

Fig. 4: Subregional distribution of the great white shark in Turkish waters by age class (n=58). YOY: young-of-the-year; JVN: juvenile; SA: subadult; A: Adult.
Sl. 4: Subregionalna porazdelitev belega morskega volka v turških vodah glede na starostne razrede (n=58). YOY: enoletni; JVN: mladostni; SA: pododrasli; A: odrasli primerki.

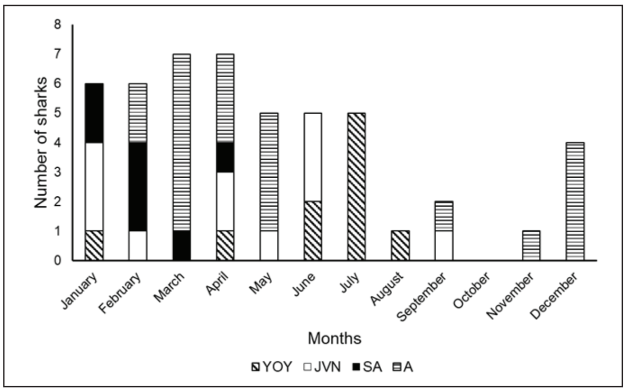

Fig. 5: Monthly distribution of the great white shark in Turkish waters by age class (n=39). YOY: young-of-the-year; JVN: juvenile; SA: subadult; A: Adult.
Sl. 5: Mesečna porazdelitev belega morskega volka v turških vodah glede na starostne razrede (n=39). YOY: enoletni; JVN: mladostni; SA: pododrasli; A: odrasli primerki.

the captures occurred in the Prince Islands region, characterised by dense human population. Records of *C. carcharias* from the Bay of Edremit (northeastern Aegean Sea), a popular tourist destination in summer with resultant hundred thousands of seasonal visitors, consist of YOY and juveniles (n=12, 15.5% of all Turkish records and 37.5% of all Aegean records).

Length distribution

A total of 58 records included information on the shark length. The sizes of the recorded great white sharks (TL) ranged from 80 cm (YOY) to an estimated 800 cm (mean 377.08±202.63 cm, Fig. 2), including all size classes, from YOY to very large adults. The TL ranges of males (n=5) and females (n=16) examined in the present study were 125.5-500 cm (mean 234.1±152.28 cm) and 85-700 cm (419.31±201.4 cm), respectively.

The study identified a significant correlation between year of capture and TL (W=0, p=0.05). The majority of the very large great white sharks (≥500 cm TL) were specimens captured between the 1880s and the 1970s. After that, the occurrence of very large sharks remarka-

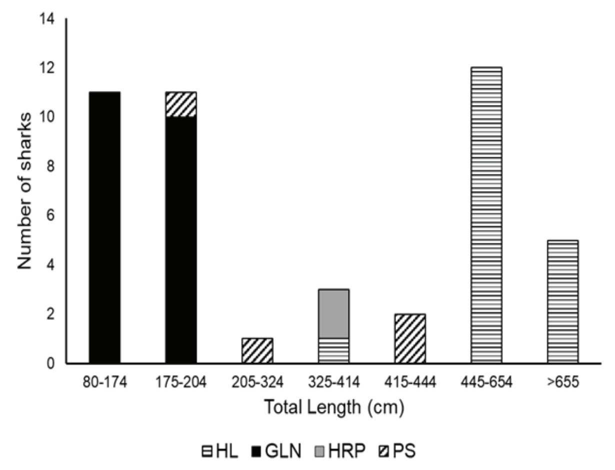

Fig. 6: Distribution of the fishing gear used in capturing the great white sharks in Turkish waters and age classes of the captured specimens (n=45). HL: hand-line; GLN: gill-net; HRP: harpoon; PS: purse-seine.

Sl. 6: Porazdelitev uporabljenega ribolovnega orodja za ulov belega morskega volka v turških vodah in starostni razredi ujetih primerkov (n=45). HL: trnek; GLN: zabodna mreža; HRP: harpuna; PS: zaporna plavarica.

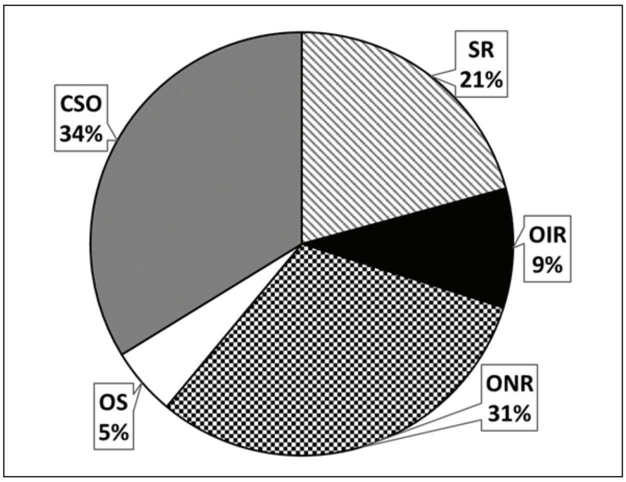

Fig. 7: Distribution of data sources: (SR) scientific reference, (OIR) old ichthyological reports or inventories, (CSO) citizen scientist observations, (OS) online or digital sources, and (ONR) old newspaper reports (n=77).

Sl. 7: Porazdelitev podatkovnih virov: strokovna literatura (SR), stara ihtiološka poročila ali inventarizacije (OIR), podatki dobljeni s pomočjo ljubiteljske znanosti (CSO), spletni in digitalni viri (OS) in starejši podatki, objavljeni v časopisih (ONR) (n=77).

bly decreased, while the numbers of YOY and juveniles increased (Fig. 3). With regard to regional distribution of length groups, adult great white sharks mostly occurred in the Sea of Marmara and the Bosphorus Strait. Aegean Sea records of *C. carcharias* were dominated by YOY and juveniles, with very few records of adult specimens collected from this region (Fig. 4). Although a difference was identified in the regional distribution of length groups, it was not statistically significant (W=3, p=0.05; ANOVA, F=3.58, p=0.904).

Seasonality of occurrences

The study revealed a significant influence of seasonality on the distribution of length groups (W=9, p=0.05). In Turkish waters, subadults and adults of *Carcharodon carcharias* were mostly observed between early autumn and early summer, the YOY mostly during summer. The occurrence of juveniles was more prominent in early autumn, and from early winter to early summer. All size groups were present from January to June, except for the YOY, which were only recorded from July to early August (Fig. 5).

Fisheries interactions and size groups

Data on the type of fishing gear and shark length were available for 45 individuals (Fig. 6). The analysis showed a significant difference between the type of fishing gear and length of the great white shark (ANOVA, F=4.121, p<0.05). Almost half of the great white shark bycatch occurred during artisanal coastal gill-net fishery (46.67%), followed by handlining for bluefin tuna (40%), purse seining (8.89%) and harpooning for sword fish (4.44%). The majority of the YOY and juveniles were recorded as bycatch in artisanal gill-net fishery (n=21, 91.3%); however, adults of *Carcharodon carcharias* were mostly captured by bluefin tuna handliners (n=17, 77.27%).

Reproduction and a potential nursery ground in the Bay of Edremit

With regard to length groups, 32.47% (n=25) of *Carcharodon carcharias* records were related to YOY and juveniles (Fig. 2), of which 11 specimens were YOY (44%) and 14 were juveniles (56%). The distribution of records of YOY and juveniles in Turkish waters extends from central to northern Aegean Sea and is concentrated in the Bay of Edremit (Fig. 1). A Bay of Edremit specific chi-square test showed a significant difference between the distribution of the YOY and other length groups (X^2, p<0.05, p=0.0001). No pregnant females were recorded in Turkish waters.

Stomach contents and human interactions

The stomach contents of 8 great white sharks are presented in Appendix 1. The prey of adult great white sharks (n=3, TL range 400-800 cm) included remains or whole specimens of large bony fishes, such as *T. thynnus*, *Sarda sarda* and *Xiphias gladius*; teleosteans *Lophius* sp., *Belone belone* and *Merluccius merluccius* were found in the stomach contents of one juvenile (TL 180 cm). Human clothing - 3 pairs of boots and a fez, traditional Ottoman men's headwear - was found in the stomach contents of an adult great white shark with a reported length of 500 cm, caught on 2 February 1926 (sp. no. 9 in Appendix 1), but no human remains. *C. carcharias* was the prime suspect in 80 % of shark attacks on boats and swimmers occurring between 1931 and 1983 (Kabasakal & Gedikoğlu, 2015). There was another fatal shark attack, occurring on 7 June 1967 in the northeastern Sea of Marmara (Kabasakal & Gedikoğlu, 2015), in which the suspected species was also *C. carcharias*, but the incident is not included in the TGWSDA due to the lack of reliable evidence.

Overview of data sources

Citizen scientist observations were the major source of data (CSO, 34% of total records) forming the TGWSDA, followed by old newspaper reports (ONR, 31%), scientific references (SR, 21%), old ichthyological inventories (OIR, 9%), and online references (OR, 5%) (Fig. 7). The analysis indicated a significant difference in the temporal distribution of types of data sources (X^2, $p<0.05$, $p=0.003$).

New records

Eleven out of the 77 great white sharks in the TGWSDA included unpublished records of *Carcharodon carcharias* (Appendix 1). One in these 11 unpublished records reported on a historical catch of *C. carcharias* in the Sea of Marmara in 1936 (sp. no. 13 in Appendix 1; Fig. 8), and the remaining 10 records (90.9% sp. nos. 51, 52, 58, 62, 63, 66, 67, 69, 70, and 74 in Appendix 1) referred to incidental captures of the great whites in the Aegean Sea since 2009 (Appendix 1).

DISCUSSION

The first assessment of the distribution and status of *Carcharodon carcharias* in Turkish waters included 46 great white sharks recorded between 1881 and 2011 (Kabasakal, 2014). In this second assessment almost ten years afterwards, the number of individuals available nearly doubled, despite relying heavily on opportunistic data collection. Due to the nature of the data collection method not all of the basic information (e.g, TL, TW, type of fishing gear, locality of capture, biological remarks) are always available for each specimen. Therefore, the interpretation of results based on opportunistic research findings presents more limitations when compared to the results of research programs employing systematic, long-term and conventional scientific methods. Also, opportunistic research may often include limited information and inaccurate measurements (McPherson & Myers, 2009). For example, the size of very large great white sharks, reported at 800 cm in historical records, especially in old newspaper reports, is mostly regarded with suspicion by great white shark experts. However, in the absence of quantifiable scientific data, opportunistic data have the potential to provide valuable insights into several aspects of the life history of *C. carcharias* (De Maddalena & Heim, 2012; Boldrocchi *et al.*, 2017; Moro *et al.*, 2020).

Our study demonstrates that the distribution of *C. carcharias* in Turkish waters underwent a significant regional shift over time. While the presence of *C. carcharias* in Turkish waters had been doubted or even denied in the past, the historical presence of the species in the region has been demonstrated by ever-growing evidence (Fergusson, 1996; Kabasakal, 2003, 2011, 2020; Kabasakal & Bayrı, 2021) and its contemporary occurrence in Turkish Aegean waters supported by new evidence (Kabasakal & Kabasakal, 2004, 2015; Kabasakal & Gedikoğlu, 2008; Kabasakal *et al.*, 2009, 2018). It is therefore time to end the skepticism and even stubborn denial of the existence of *C. carcharias* in Turkish waters in the face of all evidence, and instead take the necessary steps to ensure the survival, occurrence, and reproduction of this valuable population in the Aegean Sea.

The maximum length and weight of *C. carcharias* have always been subject of debates among great white shark experts (Randall, 1973; Mollet *et al.*, 1996; De Maddalena *et al.*, 2001). Randall (1973) stated that TL size of the great white shark can reach up to 750 or even 800 cm; Mollett *et al.* (1996), on the other hand, emphasised that the reported TL for specimens exceeding 600 cm can be rough estimations at best or mere speculation. Nevertheless, based on a detailed morphometric analysis of two very large great white sharks caught in Maltese and Australian waters, Mollet *et al.* (1996) also stated that a *C. carcharias* can attain 700 cm in TL. The major problem with very old photographs, newspapers or ichthyological records depicting *C. carcharias* specimens is that they contain no appropriate visual reference that could be used for obtaining accurate data on the length of the specimens through visual analysis (De Maddalena & Heim, 2012; De Maddalena *et al.*, 2001). Based on a visual analysis of several old photographs of *C. carcharias* specimens caught in the Mediterranean Sea, De Maddalena *et al*. (2001) stated that the maximum TL of the great white shark can exceed 660 cm. In a recent analysis of Mediterranean great white sharks, Boldrocchi *et al*. (2017) reported the maximum TL for *C. carcharias* to be 675 cm. Information on the length of very large great white sharks (≥600 cm) listed in the TGWSDA were collected from the relevant references or historical data sources (Appendix 1). Among these, the historical record of the great white shark (ca. 800 cm TL, sp. no. 8, Appendix 1) reported by Ayaşlı (1937) can be considered an exception because it is based on scientific reference, which however, includes no information on the measurement method of the TL of the specimen. The results of the present study show that the TL of *C. carcharias* occurring in Turkish waters ranges between 80 cm (YOY) and ≥600 cm (large adults). However, for the sake of measurement accurracy and the currently accepted definition of measuring TL (Compagno, 2002), the size of the largest great white shark to be recorded in Turkish waters and measured accurately is 550 cm (Kabasakal & Kabasakal, 2004; sp. No. 46, Appendix 1). This size coincides with the maximum TL reported for Mediterranean great white sharks (De Maddalena & Heim, 2012; De Maddalena *et al*., 2001; Boldrocchi *et al*., 2017).

The majority of adult specimens (>450 cm TL) of *C. carcharias* were caught off the Prince Islands (northeastern Sea of Marmara) and in the Bosphorus Strait between September and May (Fig. 5). The captures of adult great white sharks in the mentioned regions took place from 1881 to 1985, with the number of captured specimens reaching its peak in the 1950-1970 period (Figs. 3, 4, and 5). The main reason for that was the bluefin tuna (*T. thynnus*) fishery, conducted intensively in these regions during the same time intervals (Karakulak & Oray, 2009). There is strong evidence that pinniped colonies (Le Boeuf, 2004; Martin *et al*., 2005) or migrations of teleosteans (Domeier & Nasby-Lucas, 2008; Weng *et al*., 2007), such as scombrid tuna and swordfish, are associated with recorded concentrations of great white sharks in certain regions around the world and at certain times of the year. The absence or paucity of pinnipeds in the stomach contents of great whites occurring in the Mediterranean is well-documented (Fergusson, 1996; De Maddalena & Heim, 2012). On the other hand, in the Mediterranean Sea, the bluefin tuna is the major prey of this apex predator, and therefore, seasonal migration and occurrence of *C. carcharias* in the mentioned region are closely associated with the dynamics of *T. thynnus* (De Maddalena, 2000; Kabasakal, 2016; Barrul & Mate, 2001; Soldo & Jardas, 2002; De Maddalena & Heim, 2012; Morey *et al*., 2003). The majority of the Mediterranean records of *C. carcharias* have been reported in bluefin tuna fisheries (e.g,. North Adriatic Sea, De Maddalena, 2000; Sea of Marmara, Kabasakal, 2016; Catalan Sea, Barrull & Mate, 2001; eastern Adriatic Sea, Soldo & Jardas, 2002; Balearic Islands, Morey *et al*., 2003). Therefore, as a result of decline or collapse of bluefin tuna fishery in several subregions of the Mediterranean Sea, incidental captures of great white sharks in the same subregions also decreased (De Maddalena & Heim, 2012). This situation, indicating a predator/prey species relationship throughout the Mediterranean, is also valid for Turkish waters.

The distribution of adult (TL >450 cm) great white sharks in Turkish waters is also significantly diversified in relation to fishing gear, with the occurrence of adult specimens significantly associated with handlining (Fig. 6). Almost all of the mentioned great white sharks were incidentally captured by bluefin tuna handliners. Until the last quarter of the 20th century, those Hemingway-like bluefin tuna handliners who used very strong handlines with large hooks baited with bonito, *S. sarda*, in the Sea of Marmara (around the Prince Islands) and in the Bosphorus Strait, were familiar images of the fishing season, lasting from early September to early May. Following the drastic decline of bluefin tuna populations in the Sea of Marmara, the artisanal handlining in the region disappeared in the early 1980s (Karakulak & Oray, 1991). The year 1985, marking the last sighting of adult great whites in the Sea of Marmara, coincides with the period when the bluefin tuna fishery in the same region collapsed. Since then, adult great white sharks in Turkish waters have only been caught in small numbers in the Aegean Sea by commercial purse seiners (Figs. 4 and 6).

Incidental captures of YOY and juvenile great white sharks in coastal artisanal gill-net fishery represent another dimension of the relation between the type of fishing gear and the occurrence of *C. carcharias* in Turkish waters (Fig. 6). Coastal artisanal gill-net fishery is reported as the major threat to the survival of the YOY and juveniles (Santana-Morales *et al*., 2012; Lyons *et al*., 2013; White *et al*., 2019). According to Santana-Morales *et al*. (2012) and Lyons *et al*. (2013), 75 to 85 % of bycatch of YOY and juveniles are recorded in demersal gill-net fisheries. In Turkish waters, particularly in the Bay of Edremit, there is a significant relationship between the bycatch of YOY and juvenile great whites and demersal gill-net fisheries (Fig. 6). Since the Bay of Edremit is currently recognised as a potential nursery ground for *C. carcharias* (Kabasakal, 2020b; (Boldrocchi et al., 2017; Kabasakal, 2020b)), gill-net fishing, which in this region is conducted year round and without any limitations, can also be considered a threat to the overall survival of *C. carcharias* in the

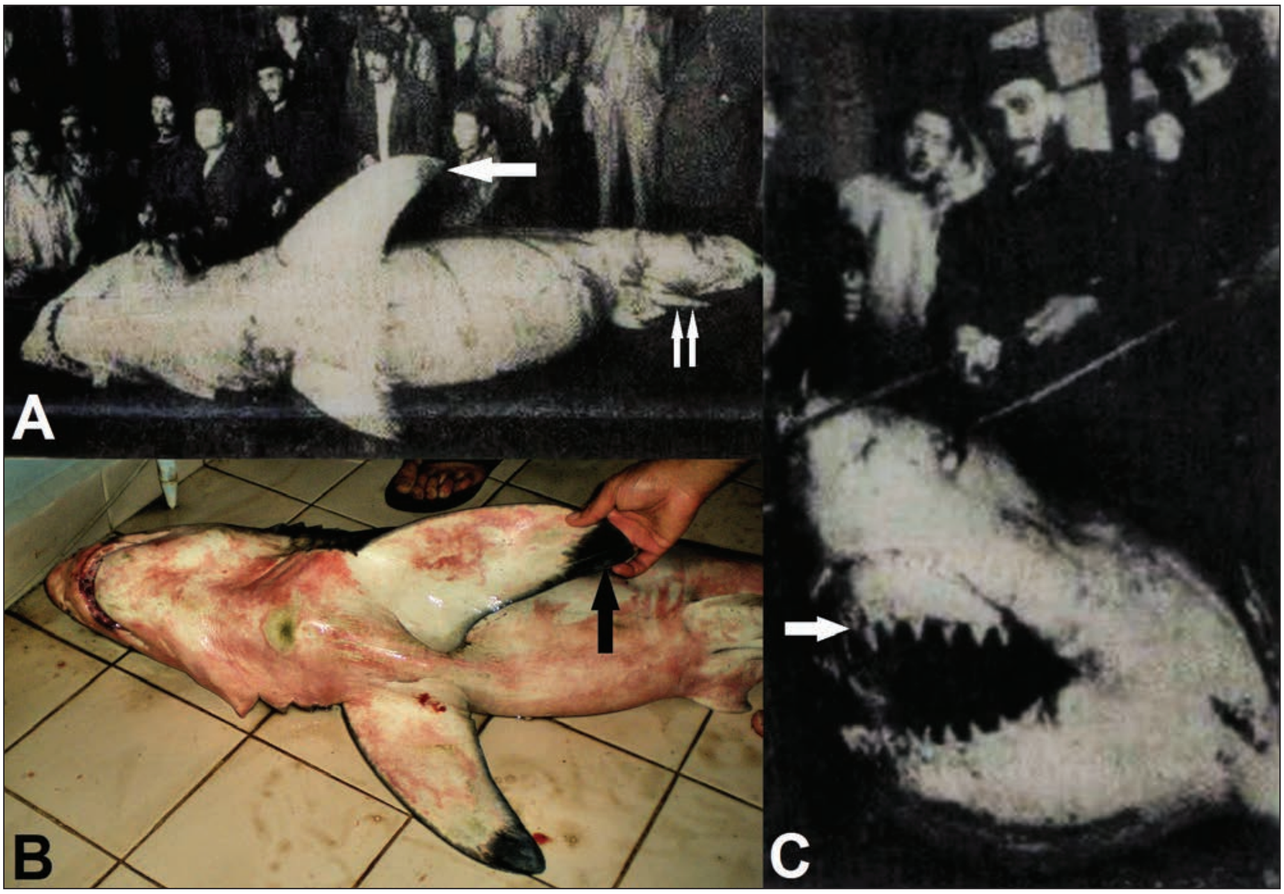

Fig. 8: Adult male great white shark (a and c) caught on 17 May 1936 off Büyükada Island (north-eastern Sea of Marmara; sp. no. 13 in Appendix 1); comparison specimen (b) published in Kabasakal & Gedikoğlu (2008). In photographs (a) and (b), (←) and (↑), respectively, indicate the characteristic black blotch on the ventral surface of the pectoral fin of C. carcharias and (↑↑) indicates the claspers of the male, which are extending well behind the pelvic fins; in photograph (c), (→) indicates the triangular teeth of the specimen.

Sl. 8: Odrasli samec belega morskega volka (a in c), ujet 17. maja 1936 blizu otoka Büyükada (severovzhodni del Marmarskega morja; primerek št. 13 v Prilogi 1); primerek (b), objavljen v viru Kabasakal & Gedikoğlu (2008). Na fotografijah (a) in (b), z znakoma (←) in (↑) je označena značilna črna zajeda na trebušni strani prsne plavuti belega morskega volka in z znakom (↑↑) samčev klasper, ki sega veliko čez trebušno plavut. Na fotografiji c je z znakom (→) označen trikotni zob primerka.

entire Mediterranean Sea.

Very few localities in the Mediterranean Sea are regarded as potential breeding and nursery grounds for *C. carcharias* (Fergusson, 1996; De Maddalena & Heim, 2012; Bradaï *et al.*, 2012; Boldrocchi *et al.*, 2017). Until the early 20th century, a habitat that enhanced the growth and survival of juvenile *C. carcharias* was Croatian waters (northeastern Adriatic Sea) (De Maddalena & Heim, 2012). Based on the spatial and temporal distribution of juvenile great whites (<185 cm TL), Fergusson (1996) indicated the marine area between the island of Sicily and the Tunisian coast as a possible breeding and nursery ground for *C. carcharias* in the central Mediterranean Sea. The suggested location off the Tunisian coast was further supported by evidence provided by Bradaï *et al.* (2012), and the capture of a pregnant great white shark (587 cm TL) in the Gulf of Gabès in 2004, which was carrying 4 developing embryons (mean TL 133.6±1.2 cm), also supports the hypothesis of a breeding and nursery ground in Tunisian waters (Saïdi *et al.* 2005; Bradaï *et al.*, 2012). Boldrocchi *et al.* (2017) reported the average TL of pregnant females in the Mediterranean Sea to be 504±81.1 cm. In the Mediterranean Sea, most YOY *C. carcharias* (n=29) were recorded in Italian waters (n=11, 37.9%; Boldrocchi *et al.*, 2017). Current evidence suggests that the nursery ground in the northeastern Adriatic is no longer used and that the area between Sicily and Tunisia may be the only remaining nursery ground for this species in the central Mediterranean. Therefore, the Bay of Edremit, where the YOY are regularly observed in summer, is of great importance for ensuring the reproduction of the Mediterranean population of *C. carcharias*.

The first documented YOY of *C. carcharias* in Turkish waters were recorded in the Bay of Edremit in 2008 (n=2; Kabasakal & Gedikoğlu, 2008), and according to the results of a systematic survey of published and unpublished data, 23 more YOY and juveniles were recorded in Turkish Aegean waters in the following 12 years (Kabasakal, 2020a; Appendix 1). Repetitive occurrences of YOY and juveniles in the region justifies the necessity of declaring the same as seasonal or year-round marine protected area.

YOY and juvenile great white sharks have also been recorded in the central and northern parts of the Turkish Aegean region (Kabasakal, 2020b). In the northern Aegean Sea, juveniles of *C. carcharias* had been previously reported off the Thasos Island and Coast of Kavala (Greece waters of the Aegean Sea), in the 1940s or earlier (Fergusson, 1996). The TL of Thasos and Kavala specimens were 180 and 230 cm, respectively (Fergusson, 1996). One of two YOY recorded just outside the Bay of Edremit was captured off the coast of Izmir (unpublished data; central Aegean Sea; sp. no. 63, Appendix 1) and the other one in the Dardanelles Strait (Kabasakal & Bayrı, 2020; northern Aegean Sea; sp. no. 76, Appendix 1). Therefore, it can be assumed that the nursery ground for *C. carcharias* may extend over a wider area exceeding the limits of the Bay of Edremit. As it is clearly seen from the map (Fig. 1), the coastal topography of Turkey's Aegean seaboard, which is characterised by the presence of numerous bays and nearshore islands, provides a habitat for the YOY and juveniles to gain experience of movement between offshore and nearshore islands before departing for long-distance migrations. According to Hoyos-Padilla *et al.* (2016), tagged juvenile sharks stay at least 1 year in areas that allow them to travel short distances between the coast and an island (in that case, the Guadaloupe island), before moving to more remote areas. Moreover, according to Weng *et al.* (2007), YOY great whites can travel 700 km in just 2 months. In another study investigating the movements of juvenile great whites, Bruce *et al.* (2019) reported that a juvenile tagged with a satellite tracking device travelled 1800 km in 190 days. The largest juvenile recorded in this study (TL 300 cm; sp. no 54; Appendix 1) was caught at the western border of the nursery ground in the Bay of Edremit (Fig. 1). On the other hand, the coastal line between the locality of capture of the juvenile recorded in Hisarönü Bay (TL 200 cm; sp. no. 70; Appendix 1; Fig. 1) and the Bay of Edremit is roughly 500 km long. Cailliet *et al.* (1985) reported of juvenile great whites measuring 200 and 300 cm in TL, respectively, which he concluded to be aged 2 and 6 years. In the light of these findings, specifically the Bay of Edremit and, on a larger scale, the insular waters of the eastern Aegean Sea can be considered as an area of development and gaining experience, where the great white shark usually spends its first 6 years of life. Considering the seasonality of the YOY and juveniles (Fig. 5), it can be deduced that birth occurs between June and August, and juveniles could be sighted in the study area from January to September. The two YOY caught in January and April may have been be individuals born in the previous summer that had not yet left the nursery area. It is rare, though not unusual, to encounter YOY in winter; for example, Curtis *et al.* (2014) reported that in winter, the incidence of YOY great whites in northwestern Atlantic waters is 2% and the rate of juveniles 75%. To sum up, in the eastern Aegean Sea, although the YOY prefer inhabiting a restricted area in their first year, the distance of juveniles' home ranges increases with growth, which is consistent with the literature (Fergusson, 1996; Boldrocchi *et al.*, 2017; Weng *et al.*, 2007; Bruce *et al.*, 2019).

To summarize the status of *C. carcharias* in the study region based on records between 1881 and 2020: the great white shark occurs in Turkish waters throughout the year. Although the occurrences of adult specimens have shown a remarkable decrease during this period, the species has not been extirpated from the region. The main reason for this decrease is assumed to be the drastic decline of bluefin tuna populations in Turkish waters, particularly in the Sea of Marmara and the Bosphorus Strait. Following the decline of bluefin tuna populations, handlining fishery, which is selectively targeting very large fish, disappeared from the Bosphorus Strait and Sea of Marmara (Kabasakal, 2016). On the other hand, since the 1990s, the number of adult great white sharks to be incidentally captured in commercial purse seinig in Turkish Aegean waters has declined. In the central Mediterranean, over 70 % of great white shark bycatch was reported by purse seiners (Serena, 2021), in Turkish waters, nearly 9%. All contemporary records of adult great white sharks are related to either captures or sightings around the periphery of the nursery ground in the Bay of Edremit.

The status and distribution of *C. carcharias* in Turkish waters has been investigated in a species-specific effort since the early 2000s (Kabasakal, 2003, 2020). Although we are still at the beginning level compared to regions with abundant great white shark research (Pacific and Atlantic coasts of North America, South Africa, Australia-New Zealand, western and central Mediterranean; Huveneers *et* *al.*, 2018), the past 20 years of research in Turkey (Kabasakal, 2020) provide a reliable background for future research of the biology, ecology, socioeconomics, management, and conservation of *C. carcharias* in Turkish waters. Besides generally accepted systematic scientific research methods, opportunistic study techniques, such as systematic review of old newspaper reports and citizen science observation data, have significantly contributed to an ever increasing collection of *C. carcharias* records over the last 20 years. Although the first scientifically validated evidence on the occurrence of YOY and juvenile great whites in the Bay of Edremit was obtained in 2008 (Kabasakal & Gedikoğlu, 2008), testimonials of some local fishermen now aged 80 to 90 years revealed that the young generations of *C. carcharias* may have regularly occurred in the region for at least the last 50 years (H. Kabasakal pers. data). In the most recent assessment of the distribution and abundance of great white sharks in the Mediterranean, Moro *et al.* (2020) reported 773 records between 1860 and 2016, but six new records from Libyan waters dating between 2017 and 2020 have been added to the existing inventory through the effort of citizen scientists (Jambura *et al.*, 2021). In the matter of great white shark, fantasy and reality are often confused, and especially nowadays a remarkable number of imprecise or incorrect sighting records are available online (Bargnesi *et al.*, 2020). If data collected by citizen scientists were properly standardised (Giovos *et al.*, 2021; Bargnesi *et al.*, 2022), they would provide cost-effective and useful information on the status and conservation of great white sharks and other shark species in Turkish waters; in fact, such standardised data stream would be a significant contribution to conservation efforts across the Mediterranean.

Compared to eastern Mediterranean records of *C. carcharias* (total n=12; Ben-Tuvia, 1971; Fergusson, 1996; Damalas & Megalofonou, 2012), records of species from the Turkish waters (n=77) provide a significant regional contribution to the knowledge of the entire Mediterranean population. For the moment, the total number of eastern Mediterranean records of *C. carcharias* is 89, which represents 11.4 % of all Mediterranean records (n=779; Moro *et al.*, 2020; Jambura *et al.*, 2021). Today, one of the main subjects of discussions on shark conservation is the eternal Noah's Ark problem - which species should be given priority (Cachera & Le Loc'h, 2017). *C. carcharias* is a K-selected apex predator, currently classified as "vulnerable" on the IUCN Red List (Rigby *et al.*, 2019) and "critically endangered" in the Mediterranean Sea (Serena *et al.*, 2020). Due to site fidelity and natal philopatry of *C. carcharias* (De Maddalene & Heim, 2012; Jorgensen *et al.*, 2010), seasonal migrations of pregnant females to nursery grounds (in case of the Mediterranean, either the Sicily-Tunisia region or the Bay of Edremit) to give birth can be predicted. As a first step to ensuring the survival of *C. carcharias*, the great white shark has been recently declared as a species under protection in Turkish waters (Official Gazette, 10 September 2022), but the next steps towards providing better protection for the species in the region are urgently required: measures for the management of artisanal coastal gill-net fishery in the Bay of Edremit and the designation of the latter as a marine protected area.

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The authors thank to fishermen and divers who shared observations, stories and old photographs of great white sharks captured or sighted in Turkish waters.

Appendix 1: Inventory of specimens in the Turkish Great White Shark Data Archive. Abbreviations in the "type of record" column indicate the type of original source on which the respective record of the great white shark is based. SR: Scientific reference; OIR: Old ichthyological record; ONR: Old newspaper report; OS: Online source; CSO: Citizen science observation data.

Priloga 1: Popis primerkov belega morskega volka iz arhiva podatkov turških belih morskih volkov. Okrajšave v stolpcu "vrsta zapisa" označujejo tip izvornega podatka, na katerem temelji zapis o belem morskem volku. Podatek iz strokovne literature - SR); stari ihtiološki zapis - OIR; stari časopisni prispevek - ONR; spletni vir – OS in podatki, pridobljeni na podlagi ljubiteljske znanosti - CSO.

No	Date	Location	TL (cm)	W (kg)	Sex	Remarks	Type of record	Reference
1	Feb. 1881	Bosphorus Strait	391	?	?	Stranded near Beylerbeyi coast.	SR	Fergusson (1996)
2	17 Nov. 1881	Bosphorus Strait	470	1500	♀	Type of fishing gear unknown.	SR	Fergusson (1996)
3	1916	Sea of Marmara	ca. 700	?	?	Entrapped in Salistra fish trap; shot by fishermen with 3 bullets in its head.	OIR	Deveciyan (1945)
4	1920	Sea of Marmara	~500	?	?	Caught off Prince Islands and displayed to public in Taksim Square, İstanbul city.	OS	Kabasakal (2014)
5	May 1920	Sea of Marmara	465	ca. 1200	?	Caught off Sedef island; a bluefin tuna, weighing ca. 200 kg, remains of a swordfish, a few bonitos, and a small stone found in its stomach.	OIR	Deveciyan (1945)
6	1923	Sea of Marmara	?	?	?	N/A	ONR	Kabasakal (2020a)
7	before 1926	Sea of Marmara	ca. 400	?	?	Displayed in İstanbul Fish Market; eight large bonitos found in its stomach.	OIR	Deveciyan (1926)
8	before 1926	Bosphorus Strait	ca. 800	ca. 4500	?	Two large tunas per weighing 200 kg, and one large dolphin found in the stomach.	OIR	Ayaşlı (1937)
9	2 Feb. 1926	Sea of Marmara	500	2000	?	Incidentally caught by tuna hand-liners off Prince Islands. Three pairs of boots, and a fez – traditional Ottoman men's headwear - having been found in the stomach of the shark	ONR	Kabasakal & Bayrı (2021)
10	20 Feb. 1926	Sea of Marmara	450	over 1500	?	Caught off Büyükada island.	ONR	Kabasakal (2003)
11	1930	Sea of Marmara	?	?	?	Attacked to a fishing boat off San Stefano (Yeşilköy).	ONR	Kabasakal (2014)
12	1936	Sea of Marmara	500	3000	?	Incidentally caught by tuna hand-liners off Büyükada	ONR	Kabasakal & Bayrı (2021)
13	17 May 1936	Sea of Marmara	ca. 500	?	♂	Incidentally caught off Büyükada.	ONR	Unpublished data
14	21 Mar. 1937	Sea of Marmara	?	1700	?	Harpooned by fishermen set sail for catching swordfish off Büyükada. Landed at the fishmarket for public display.	ONR	Kabasakal (2016)
15	1939	Sea of Marmara	?	ca. 3000	?	Caught by the tuna handliner Karnilyas and delivered to the fishmarket.	ONR	Kabasakal (2016)
16	1950s	Sea of Marmara	ca. 400	?	?	Caught by a tuna handliner off Burgazada coast.	OS	Kabasakal (2020c)
17	30 Mar. 1954	Sea of Marmara	450	1500	?	Caught off Tuzla island.	ONR	Kabasakal (2003)
18	1 Feb. 1955	Sea of Marmara	?	1500	?	Caught by the fisherman Mr. Hayri Kuloğlu, after struggling nearly 4 and half hours. Almost 50 kg of bonito, *Sarda sarda* found in the stomach contents.	ONR	Kabasakal (2016)
19	15 Apr. 1956	Sea of Marmara	?	2500	?	Caught by the handliner Mr. Necdet Şarcı off Ahırkapı. According to newspaper report, fisherman struggled the shark nearly 8 hours before harpooned it.	ONR	Kabasakal (2016)
20	15 Apr. 1956	Sea of Marmara	618	ca. 3000	♀	Caught off Prince Islands; its mass surely incorrectly estimated.	ONR	Kabasakal (2003)
21	1957	Mediterranean Sea	?	?	?	Caught in İskenderun Bay.	SR	Akyüz (1957)
22	1958	Bosphorus Strait	ca. 700	?	?	Caught off Ahırkapı, but escaped from the hook and attacked to a fishing boat.	ONR	Kabasakal (2014)
23	5 Mar. 1958	Sea of Marmara	500	2500	♀	Caught off Prince Islands. Delivered to fishmarket for public display and auction.	ONR	Kabasakal (2016)
24	25 Dec. 1958	Sea of Marmara	ca. 700	ca. 2000	♀	Caught off Prince Islands by fishermen Niyazi Dalgın, Cemil Unalır and Şadan Şalvarlı, then landed at Ahırkapı coast.	ONR	Kabasakal (2020a)
25	28 Dec. 1958	Bosphorus Strait	ca. 800	?	?	Caught off Ahırkapı coast by fishermen Yunus Potur and Ali Durmaz. Great white shark attacked the boat and caused damage.	ONR	Kabasakal (2020a)
26-33	Between 1958-1960	Bosphorus Strait	500 to 700	ca. 1500 to 4000	?	Seven great white sharks captured in bosphoric and prebosphoric area by the same fisherman, "Samatyalı" İrfan Yürür. Voice record of an interview with Mr. Yürür is available on the following link (in Turkish): https://youtu.be/OZYzJaCpzN0	CSO	Kabasakal (2014)
34	Feb. 1962	Bosphorus Strait	500+	3750	♀	Mass surely incorrectly estimated.	SR	Fergusson (1996)
35	19 Mar. 1962	Bosphorus Strait	?	3000	♀	Caught by the fishermen Mr. Hayri Kuloğlu and Mr. Ziya Zeki Zayni off Ortaköy.	ONR	Kabasakal (2016)
36	28 Dec. 1965	Bosphorus Strait	500	ca. 4000	♀	Caught off Dolmabahçe coast; mass surely incorrectly estimated.	ONR	Kabasakal (2003)
37	28 Dec. 1965	Bosphorus Strait	700	ca. 3000	♀	Caught near Maiden's Tower.	ONR	Kabasakal (2003)
38	13 Jan. 1966	Sea of Marmara	?	?	?	Incidentally caught by tuna handliners and harpooned off Kumkapı. Auctioned at the fishmarket for its liver oil.	ONR	Kabasakal (2016)
39	13 Jan. 1966	Bosphorus Strait	ca. 400	ca. 2000	?	Harpooned off Kabataş coast.	ONR	Kabasakal (2003)
40	13 Jan. 1966	Bosphorus Strait	ca. 400	ca. 2000	?	Harpooned off Kabataş coast; belly of the second specimen shown overturned on the left of the photograph presented in Kabasakal (2003)	ONR	Kabasakal (2003)

41	1967	Sea of Marmara	?	?	?	Caught off Büyükada coast by a tuna hand-liner.	OIR	Kabasakal (2008)
42	Mar. 1968	Bosphorus Strait	551	?	♀	Caught by a tuna hand-liner.	ONR	Kabasakal (2011)
43	before 1974	Sea of Marmara	?	ca. 2000	?	Caught off Prince Islands.	OIR	Güney (1974)
44	May 1985	Sea of Marmara	ca. 500	?	?	Sighted off Kapıdağ peninsula.	CSO	Kabasakal (2003)
45	18 Mar. 1991	Aegean Sea	ca. 500	3500	♀	Caught off Foça coast by a commercial purse-seiner; transported to İstanbul Fish Market and displayed to public.	ONR	Kabasakal (2008)
46	Mar. 1996	Aegean Sea	550	?	♀	Caught off Bozcaada island by a commercial purse-seiner.	OIR	Kabasakal & Kabasakal (2004)
47	Apr. 1998	Aegean Sea	ca. 450	?	?	Sighted by a gill-netter.	CSO	Kabasakal & Kabasakal (2004)
48	May 1999	Aegean Sea	ca. 500	?	?	Sighted by a diver off Büyükkemikli cape.	CSO	Kabasakal & Kabasakal (2004)
49	1 Jul. 2008	Aegean Sea	125.5	30	♂	Caught in Bay of Edremit, off Altınoluk coast by a commercial gill-netter; unhealed birth mark was visible on the belly.	SR	Kabasakal & Gedikoğlu (2008)
50	4 Jul. 2008	Aegean Sea	145	?	♂	Caught in Bay of Edremit, off Altınoluk coast by a commercial gill-netter; unhealed birth mark was visible on the belly.	SR	Kabasakal & Gedikoğlu (2008)
51	2009	Aegean Sea	160	?	?	Captured by commercial artisanal fisherman off Babakale.	OS	Unpublished data
52	2009	Aegean Sea	ca. 200	?	?	Captured in Bay of Edremit.	OS	Unpublished data
53	21 Feb. 2009	Aegean Sea	180	47.5	♀	Caught off Gökçeada island; two angler fish (*Lophius* sp.), one gar fish (*Belone belone*) and one hake (*Merluccius merluccius*) were found in the stomach.	SR	Kabasakal *et al.* (2009)
54	15 Apr. 2009	Aegean Sea	300	102	♀	Caught off Çanakkale coast by a commercial purse-seiner; transported to İstanbul and displayed to public.	SR	Kabasakal *et al.* (2009)
55	2010; late Jun., early Jul.	Aegean Sea	80	?	?	Captured by coastal gill-netters in Bay of Edremit, off Altınoluk.	SR	Kabasakal (2014)
56	2010; late Jun., early Jul.	Aegean Sea	100	?	?	Captured by coastal gill-netters in Bay of Edremit, off Altınoluk.	SR	Kabasakal (2014)
57	2010; late Jun., early Jul.	Aegean Sea	?	?	?	Captured by coastal gill-netters in Bay of Edremit, off Altınoluk.	SR	Kabasakal (2014)
58	21 Jun. 2010	Aegean Sea	230	60	?	Captured off Bozcaada island.	CSO	Unpublished data
59	14 Jul. 2010	Aegean Sea	150	30		The great white shark, which was entangled in unspecified nets deployed by local fisherman in Bay of Edremit	CSO	Kabasakal & Bayrı (2021)
60	6 Jul. 2011	Aegean Sea	85	12	♀	Caught in Bay of Edremit, off Altınoluk by a trammel-netter in inshore waters. After landing, the specimen transferred to seawater tank but upon observing stress signs, it was released after a couple of hours of captivity. A video of this specimen is available on the following link: http://vimeo.com/46296179	CSO	Kabasakal (2014)
61	28 Sep. 2011	Aegean Sea	~500	?	?	Sighted by a diver at a depth of 15 m, while he was spearfishing off Marmaris coast. According to interview with the diver, great white shark approached to him, but no attack occurred.	CSO	Kabasakal (2014)
62	7 May 2013	Aegean Sea	ca. 200	50	?	Captured off Çanakkale.	CSO	Unpublished data
63	21 Aug. 2014	Aegean Sea	ca. 150	40	?	Captured off İzmir.	CSO	Unpublished data
64	19 Sep. 2014	Aegean Sea	200	40	♂	It was incidentally caught by a stationary net off Yeni Foça, which was deployed for lobster fishing.	CSO	Kabasakal & Kabasakal (2015)
65	2 Jan. 2016	Aegean Sea	175	?	♀	Entangled in a coastal stationary net in the Bay of Edremit. The dried head, jaws and caudal fin of the specimen are preserved by local fishermen in Altınoluk province.	CSO	Kabasakal *et al.* (2018)
66	2017	Aegean Sea	ca. 180	35	?	Captured off Altınoluk.	CSO	Unpublished data
67	2017	Aegean Sea	ca. 180	40	?	Captured in Saroz Bay by means of gill-net. Released alive	CSO	Unpublished data
68	Jan. 2017	Aegean Sea	180	?	?	Entangled in coastal stationary net off Gökçeada coast.	CSO	Kabasakal (2020a)
69	4 Jan. 2017	Aegean Sea	160	?	?	Juvenile specimen incidentally captured in unspecified artisanal fishery off Burhaniye coast.	CSO	Unpublished data
70	27 Feb. 2017	Aegean Sea	ca. 200	?	♀	Incidentally captured in unspecified artisanal net in Bay of Hisarönü, Muğla. A video of the specimen is available in the archive of first author.	CSO	Unpublished data
71	Apr. 2017	Aegean Sea	160	?	?	Entangled in coastal stationary net in the Bay of Edremit.	SR	Kabasakal (2020a)
72	4 Jun. 2017	Aegean Sea	200	60	♂	Captured by a commercial purse-seiner off the Didim coast.	SR	Kabasakal *et al.* (2018)
73	14 Apr. 2018	Aegean Sea	180	?	♀	Captured by a coastal stationary-netter, off the İzmir coast.	SR	Kabasakal *et al.* (2018)
74	28 Jul. 2018	Aegean Sea	?	?	?	Captured off İzmir coast.	CSO	Unpublished data
75	Spring 2019	Aegean Sea	ca. 500	?	?	Sighted by a commercial fisherman off northern coast of Gökçeada.	SR	Kesici *et al.* (2021)
76	8 Jun. 2020	Dardanelles Strait	155	?	?	Captured by means of a stationary-netter, off Kumkale coast (southern entrance of Dardanelles Strait).	SR	Kabasakal & Bayrı (2020)
77	14 Jun. 2020	Aegean Sea	ca. 200	?	?	Sighted by the amateur fishermen in waters of Saroz Bay, off Enez coast. First documented case of leucism in *C. carcharias*.	CSO	Kabasakal (2020d)

STATUS IN RAZŠIRJENOST BELEGA MORSKEGA VOLKA (*CARCHARODON CARCHARIAS)* V TURŠKIH VODAH: PREGLED IN NOVI ZAPISI O POJAVLJANJU

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POVZETEK

O pojavljanju vrste Carcharodon carcharias v turških vodah poročajo že od konca 19. stoletja. Od leta 1881 do 2020 je bilo zbranih skupno 77 zapisov o pojavljanju belega morskega volka. Razpoložljivi podatki kažejo, da se ta vrsta v turških vodah pojavlja skozi vse leto. Število odraslih osebkov se je v tem obdobju znatno zmanjšalo, kljub temu pa vrste v regiji niso iztrebili. Ta študija dokazuje, da se je razširjenost vrste C. carcharias v turških vodah sčasoma znatno regionalno spremenila, pri čemer trenutna razširjenost mladičev in nedoraslih osebkov sega od osrednjega do severnega Egejskega morja in je skoncentrirana v zalivu Edremit. C. carcharias je bil nedavno razglašen za zaščiteno vrsto v turških vodah, vendar so naslednji koraki k zagotavljanju boljšega varovanja te vrste v regiji nujno potrebni.

Ključne besede: status, upravljanje, ohranjanje, vzhodno Sredozemlje, Lamnidae, obalni ribolov

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200 YEARS OF RECORDS OF THE BASKING SHARK, *CETORHINUS MAXIMUS*, IN THE EASTERN ADRIATIC

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ABSTRACT

The basking shark was relatively rare in the Adriatic, but since the beginning of the 21st century, its occurrence was substantially increased. It was suggested that basking sharks migrate from the Mediterranean toward the northern Adriatic, following water masses carrying specific copepod species that are sufficiently abundant for their feeding. In this paper, recent and historical data are compiled to re-examine spatial and temporal trends of the basking shark occurrence in the Adriatic. During the last 200 years, a total of 75 records were reported since the first one in 1822. The majority is reported during the spring season when the copepod abundance is the highest. After spring, the winter, especially the second half, is the time of the year when most of the basking sharks are reported, while during autumn and summer only a low number of records exist, 7 and 6 respectively.

Key words: basking shark, *Cetorhinus maximus*, Adriatic, occurrence, public perception

200 ANNI DI SEGNALAZIONI DELLO SQUALO ELEFANTE, *CETORHINUS MAXIMUS*, NELL'ADRIATICO ORIENTALE

SINTESI

Lo squalo elefante era relativamente raro nell'Adriatico, ma dall'inizio del XXI secolo la sua presenza è aumentata in modo sostanziale. È stato ipotizzato che gli squali elefante migrino dal Mediterraneo verso l'Adriatico settentrionale, seguendo masse d'acqua che trasportano specifiche specie di copepodi sufficientemente abbondanti per la loro alimentazione. In questo lavoro vengono raccolti dati recenti e storici per riesaminare le tendenze spaziali e temporali della presenza dello squalo elefante nell'Adriatico. Nel corso degli ultimi 200 anni sono state raccolte in totale 75 segnalazioni, a partire dalla prima del 1822. La maggior parte degli avvistamenti risale alla stagione primaverile, quando l'abbondanza dei copepodi è più elevata. Dopo la primavera, l'inverno, soprattutto la seconda metà, è il periodo dell'anno in cui è stata avvistata *la maggior parte degli squali elefante, mentre durante l'autunno e l'estate sono stati registrati solo, rispettivamente, 7 e 6 esemplari di squalo elefante.*

Parole chiave: squalo elefante, *Cetorhinus maximus*, Adriatico, presenza, percezione pubblica

INTRODUCTION

The basking shark, *Cetorhinus maximus* (Gunnerus, 1765), is a coastal-pelagic and semioceanic or oceanic shark species found in boreal to warm-temperate waters of the continental and insular shelves, occurring well offshore and often very close to land, just off the surf zone, and entering enclosed bays (Compagno, 2002; Ebert *et al.*, 2021). It is a highly seasonal species, noteworthy for its seasonal appearance in given localities and subsequent disappearance (Ebert *et al.*, 2021). The numbers of basking sharks sighted may fluctuate greatly in given areas each year, with irregular increases ('invasions') and decreases that are of uncertain cause. In Eastern Atlantic it occurs from Iceland and Norway to North Africa and the Mediterranean (Compagno, 2002; Ebert *et al.*, 2021). Although the basking shark records are widespread in the Mediterranean most of the records are reported in the Tyrrhenian, Balearic and Adriatic regions (Mancusi *et al.*, 2005, 2020).

Soldo & Jardas (2002a, 2002b) reported 27 records of the basking shark in the Eastern Adriatic from 1822 until mid of 2001. The records were widespread all over the coastal area of the Eastern Adriatic, although most were reported in the area of Kvarner Bay in northern Adriatic. The majority of the records were related to the accidentally caught specimens, either in the gillnet or trawl. Hence, not many records were recorded during the 19th century as most of them were from the 20th century, thus the basking shark was considered rare species in the Adriatic (Soldo *et al.*, 1999). However, during 2000 and the first half of 2001, a lot of new records were reported along the eastern and western coasts of Central and Northern Adriatic (Zuffa *et al.*, 2001). Some records were related to the individual specimens but some were sightings of relatively large schools of adult sharks. What Zuffa *et al.* (2001) also noted was the absence of the basking shark along the Tuscany coast, which was frequently visited by *C. maximus*, at the same time when an increasing number of records were reported from the Adriatic coast. At that time, due to the lack of data, Zuffa *et al.* (2001) could not give an accurate reason for such a phenomenon but further research provided a reliable explanation. Soldo *et al.* (2008) compared the records of the basking shark in the Northern Adriatic during the period from January 2000 to October 2002 with various seawater characteristics. Comparing the occurrence of basking sharks and fluctuations in temperature and salinity showed no evident pattern. However, when the occurrence of the basking sharks was compared to fluctuations in zooplankton structure and abundance it was evident that the basking sharks were found exactly in the time of high density of large copepods, particularly *Calanus helgolandicus*, which is their major prey. Thus, it was suggested that basking sharks migrate from the Mediterranean toward the Northern Adriatic, following water masses carrying specific copepod species that are sufficiently abundant for their feeding (Soldo *et al.*, 2008). Hence, segregation of adults and young-of-the-year was also observed as adults were arriving during the second half of winter and then in the following months seen near the surface usually feeding on patches of plankton. From mid of spring until its end, with the decline of zooplankton abundance, adults were leaving the Adriatic along the eastern coast but in deeper waters, and later, with the start of the summer season, the arrival of newborn sharks from deep water to coastal feeding grounds was observed (Soldo *et al.*, 2008). Furthermore, what has to be noted is that this kind of behavior observed in the Adriatic was very similar to the behavior of the basking sharks described from southwest England (Sims & Merrett, 1997; Sims *et al.*, 1997, 2003).

In the Mediterranean, thus even in the Adriatic, the basking shark is protected under recommendation GFCM/36/2012/3 (later amended to GFCM/42/2018/2) of the General Fisheries Commission of the Mediterranean (GFCM). This recommendation is aimed at protecting those species of sharks and rays that are listed in Annex II of the Protocol of the Barcelona Convention on specially protected areas and biological diversity in the Mediterranean. Furthermore, *C. maximus* is listed in Annex I of Regulation (EU) 2019/1241 that prohibits for EU vessels to fish for, retain on board, tranship, land, store, sell, display or offer for sale this shark for all EU waters. In Croatian waters, which encompass most of the Eastern Adriatic, the highest level of protection is given to the basking shark as it is declared as a Strictly protected species (Soldo & Lipej, 2022).

The aim of this study is to compile recent and historical data to re-examine spatial and temporal trends in basking shark occurrence in the Adriatic. Such information is essential to differentiate whether changes in the occurrence of the Mediterranean basking shark population happen due to changes in population size or due to the movement patterns and distribution because of environmental change.

MATERIAL AND METHODS

The study area presented in this paper relates to the Eastern Adriatic which in the north is separated from the Western Adriatic at the point of Lido di

Jesolo. The timespan covered by this study started in 1822, when the first record was reported and ends by March 2022, thus resulting in 200 years period.

Data presented in this paper were retrieved from studies focusing on the basking shark in the Adriatic (Lipej *et al*., 2000; Zuffa *et al*., 2001; Soldo & Jardas, 2002a, 2002b; Soldo *et al*., 2008; Lipej & Mavrić, 2015) and from records published in different media. However, only published records that were accompanied by photo and/or video evidence that could be verified were used. Luckily, being the world's second largest fish and one of three filter-feeding shark species, the basking shark is put at the center of public interest, thus most of the new records were published by several media sources with additional data which simplified the confirmation of the record.

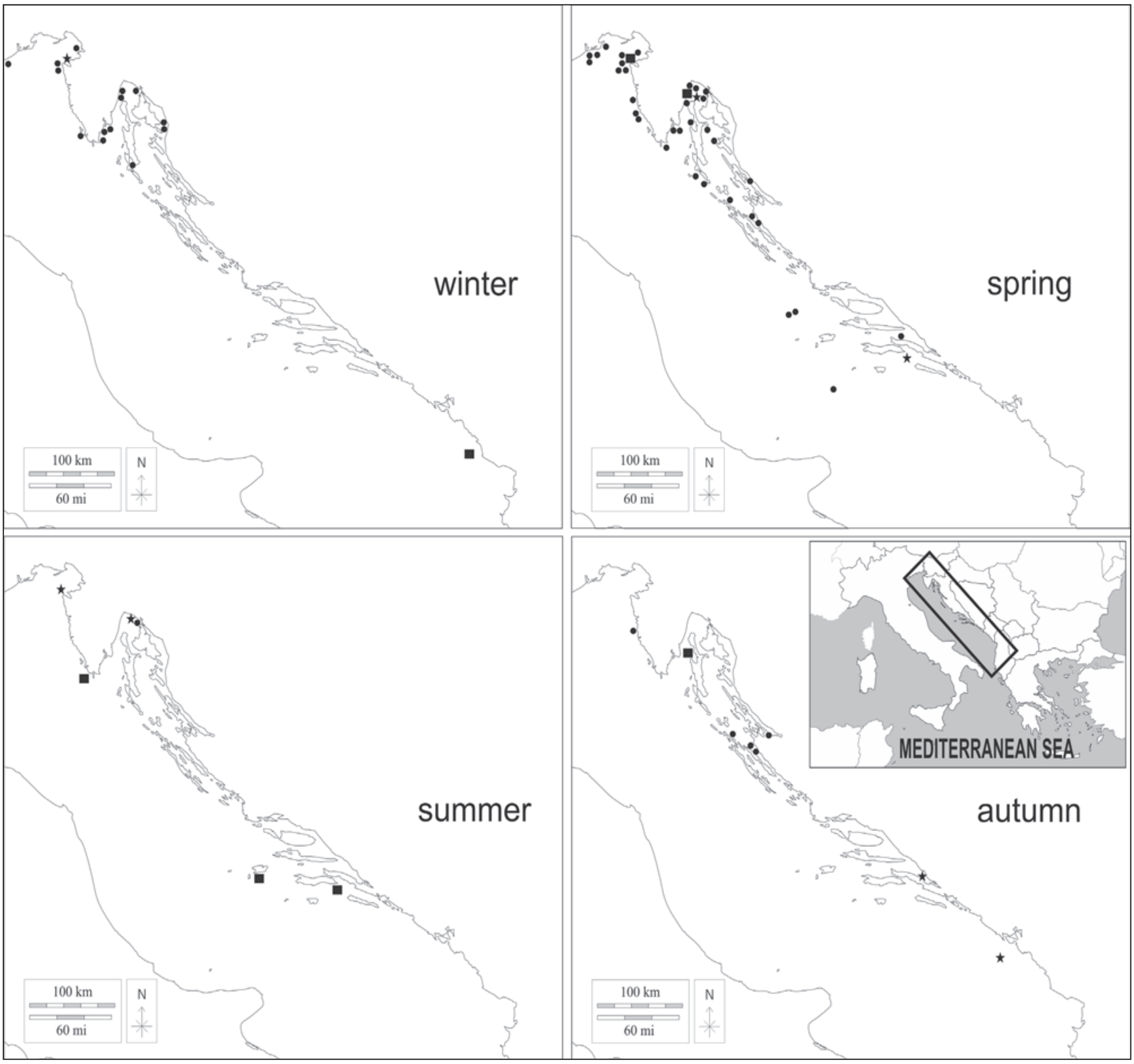

Fig. 1: Geographical locations of records of* C. maximus *per season in the Eastern Adriatic Sea; ★ - juveniles (<299 cm TL), ■ - subadults (300–499 cm TL), ● - adults (>500 cm TL).
Sl. 1: Geografske lokacije primerov pojavljanja vrste* C. maximus *v vzhodnem Jadranskem morju glede na sezono; ★ - mladostni primerki (<299 cm telesne dolžine), ■ - subadulti (300–499 cm), ● - odrasli primerki (>500 cm).

To investigate the segregation of adults and young basking sharks three size classes were compared, specifically < 299 cm (juveniles), 300–499 cm (subadults), and adults > 500 cm in total length.

RESULTS AND DISCUSSION

During the last 200 years, a total of 75 records were reported since the first one in 1822 (Appendix 1). Appendix 1 contains even an additional record, which is not numbered, from 12th February 2008 when public media reported about the catch of the basking shark 9 NM from Rogoznica in the Central Adriatic. However, later examination of the available photos revealed that the shark in the case is not a basking shark but the bluntnose sixgill shark, *Hexanchus griseus* (Bonnaterre, 1788). This record also proves that although citizen science and social media are useful for gathering additional information, careful investigation of the available data is needed as reporting and successive publishing of incorrect data can result in misleading conclusions.

Although records that contain an exact location are widespread along the Eastern Adriatic coast, most are reported from the Northern Adriatic, including Kvarner Bay, which is well known as the area of Adriatic with the highest zooplankton biomass. Soldo *et al*. (2008) reported that during the investigation carried out in the Northern Adriatic many basking sharks were observed feeding on patches of plankton which coincides with the available information from new records as only for the basking sharks from that area similar feeding behavior is reported. When the records are divided by the season (Fig. 1), it is clear that the majority is reported during the spring season when the copepod abundance is the highest, which corresponds with the findings of Soldo *et al*. (2008). After spring, the winter, especially the second half, is the time of the year when most of the basking sharks are reported, while during autumn and summer only a low number of records exist, 7 and 6 respectively. The increasing numbers of records of *C. maximus* in spring and winter months due to the increasing abundance of larger copepods is later also reported from northern Aegean waters (Kabasakal, 2013). A similar phenomenon was also observed in the northeastern Mediterranean, where records of *C. maximus* in the Bay of Mersin (Turkey) were associated with annual average zooplankton biomass in coastal waters that was about nine times higher than in open waters (Zenginer & Beşiktepe, 2007; Kabasakal, 2013). Hence, during the summer, out of 6 records, 2 are juveniles and 3 subadults which also coincides with the temporal segregation of juvenile and adult age classes observed by Soldo *et al*. (2008) who suggested that younger sharks are arriving in summer after adults leave the Adriatic. Two juveniles were reported during the autumn but only in southern Adriatic which can be explained by a late exit from the Adriatic of juveniles that were inhabiting more northern areas during the summer. The only exception from the observed pattern is the case of a male juvenile basking shark of 217 cm in total length and 40 kg of weight caught on 25th December 2014 (Lipej & Mavrič, 2015). Soldo *et al*. (2008) already proved that the migration of the basking sharks in the Adriatic is not related to changes in temperature and/or salinity, which was recently also confirmed by studies performed in other world regions (Finnuci *et al*., 2021; Johnston *et al*., 2022). Thus, such surprising early winter arrival of the juvenile basking shark in very shallow waters of the Northern Adriatic (20 m depth) can not be precisely explained as the reasons can be various. Basking sharks are known to exhibit high interannual variability in occurrence, but the forcing mechanisms behind this are not known, especially for the juveniles for which the data is even more scarce than for the adults. The reason can be attributed to the feeding behavior, but on the other hand, it is unclear if basking sharks continue to actively feed during the winter (Doherty *et al*., 2019). It is also possible that such behavior is related to thermoregulation or aid energy conservation (Thums *et al*., 2013) but again all the possible explanations are difficult to confirm due to the limited amount of biological data available. Hence, what also has to be noted is that this case is not a unique one as a female juvenile basking shark at the transition stage with S-shaped snout and a total length of 3.02 m, was captured in Sagami Bay, Japan, on December 26, 2020, however, again without meaningful explanation (Katooka *et al*., 2020).

During the last few decades records that are reported mainly come from sightings while incidental catches are decreased. Even more, when basking sharks are accidentally caught, if still alive, they are usually released by the fishermen (e.g. the record from Savudrija in March 2019), which shows that the basking shark today are perceived by the general public as harmless and gentle marine giants in comparison to late 20th century period when any large shark was portrayed negatively (Soldo & Jardas, 2002b). Although the increased occurrence of the basking shark is linked to environmental factors, it can be also presumed that basking sharks appear to be responding well to protective measures that are existing in the eastern Adriatic, especially as they are combined with positive media and public perception that enhance conservation efforts. That is particularly important

Appendix 1: Records of the basking shark, *Cetorhinus maximus*, **in the Eastern Adriatic from 1822 until April 2022.**
Priloga 1: Zapisi o pojavljanju morskega psa orjaka, *Cetorhinus maximus*, **v vzhodnem Jadranu od leta 1822 do aprila 2022.**

No	Date	Location	TL (cm)	Weight (kg)	Sex	Remarks
1	1822	Kvarner Bay	-	-	-	-
2	15.03.1825	Trieste Bay	-	-	-	-
3	1846	Dalmatia	-	-	-	-
4	1866	Kvarner Bay	800	-	-	-
5	1903	Hvar	-	-	-	-
6	23.07.1908	Vis	310	289	female	-
7	07.10.1921	Cres	320	-	male	-
8	15.03.1925	-	-	-	-	-
9	09.09.1926	-	600-700	800-1000	-	-
10	1931	Bakarac	-	-	-	caught in tuna gillnet
11	02.06.1933	Bakar	500	1000	-	caught in tuna gillnet
12	01.09. 1934	Kraljevica	762	2400	-	-
13	10.07.1937	Lumbarda	350	250	-	caught in gillnet
14	07.11.1952	Poreč	-	-	-	caught in gillnet
15	August 1954	Peškera	470	-	-	-
16	07.12.1968	Ston	250	80	-	-
17	1974	Trieste	392	386	male	caught in gillnet
18	25.11.1980	Molat	550	-	-	-
19	14.02.1981	Bar	400	-	-	caught in gillnet
20	18.06.1981	Ičići	265	120	-	-
21	20.05.1985	Volosko	647	2000	-	caught in tuna gillnet
22	11.01.1991	Ičići	600	-	-	photographed in the sea
23	05.04.1995	Palagruža	650	1500	female	caught by trawl
24	08.10.1995	Ugljan	700	2000	-	caught in gillnet
25	23.03.1999	Pelješac	722	2500	female	caught in gillnet
26	March and April 2000	Rovinj	700	2000	-	several sightings and encounters with boats, finally caught in gillnet and released
27	22.05.2000	Piran	299	120	male	caught in gillnet
28	23.05.2000	Blitvenica area	700	2000	-	caught by trawl
29	05.06.2000	Blitvenica area	850	2500	-	caught by trawl
30	19.07.2000	Piran	249	70	male	caught in gillnet
31	22.03.2001	Umag	800	-	-	several sightings in following days
32	28.03.2001	Caorle	500	-	-	sighted several times and photographed
33	29.03.2001	Caorle	<500	-	-	according to photo, different specimen
34	April 2001	Slovenian waters	-	-	-	school of 9 sharks
35	09.05.2001	Trieste	600	-	-	sighting
36	20.05.2001	Kali	800	-	-	several sightings (specimen with wounded head)
37	25.09.2001	Pašman channel	700	-	-	sighting
38	16.03.2002	Sv.Juraj	740	-	female	accidentally caught in lobster pot mainline
39	16.03.2002	Jesolo	600	-	-	sighting
40	8.04.2002	Lignano	600	-	-	caught 23 miles in front of Tagliamento estuary
41	01.05.2002	Karin sea	700	-	-	caught in gillnet, released, found dead after month, probably the same specimen
42	May 2002	Jesolo	600	-	-	sighted and photographed
43	03.03.2003	Osor	600	-	-	caught in gillnet
44	24.03.2003	Paška vrata	650	-		caught in lobster pot line
45	01.04.2003	Supetarska Draga-Rab	710	-	-	caught in gillnet and released
46	07.04.2003	in front of Ugljan	500-600	-	-	sighting
47	12.05.2003	Savudrija	>700	-	female	caught in gillnet, towed into Savudrija and released
48	October 2004	Herceg Novi	420	300	-	caught on longline
49	20.02.2007	Umag	600	-	-	sighting
50	29.04.2007	Lumbarda	270	-	-	juvenile caught in gillnet and released
	12.02.2008	9 NM from Rogoznica	350	350	female	caught and reported as the basking shark but probably misidentified as sixgill shark *Hexanchus griseus*
51	11.07.2008	Rijeka port	250	-	-	juvenile
52	17.01.2009	Pula port	6 m	-	-	sighting
53	31.03.2009	Plavnik	7 m	-	-	caught in lobster pot line
54	26. 04.2010	Koromačno	6 m	-	-	sighting
55	01.05.2010	Premantura	6 m	-	-	seen with mouth wide open during feeding
56	30.05.2010	Ičići	5 m	-	-	sighting
57	03.06.2010	Omišalj	8 m	-	female	caught in lobster pot line
58	09.06.2010	Umag	7 m	-	-	sighting
59	16.6.2010	Koromačno	6 m	-	-	sighting
60	22.04.2011	Molat	10 m	-	-	caught in gillnet
61	29.04.2011	Ilovik	7 m	-	-	seen with mouth wide open during feeding
62	29.04.2011	Moščenička draga	3,7 m	-	-	sighting
63	12.05.2011	Rovinj	7 m	-	-	carcass found
64	26.04.2012	Poreč	8 m	-	female	caught in gillnet
65	31.01.2013	Senj	8 m	-	-	caught in gillnet and reportedly released
66	14.01.2014	Ičići, Ika	6-7 m	-	-	sighting
67	08.06.2014	Between Mali Lošinj and Susak	5.5 m	-	-	sighting
68	25.12.2014	Piran	217 cm	40	male	juvenile
69	22.02.2015	Ližnjan	8 m	-	-	sighting
70	29.04.2015	Cres	7 m	-	-	sighting
71	02.02.2016	Rijeka	6 m	-	female	carcass with the rope around the body
72	10.05.2017	Porozina-Brestova	5 m	-	-	sighting
73	02.03.2019	Savudrija	8 m	-	-	caught in gillnet and released
74	05.03.2021	Koromačno	8 M	-	-	sighting
75	12.03.2022	Cape Ubaš	8 m	-	-	sighting, missing of the dorsal fin part reported

for this species as the basking shark in the Adriatic is assessed as Critically Endangered by the latest study (Soldo & Lipej, 2022). A huge amount of media articles presenting scientific facts and conservation issues were published in the media each time after basking shark sightings or accidental catches occurred, thus, changing the public attitude toward this large shark. Therefore, the case of the basking sharks in the Adriatic can be an example for other shark species' conservation as, obviously, the combination of science, proper management and positive public perception is giving results.

DVESTO LET OPAZOVANJ MORSKEGA PSA ORJAKA, *CETORHINUS MAXIMUS*, V VZHODNEM JADRANSKEM MORJU

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POVZETEK

Morski pes orjak je relativno redka vrsta v Jadranu, toda od začetka 21. stoletja se je število opazovanj te vrste znatno povečalo. Domnevali so, da se morski psi orjaki selijo iz Sredozemskega morja proti severnemu Jadranu zasledujoč vodne mase z določenimi vrstami rakov ceponožcev, ki so dovolj številčni za njihovo prehrano. V pričujočem prispevku je avtor zbral in analiziral podatke o prostorskem in časovnem trendu pojavljanja morskih psov orjakov v Jadranskem morju. V zadnjih dvesto letih je bilo objavljenih skupaj 75 zapisov o pojavljanju te vrste po prvemu zapisu iz leta 1822. Večina podatkov se nanaša na spomladansko sezono, v kateri so največje gostote rakov ceponožcev. Poleg pomladi je največ zapisov o pojavljanju znanih pozimi, še posebej v drugi polovici, medtem ko je iz jesenskega in poletnega obdobja znanih le 7 oziroma 6 zapisov.

Ključne besede: morski pes orjak, *Cetorhinus maximus*, Jadran, pojavljanje, dojemanje javnosti

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MORPHOMETRICS OF AN INCIDENTALLY CAPTURED LITTLE GULPER SHARK, *CENTROPHORUS UYATO* (SQUALIFORMES: CENTROPHORIDAE), FROM THE GULF OF ANTALYA, WITH NOTES ON ITS BIOLOGY

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ABSTRACT

On 19 May 2022, a specimen of Centrophorus uyato *(Rafinesque, 1810) was incidentally hooked by a commercial longliner at a depth of 140 m in the Gulf of Antalya (northeastern Mediterranean Sea). It was an immature female with a total length of 663 mm and a total weight of 1,505 g. The reproductive tract was thin and threadlike. Remains of teleostean fishes (*Scomber *sp., n=1;* Boops boops*, n=1) were found in the stomach contents. The morphometric measurements of this specimen coincided with those of* C. uyato *Clade A previously outlined.*

Key words: Elasmobranchii, *Centrophorus*, Levant, bathyal

MORFOMETRIA DI UN PICCOLO CENTROFORO BOCCANERA, *CENTROPHORUS UYATO* (SQUALIFORMES: CENTROPHORIDAE), CATTURATO ACCIDENTALMENTE NEL GOLFO DI ANTALYA, CON NOTE SULLA SUA BIOLOGIA

SINTESI

Il 19 maggio 2022, un esemplare di Centrophorus uyato *(Rafinesque, 1810) è stato accidentalmente agganciato da un peschereccio con palangari commerciali a 140 m di profondità nel Golfo di Antalya (Mediterraneo nord-orientale). Si trattava di una femmina immatura con una lunghezza totale di 663 mm e un peso totale di 1.505 g. Il tratto riproduttivo era sottile e filiforme. Nel contenuto dello stomaco sono stati trovati resti di pesci teleostei (*Scomber *sp., n=1;* Boops boops*, n=1). Le misure morfometriche di questo esemplare coincidono con quelle del clade A di* C. uyato *precedentemente delineato.*

Parole chiave: Elasmobranchii, *Centrophorus*, Levante, batiale

INTRODUCTION

The genus *Centrophorus* Müller and Henle, 1837 is comprised of small- to medium-sized (<200 cm TL) deepwater bentopelagic sharks often found along outer continental shelves and upper continental and insular slopes at depths between 50 and 2,350 m throughout the world's oceans (Ebert & Stehmann, 2013; Veríssimo *et al.*, 2014). Although the type species of the genus was first described in the early 19th century as *Squalus granulosus* Bloch and Schneider, 1801 (Ebert & Stehmann, 2013), the validity of several *Centrophorus* species has been considered controversial for the last few decades (Veríssimo *et al.*, 2014; White *et al.*, 2013, 2017; Serena *et al.*, 2020; Bellodi *et al.*, 2022). For many years, two *Centrophorus* species (*granulosus* and *uyato*) had been reported to occur in the Mediterranean Sea (Tortonese, 1956; Compagno, 1984; McEachran & Branstetter, 1984; Serena, 2005), however, recent studies support the presence of a single Centrophoridae species in the Mediterranean and, following the recommendation by White *et al.* (2022), *Centrophorus uyato* (Rafinesque, 1810) should be the name used for it until the taxonomical issue is resolved.

Still, any morphometric data of specimens from different geographical localities may contribute to a better description of intraspecific variation of *C. uyato*. Thus, in the present paper, the authors report the morphometric measurements of a *C. uyato* from Turkish Mediterranean waters, complete with brief biological notes on the examined specimen, and compare the percentages of TL for the present measurements with those reported in Kousteni *et al.* (2021), Bellodi *et al.* (2022) and White *et al.* (2022).

MATERIAL AND METHODS

On 19 May 2022, a female specimen of *Centrophorus uyato* (663 mm TL) was incidentally hooked by a commercial longliner at a depth of 140 m in the Gulf of Antalya (Fig. 1). No longer alive when hauled on deck, it was preserved on ice and sent to first author for further inspection. Species identifica-

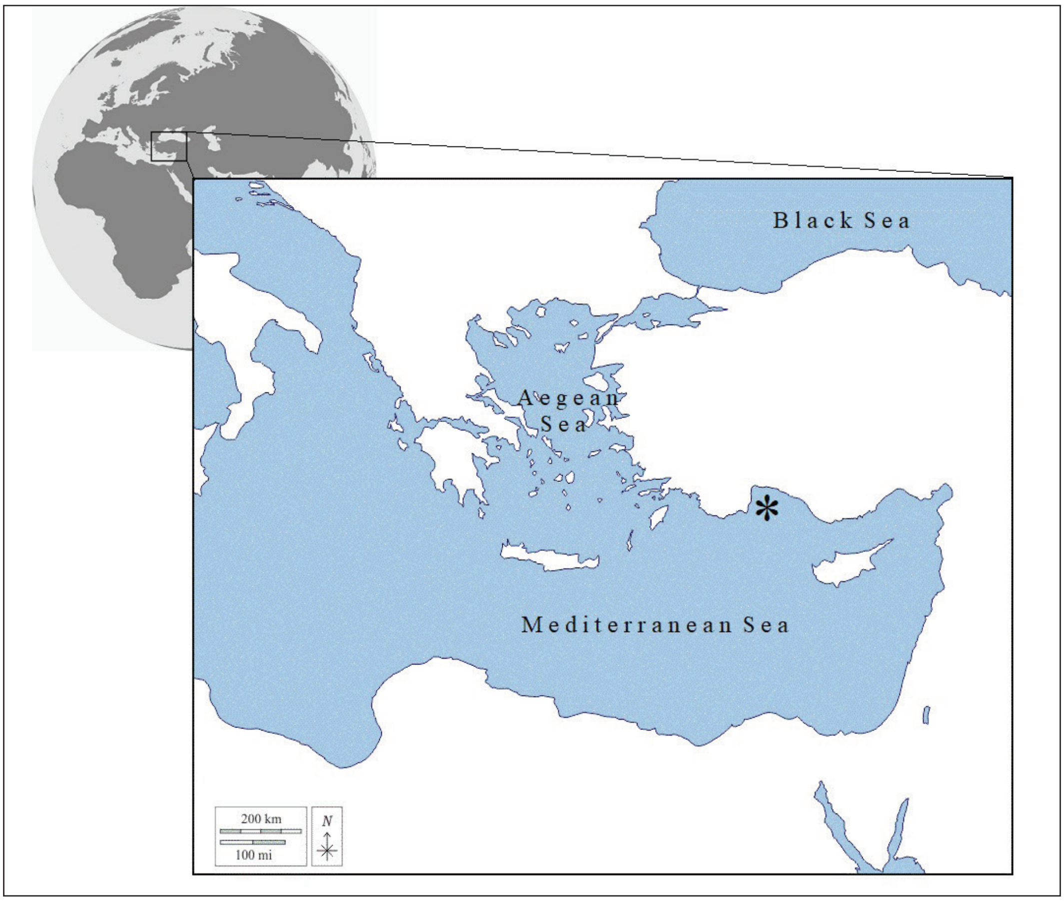

Fig. 1: Map showing the locality of capture (*) of the female *Centrophorus uyato* ***in the Gulf of Antalya.***
Sl. 1: Zemljevid obravnavanega območja z lokaliteto ulova (*) samice vrste *Centrophorus uyato* ***v Antalijskem zalivu.***

Tab. 1: Morphometric measurements for the present specimen of* Centrophorus uyato *in mm, and expressed as percentages of total length (TL) for the present specimen and the specimens examined by Kousteni et al. (2021), from neighbouring Cypriot waters, and specimens examined by Bellodi et al. (2022) and White et al. (2022).

Tab. 1: Morfometrične meritve primerka vrste* Centrophorus uyato *v mm, in izražene kot delež celotne dolžine (TL) v primerjavi s primerki iz bližnjih ciprskih voda, ki so jih pregledali Kousteni et al. (2021), ter primerki, ki so jih pregledali Bellodi et al. (2022) in White et al. (2022).

Measurements mm		Present Specimen (TOT = 663 mm)		Kousteni *et al.* (2021)		Bellodi *et al.* (2022)	White *et al.* (2022)
		mm	% of TL	% of TL sp1 (TL = 522 mm)	% of TL sp2 (TL = 483 mm)	Mean of measurements	% of TL (TL = 983 mm)
PRC	**Precaudal length**	**505**	**76.17**	**79.5**	**79.11**		**79.3**
PD2	**Pre-second dorsal length**	**431**	**65.01**	**63.51**	**63.69**	**69.72**	**64.6**
PD1	**Pre-first dorsal length**	**205**	**30.92**	**32.6**	**32.23**	**32.89**	**28.7**
PP1	Prepectoral length	146	22.02	24.05	24.47		22.1
PP2	**Prepelvic length**	**383**	**57.77**	**58.18**	**60.69**	**62.90**	**57.1**
PCA	Pelvic-caudal space	95.8	14.45	14.48	12.67		13.9
SVL	Snout-vent length	396	59.73	61.13	63.9		
IDS	**Interdorsal space**	**161**	**24.28**	**20.27**	**20.04**	**31.28**	**23.2**
DCS	Dorsal-caudal space	53.5	8.07	7.89	6.9		6.4
PPS	Pectoral-pelvic space	211	31.83	28.49	29.82		31.3
HDL	**Head length**	**150**	**22.62**	**24.82**	**23.82**	**21.93**	**22.5**
PGL	**Prebranchial length**	**122.4**	**18.46**	**20.5**	**20.2**	**17.23**	**18.5**
PSP	Prespiracular length	86.9	13.11	14.66	14.1		12.1
POB	Preorbital length	44.1	6.65	7.44	6.9		5.3
PRN	Prenarial length	21.5	3.24	4.7	4.29		3.7
POR	Preoral length	63.7	9.61	10.33	9.29		9.5
EYL	Eye length	31.6	4.77	6.3	6.54		5.3
EYH	Eye height	15	2.26	1.73	1.77		1.4
INO	Interorbital space	37.9	5.72	7.9	8.27		8.3
SPL	Spiracle length	12.3	1.86	1.27	1.07		1.2
ESL	Eye-spiracle space	17.4	2.62	2	1.55		
MOW	Mouth width	55	8.30	8.1	6.91		
ING	Intergill length	34.1	5.14	4.32	3.62		
GS1	First gill slit height	13.8	2.08	1.82	1.8		
GS2	Second gill slit height	15.7	2.37	1.93	1.97		
GS3	Third gill slit height	18.1	2.73	2.07	2.07		
GS4	Fourth gill slit height	20.1	3.03	2.21	2.36		
GS5	Fifth gill slit height	20.2	3.05	2.38	2.57		
P1A	Pectoral anterior margin	77.4	11.67	11.63	11.36		12.3
P1B	Pectoral base	45.1	6.80	5.71	5.86		5.8
P1I	**Pectoral inner margin**	**85.1**	**12.84**	**11.71**	**11.95**	**13.57**	**12.3**

P1P	Pectoral posterior margin	59.7	9.00	10.46	10.53		
P2A	Pelvic anterior margin	40.7	6.14	6.52	6.71		
P2L	Pelvic length	65.8	9.92	10.42	9.9		11.2
P2B	Pelvic base	23.6	3.56	4.85	4.36		5.8
P2I	Pelvic inner margin length	49	7.39	5.84	5.86		5.8
D1L	First dorsal length	119.2	17.98	17.39	16.7		19.0
D1H	First dorsal height	41.7	6.29	6.37	6.31		5.8
D1A	First dorsal anterior margin	60.8	9.17	12.15	10.28		12.6
D1B	First dorsal base	69.4	10.47	11.54	11.49		13.5
D1I	First dorsal inner margin	47.3	7.13	5.84	5.2		5.8
D1P	First dorsal posterior margin	64.7	9.76	8.68	8.31		9.3
D2L	Second dorsal length	75.4	11.37	12.36	12.69		12
D2H	Second dorsal height	32.9	4.96	3.86	4.28		4.7
D2A	Second dorsal anterior margin	45.9	6.92	9.23	9.13		8.6
D2B	Second dorsal base	42.9	6.47	8.1	8.53		8.3
D2I	Second dorsal inner margin	27.1	4.09	4.26	4.17		4.1
D2P	Second dorsal posterior margin	43.6	6.58	6.36	5.44		6.3
CDM	**Dorsal caudal margin**	**132.5**	**19.98**	**20.44**	**20.62**	**17.88**	**20.1**
CPV	Preventral caudal margin	76.3	11.51	12.89	11.52		11.9
CST	Subterminal caudal margin	23.3	3.51	3.1	3.23		2.9
CTR	Terminal caudal margin	51.9	7.83	5.5	5.72		

tion was performed in accordance with Veríssimo *et al.* (2014) and taxonomic nomenclature follows White *et al.* (2022). Fifty-three morphometric measurements (Compagno, 1984) were performed either with a measurement tape to the nearest 1 mm (for measurements >10 cm) or with a vernier caliper to the nearest 0.05 mm (for measurements <10 cm). Although 53 measurements were recorded on the present specimen, only eight of them, which are typed bold in Table 1, were used to describe the present specimen or compared with the published morphometric data (Kousteni *et al.*, 2021; Bellodi *et al.*, 2022; White *et al.*, 2022). Total length (TL) is the distance between the tip of the snout and tip of the upper caudal lobe, where the upper caudal lobe is in depressed position (Compagno, 1984). Total, eviscerated and liver weights (TW, EW and HW) were weighed with an electronic hand balance to the nearest 1-gram precision. Stomach contents were identified to the lowest possible taxonomical level. Since the specimen could not be formalin-fixed and preserved, the upper and lower jaws were excised and preserved in the archive of the first author as local proof of specimen. The maturity stage of the specimen was evaluated following the FAO guidelines on the maturity stages of Mediterranean fishery resources (Follesa & Carbonara, 2019). The present study was supported by the WWF Turkey Wildlife Program within the scope of Cartilaginous Fish (Chondrichthyes) Data Generation project.

RESULTS AND DISCUSSION

Description of the present female little gulper shark (TL = 663 mm): a typical squaliform shark with spines in front of dorsal fins. No anal fin. Pelvic insertion to lower caudal origin (PCA) is 14.45% of TL. Tip of snout to anterior edge of eye distance (POB) is 0.29 of head length (HDL). Height of first dorsal fin (D1H) is 6.29% of TL. First dorsal base (D1B) is 10.47% of TL. First dorsal fin moderately high and short, second dorsal moderately large, nearly as high as first; length of second dorsal base (D2B) is 0.61 of first dorsal base (D1B). Free rear tips of pectoral fins formed into narrow, angular and elongated lobes that reach well beyond the

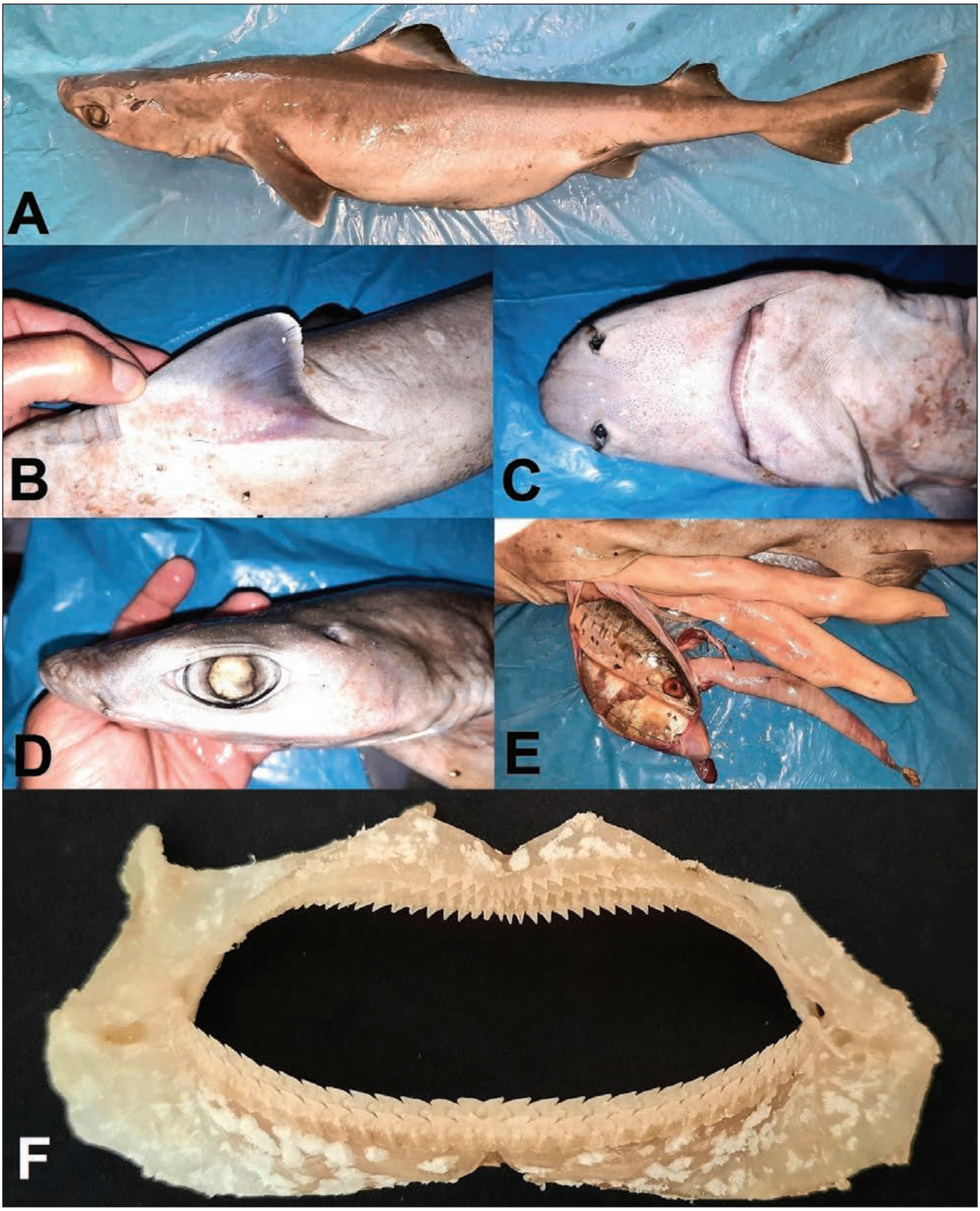

Fig. 2: Examined specimen of *Centrophorus uyato*: **(a) lateral view, (b) pectoral fin in ventral view, (c) mouth and snout, (d) eye and spiracle from left, (e) stomach contents, spiral valve and bilobed liver, and (f) upper and lower jaws.**

Sl. 2: Pregledan primerek vrste *Centrophorus uyato*: **(a) pogled s strani, (b) prsna plavut s trebušne strani, (c) usta in gobec, (d) oko in spirakel z leve, (e) vsebina želodca, zavitnica in dvokrpa jetra, ter (f) zgornja in spodnja čeljust.**

level of first dorsal spine. Caudal fin with a strongly notched posterior margin. Bladelike unicuspid teeth in upper and lower jaws, lower teeth much larger than the upper; tooth counts for upper and lower jaws are 21-21 and 16-16, respectively. Coloration is brownish-grey dorsally and lighter in the same colour ventrally; wide blackish-dark bands on posterior margins of dorsal fins; pectoral, pelvic and caudal fins with conspicuous white margins. The diagnostic features of the examined specimen are depicted in Figure 2. Morphometric measurements are presented in Table 1. TW, EW and HW of the present specimen are 1505, 1045 and 255 grams, respectively.

Reproductive tract was thin and threadlike. *Centrophorus uyato* is an ovoviviparous shark and females mature at a length between 75 and 89 cm (Serena, 2005). The condition of the reproductive organs and size (663 mm TL) of the present specimen confirm that it was an immature female (maturity stage 1) (Follesa & Carbonara, 2019). Remains of teleostean fishes (*Scomber* sp., n=1; *Boops boops*, n=1) were found in the stomach contents; total mass of stomach contents was 132 grams (Fig. 2). According to Compagno (1984), major food items of *C. uyato* are bony fishes and squid.

Veríssimo *et al*. (2014) reported that in *C. uyato*, PCA is <16% of TL and POB is ≤ 0.33 of HDL, which equals 14.45% and 0.29, respectively, in the examined specimen. According to McEachran and Branstetter (1984), in *C. uyato* D1H is 6.5% of TL and D1B 11% of TL, which equals 6.29% of TL and 10.47% of TL, respectively, in the examined specimen. Finally, D2B was reported to be about ¾ or 0.75 of D1B, which equals 0.61 in the examined little gulper shark. Since the observed morphometric measurements were very close to or coincided with those reported in the literature, the present specimen was identified as *C. uyato*. The slight differences observed between the ratios in the present specimen and those reported in the taxonomic literature may be due to intraspecific or intraregional variation. Kousteni *et al*. (2021) reported morphometric data of two females captured in Cypriot waters identified and genetically confirmed as *C. uyato*. According to Kousteni *et al*. (2021), the POB to HDL ratios of the two females (483 and 522 mm TL, respectively) varied between 0.28 and 0.29. Moreover, the PCA to TL percentage ratios in these Cypriot specimens were 12.67% (483 mm TL) and 14.48% (522 mm TL). The ratios for the present specimen coincide with or are within the ranges of those reported for specimens from neighbouring Cypriot waters (Tab. 1).

For the Mediterranean Sea, Veríssimo *et al*. (2014) retain the globally distributed species historically referred to as *Centrophorus granulosus* or *C. uyato* in Clade A, under the name of *C.* cf. *uyato*, until nomenclatural confusion associated with this clade is resolved. In addition to above-mentioned POB/HDL and PCA/TL ratios, Veríssimo *et al*. (2014) propose further ratios for Clade A as follows: PN/POR < 0.45, D1H/D2H > 1.0 and P1A/P1I < 1.14. In the present specimen PN/POR, D1H/D2H and P1A/P1I were 0.33 (<0.45), 1.26 (>1.0) and 0.9 (<1.14), respectively. In terms of these further ratios, the morphometric measurements of the examined specimen coincide with those reported by Veríssimo *et al*. (2014); however, the morphological classification of Clade A is based on the measurement of mere 19 specimens, while for more precise mean values of these ratios that could distinguish the northeastern Mediterranean population of *C.* cf. *uyato*, further specimens would be necessary. In a recent assessment of Mediterranean *Centrophorus*, Bellodi *et al*. (2022) reported that morphometric results supporting the presence of a unique and distinct morphological group and indicating the occurrence of a single species in the region, are ascribable to *C.* cf. *uyato*. Finally, White *et al*. (2022) concluded that to preserve nomenclatural stability within the genus, the name *Centrophorus uyato* should be retained for this species and a neotype from close to the original type locality off Italy should be designated.

Geographically distant (allopatric) populations of the same fish species tend to exhibit morphometric characters at the opposite margins of the value ranges (Cailliet *et al*., 1986). Although slight differences have been observed between the present morphometrics and those reported in Bellodi *et al*. (2022) and White *et al*. (2022), these variations can be considered admissible in view of the mentioned situation.

In conclusion, morphometric measurements reported for a single specimen from the Gulf of Antalya can contribute to providing a more accurate description of *Centrophorus uyato*, a squaliform shark with remarkable intraspecific variation, and to filling the gap in the data on the northeastern Mediterranean population of this species.

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MORFOMETRIJA NAKLJUČNO UJETEGA GLOBINSKEGA TRNEŽA, *CENTROPHORUS UYATO* (SQUALIFORMES: CENTROPHORIDAE), IZ ANTALIJSKEGA ZALIVA Z ZAPISKI O NJEGOVI BIOLOGIJI

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POVZETEK

Devetnajstega maja 2022 se je na parangal naključno ujel primerek globinskega trneža, Centrophorus uyato *(Rafinesque, 1810), na globini 140 m v Antalijskem zalivu (severovzhodno Sredozemsko morje). Bila je nedorasla samica, ki je merila 663 mm v dolžino in tehtala 1,505 g. Razmnoževalni trakt je bil tanek in nitaste oblike. Avtorji so v želodcu našli ostanka dveh primerkov plena in sicer skuše (*Scomber *sp.) in bukve (*Boops boops*). Morfometrične meritve so se ujemale s tistimi od predhodno odkritega klada* C. uyato *Clade A.*

Ključne besede: Elasmobranchii, *Centrophorus*, Levant, batijal

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ATYPICAL CLASPERS IN SMOOTHHOUND, *MUSTELUS MUSTELUS* (CHONDRICHTHYES: TRIAKIDAE) FROM THE COAST OF SENEGAL (EASTERN TROPICAL ATLANTIC)

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ABSTRACT

The authors report the capture of an abnormal specimen of smouthhound Mustelus mustelus *(Linnaeus, 1758). The specimen measured 1045 mm in total length (TL) and weighed 3615 g. It exhibited claspers of dissimilar morphology: a normally developed right clasper characteristic of an adult male, and a smaller left clasper, rounded in its distal end, with a large aperture on the ventral surface. An examination of the abdominal cavity revealed a total absence of the genital apparatus on the left side, which probably explains the aberrant shape of the left clasper. The relationship of total body weight to total length revealed that the abnormal specimen was considerably less heavy than normal specimens from the same TL class.*

Key words: *Mustelus mustelus*, abnormality, weight, condition, genital apparatus

PTERIGOPODI ATIPICI IN *MUSTELUS MUSTELUS* (CHONDRICHTHYES: TRIAKIDAE) LUNGO LA COSTA DEL SENEGAL (ATLANTICO TROPICALE ORIENTALE)

SINTESI

Gli autori riportano la cattura di un esemplare anomalo di palombo, Mustelus mustelus *(Linnaeus, 1758). L'esemplare misurava 1045 mm di lunghezza totale (TL) e pesava 3615 g. Presentava pterigopodi di morfologia diversa: quello destro normalmente sviluppato, caratteristico di un maschio adulto, e quello sinistro più piccolo, arrotondato nella sua estremità distale, con una grande apertura sulla superficie ventrale. L'esame della cavità addominale ha rivelato l'assenza totale dell'apparato genitale sul lato sinistro, il che spiega probabilmente la forma aberrante dello pterigopodio sinistro. Il rapporto tra il peso corporeo totale e la lunghezza totale ha rivelato che l'esemplare anormale era notevolmente meno pesante degli esemplari normali della stessa classe di TL.*

Parole chiave: *Mustelus mustelus*, anomalia, peso, condizione, apparato genitale

INTRODUCTION

The smoothhound *Mustelus mustelus* (Linnaeus, 1758) is a medium-sized shark known in the eastern Atlantic from the British Isles to the coast of Portugal (Branstetter, 1984). To the south of the Strait of Gibraltar, the species occurs from Morocco (Lloris & Rucabado, 1998), Mauritania (Kallahi, 2013) to the Gulf of Guinea (Blache *et al.*, 1970), as far as south African waters (Smale & Compagno, 1997).

M. mustelus is commonly reported throughout the Mediterranean Sea, and generally greatly appreciated for human consumption (Branstetter, 1984; Compagno, 1984). However, the species is facing fishing pressure and a drastic decline in some areas where it was previously considered abundant (Capapé *et al.*, 2000).

Along the coast of Senegal, *M. mustelus*, like other shark species, is the focus of intensive fishing, both commercial and artisanal. Its flesh is dried and used locally or exported to other African countries under the vernacular name of *sali*. Fins of larger specimens are collected and prepared as *laâf* and exported to Asian markets (Gueye-Ndiaye, 1993).

The landings of shark species in fishing sites located along the Senegalese shore offered us the opportunity to collect data and describe some aspects of the smoothhound's reproductive biology (Capapé *et al.*, 2006). Recent investigations conducted throughout the Senegalese coast and supported by local and experienced fishermen, allowed the collection of a specimen of *M. mustelus* from the examined area which displayed an anomalous clasper. The aim of this paper is to describe the specimen and comment on this atypical characteristic in the mentioned elasmobranch species.

MATERIAL AND METHODS

The abnormal specimen of *M. mustelus* was captured off Dakar, Cape Verde Peninsula, and collected on 18 January 2021at the fishing site of Hann, 14°43′32.1″ N and 17°25′35.4″ W (Fig. 1). It was caught by a commercial 3-layer trammel net measuring 50 m in length and 2 m in height, with stretched mesh sizes of 48 mm, 50 mm, and 60 mm, respectively. The capture occurred at a depth between 5 and 16 m, on a sandy-muddy bottom, together with striped panrays, *Zanobatus schoenleinii* (Müller & Henle, 1841), marbled stingrays *Dasyatis marmorata* (Steindachner, 1892) and other teleost species.

Morphometric measurements of the abnormal specimen, recorded to the nearest millimetre following Compagno (1984), are presented in Table 1. The claspers of the abnormal specimen were fixed in 10% buffered formaldehyde, successively preserved in 75% ethanol and deposited in the Ichthyological Collection of Institut Supérieur d'Aquaculture et de Pêche of Bizerte (Tunisia), under the catalogue number, ISPAB-Must-must-01.

Additionally, in order to know if the abnormal *M. mustelus* was able to develop in the wild like normal specimens, the relation between total length (TL) and total body weight (TBW) was used as a complement following Froese *et al.* (2011). This relation – TBW = $a\mathrm{TL}^b$ – was studied in the abnormal specimen and 14 normal previously sampled in the same area (see Capapé *et al.*, 2006), and converted into its linear regression, expressed in decimal logarithmic coordinates. Correlations were assessed by least-squares regression as log TBW = log a + b logDW. The values of constant b were used to confirm or reject the hypothesis of isometric growth, indicating: isometry if $b = 3$, positive allometry if $b > 3$, negative allometry if $b < 3$ (Pauly, 1983). These two latter tests were performed using logistic model STAT VIEW 5.0.

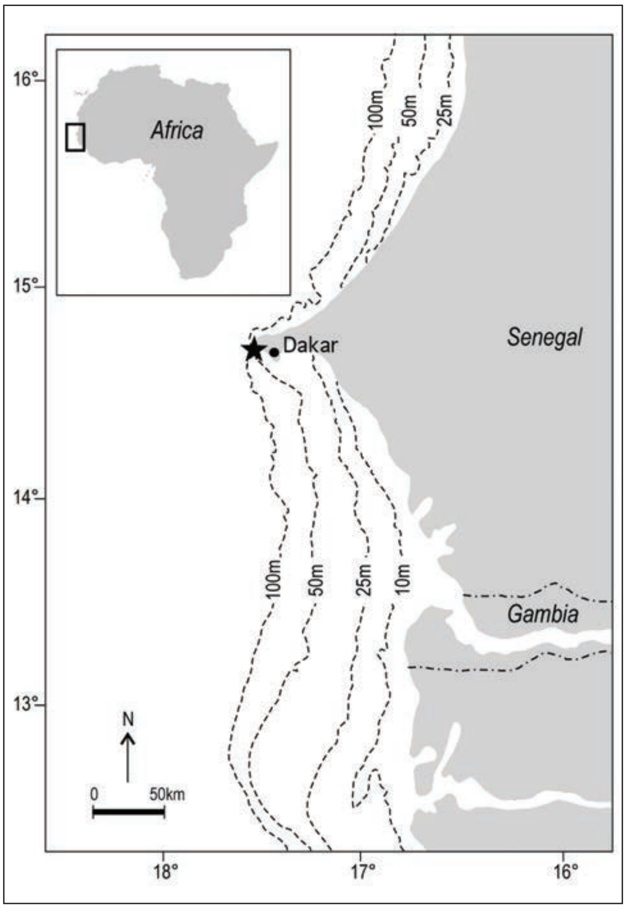

Fig. 1: Map of the Senegalese coast with the capture site of the abnormal specimen of* Mustelus mustelus *indicated (black star).

Sl. 1: Zemljevid senegalske obale z označeno lokaliteto ulova atipičnega primerka vrste* Mustelus mustelus *(črna zvezdica).

Tab. 1: Absolute and relative values of selected morphometric measurements (in millimetres) and total body weight (in grams) of the abnormal specimen of *Mustelus mustelus* ***collected from the coast of Senegal.***
Tab. 1: Absolutne in relativne vrednosti izbranih morfometričnih meritev v milimetrih in celokupna telesna teža v gramih atipičnega primerka vrste *Mustelus mustelus****, ujetega ob senegalski obali.***

References	**ISPAB-Must -must-01**	
Sex	**male**	
Measurements	**mm**	**% TL**
Total length (TL)	1045	100.00
Fork length	891	85.26
Standard length	825	78.95
Pre-caudal length	835	79.90
Pre-first dorsal length	305	29.19
Pre-second dorsal length	660	63.16
Head length	205	19.62
Head height	60	5.74
Mouth width	56	5.36
Abdomen height	80	7.66
Eye length	20	1.91
Eye height	10	0.96
Pre-pectoral fin length	210	20.10
Interdorsal space	252	24.11
Pectoral fin base	46	4.40
Pectoral fin anterior margin	141	13.49
Pectoral inner margin	56	5.36
Pectoral posterior margin	106	10.14
First dorsal fin base	100	9.57
First dorsal fin anterior margin	110	10.53
First dorsal fin inner margin	40	3.83
First dorsal fin posterior margin	83	7.94
Second dorsal fin anterior margin	82	7.85
Second dorsal fin inner margin	25	2.39
Second dorsal fin posterior margin	47	4.50
Pelvic fin base	50	4.78
Pelvic fin anterior margin	72	6.89
Pelvic inner margin	44	4.21
Pelvic fin posterior margin	75	7.18
Caudal base	21	2.01
Dorsal caudal margin	205	19.62
Terminal caudal lobe	70	6.70
Lower post-ventral caudal margin	80	7.66
Pre-ventral caudal margin	72	6.89
Right clasper length	101	9.67
Left clasper length	44	4.21
Total body weight (g)	3615	

RESULTS AND DISCUSSION

The studied specimen measured 1045 mm in TL and weighed 3615 g. It was identified as *M. mustelus* following a combination of main morphometric characters: body slender, head short, snout slightly rounded and moderately long, first dorsal origin over free pectoral fin, both dorsal fins similar in shape, second slightly smaller, pectoral fins broadly triangular, large notch on upper caudal lobe, dermal denticles tridentate, teeth molariform with reduced cusplets; dorsal surface grey to brown, belly whitish to beige (Fig. 2). This description is in total agreement with Quignard & Capapé (1972a), Branstetter (1984), Compagno (1984) and Ebert & Stehmann (2013).

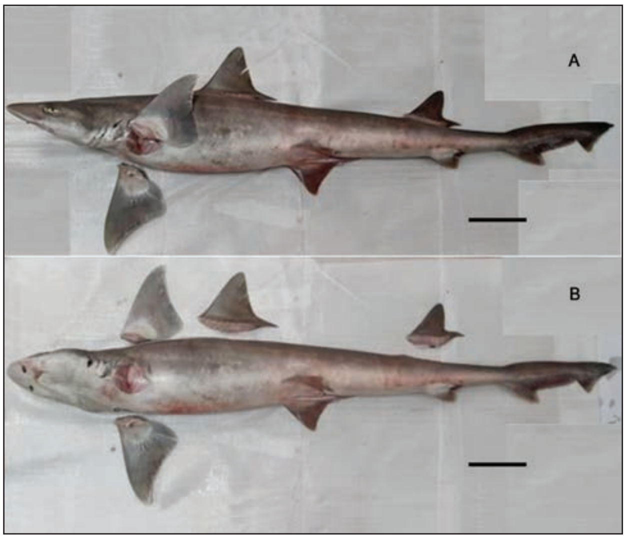

Fig. 2: Abnormal specimen of *Mustelus mustelus* ***collected from the coast of Senegal. A. Entire specimen. B. Fins of larger specimens are collected and prepared as laâf and exported to Asian markets (Gueye-Ndiaye, 1993). Scale bar = 100 mm for both A and B.***
Sl. 2: Atipični primerek vrste *Mustelus mustelus****, ujet ob senegalski obali. A. Cel primerek. B. Plavuti večjih primerkov uporabljajo za pripravo laâf in ga izvažajo na azijski trg (Gueye-Ndiaye, 1993). Merilo = 100 mm za oba, A in B.***

The specimen exhibited two claspers of dissimilar morphology (Fig. 3). The right clasper was normally developed and characteristic of an adult male (Capapé *et al.*, 2006). It was rigid, calcified and longer than the right pelvic fin, slender and pointed at its distal end. The left clasper was smaller than the right clasper and both pelvic fins, rounded in its distal end, exhibiting a large aperture on the ventral surface. This clasper was

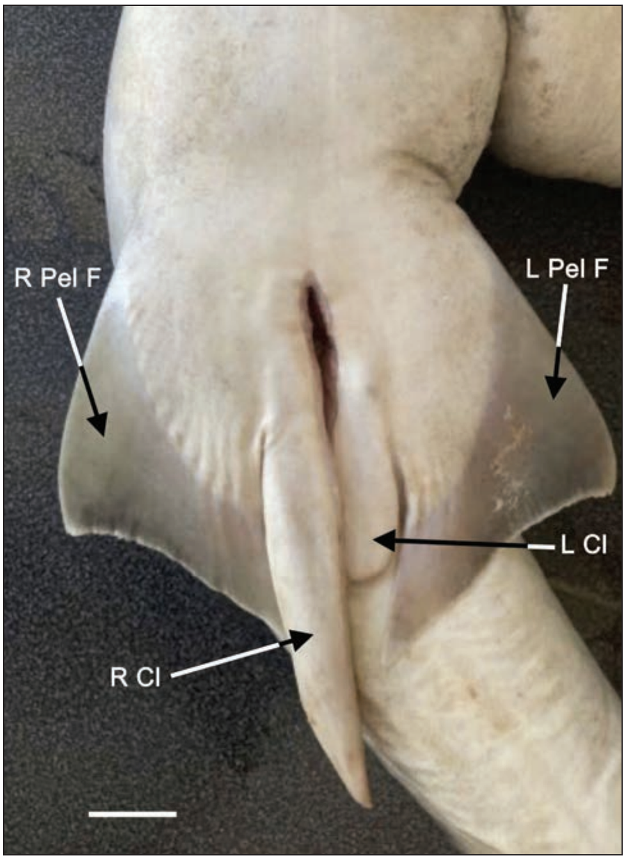

Fig. 3: Claspers of the abnormal specimen of** Mustelus mustelus **collected from the coast of Senegal. L Cl: left clasper, L Pel F: left pelvic fin, R Cl: right clasper, R Pel F: right pelvic fin. Scale bar = 20 mm.

Sl. 3: Klasperja atipičnega primerka vrste** Mustelus mustelus**, ujetega ob senegalski obali. L Cl: levi klasper, L Pel F: leva trebušna plavut, R Cl: desni klasper in R Pel F: desna trebušna plavut. Merilo = 20 mm.

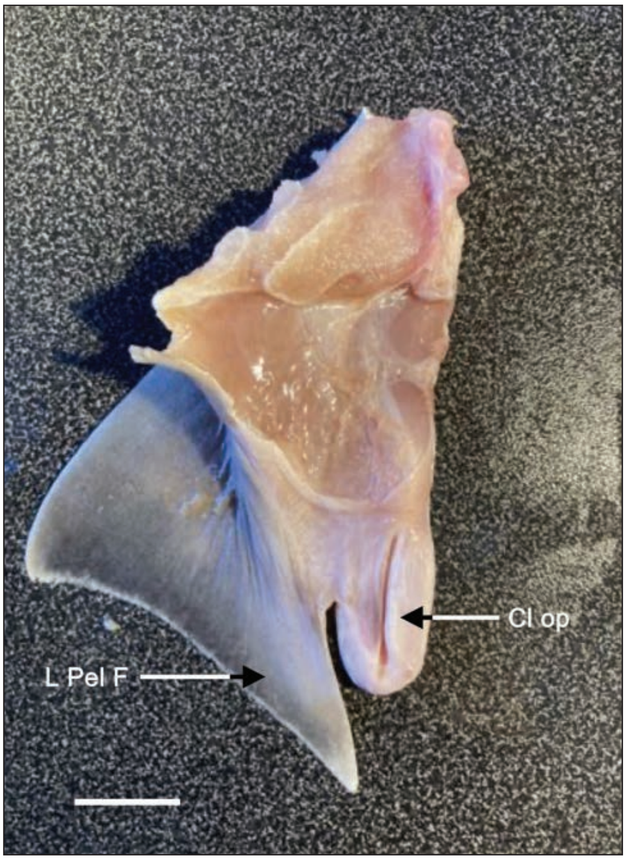

Fig 4: Left clasper of the abnormal specimen of** Mustelus mustelus **collected from the coast of Senegal. Cl Op: clasper opening, L Pel F: left pelvic fin. Scale bar = 20 mm.

Sl. 4: Levi klasper atipičnega primerka vrste** Mustelus mustelus**, ujetega ob senegalski obali. Cl Op: odprtina na klasperju, L Pel F: leva trebušna plavut. Merilo = 20 mm.

soft and flexible due to the complete absence of internal cartilages (Fig. 4).

An examination of the specimen's abdominal cavity showed a complete genital apparatus on the right side, comprising a testicle, a Leydig gland, a rather convoluted spermiduct, and a well-developed seminal vesicle with sperm. Conversely, the left side revealed a total lack of genital apparatus, which probably explains the aberrant shape of the left clasper (Fig. 5). Generally, in elasmobranch species lacking claspers, the presence of aberrant or reduced claspers is a morphological consequence of hermaphroditism or pseudo-hermaphroditism (Quignard & Capapé, 1972b; Capapé *et al.*, 2012; Rafrafi-Nouira *et al.*, 2017). Previously, Ehemann & Gonzàlez-Gonzàlez (2018), Quigley *et al.* (2018, 2019) and Capapé *et al.* (2021) noted that of the 16 cases of abnormal claspers recorded among elasmobranch species, only 4 cases could be considered monstrosities (*sensu* Ribeiro-Prado *et al.*, 2008), or 5 cases including the studied specimen.

The causes of aberrant claspers are diverse, following Capapé *et al.* (2021); they probably have an endogenous origin, genetic and/or hormonal, like in other vertebrates. However, the role of unfavourable environmental conditions, such as pollution due to anthropogenic activity, cannot be totally ruled out. The coast of Senegal, in fact, has been affected by an increase of pollutants in the wild (Diop *et al.*, 2012; Bonnin *et al.*, 2016). Consequently, several cases of abnormalities have been reported from the area with regard to benthic species, especially the most sensitive and locally abundant ones, such as *Zanobatus schoenleiniii* (Diatta *et al.*, 2013; Capapé *et al.*, 2021).

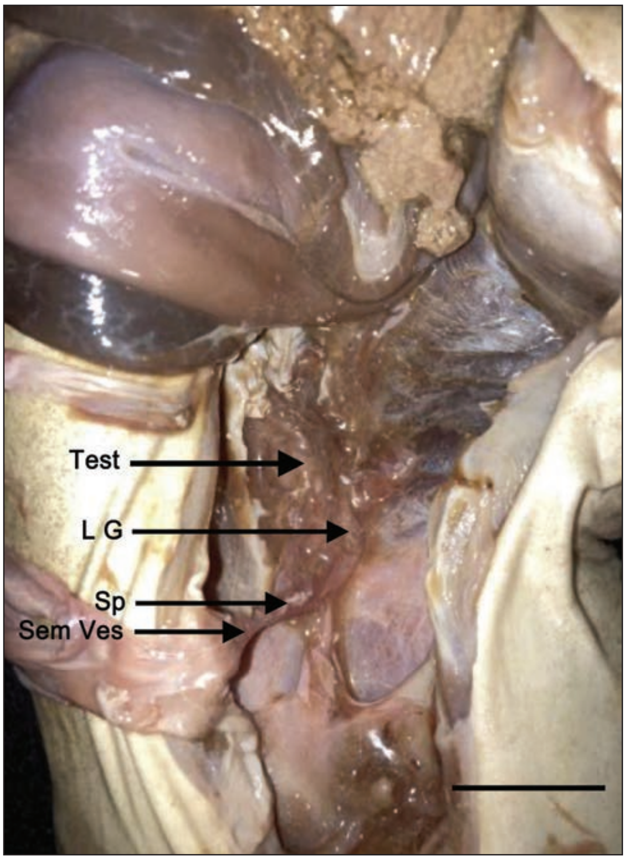

Fig. 5: Abdominal cavity of the abnormal specimen of *Mustelus mustelus* ***collected from the coast of Senegal. L G: Leydig gland, Sem Ves: seminal vesicle, Sp: spermiduct, Test: testicle. Scale bar = 20 mm.***

Sl. 5: Trebušna votlina atipičnega primerka vrste *Mustelus mustelus****, ujetega ob senegalski obali. L G: Leydigova žleza, Sem Ves: semenski mešiček, Sp: semenovod, Test: modo. Merila = 20 mm.***

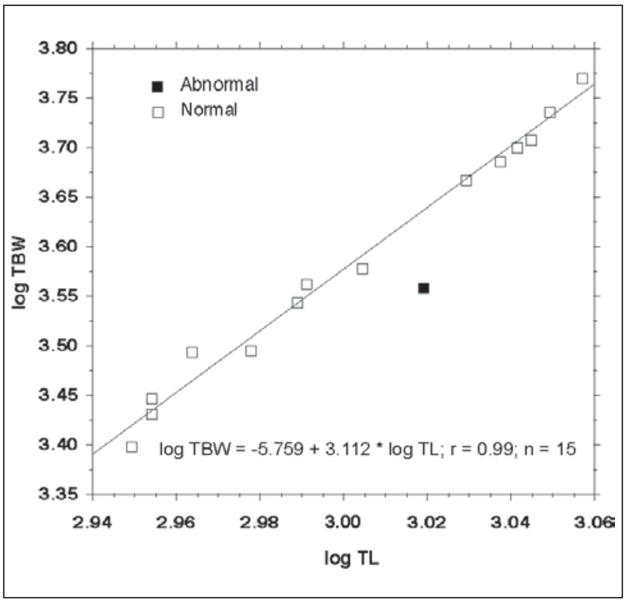

Fig. 6: The total body mass (TBW) to total length (TL) relationship expressed in logarithmic co-ordinates for abnormal and normal specimens of *Mustelus mustelus* ***collected from the coast of Senegal.***

Sl. 6: Odnos med celokupno telesno težo (TBW) in totalno dolžino (TL) izražena z logaritmičnimi osmi za atipičnega in normalne primerke vrste *Mustelus mustelus****, ujetih ob senegalski obali.***

The atrophy of the left clasper could not be considered as very important, because males only use a single clasper during copulation (Chapman *et al.*, 2003). The TBW *vs.* TL relationship was: log TBW = -5.759 + 3.112 * log TL; r = 0.99; n = 15, displaying positive allometry (Fig. 6), as all specimens exhibit a regular increase in growth. Conversely, the abnormal specimen was considerably less heavy than normal specimens of the same TL class. This suggests that it did not develop in the same way as other normal specimens, possibly due to the absence of the left genital apparatus, which may play an important physiological (hormonal) role in elasmobranch species (Mellinger, 1989). It is, in fact, well known that the lack of organs reduces to some degree the development of the body in elasmobranch species (see El Kamel *et al.*, 2009).

NETIPIČNA KLASPERJA NAVADNEGA MORSKEGA PSA, *MUSTELUS MUSTELUS* (CHONDRICHTHYES: TRIAKIDAE) IZ SENEGALSKE OBALE (VZHODNI TROPSKI ATLANTIK)

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POVZETEK

Avtorji poročajo o ulovu netipičnega primerka navadnega morskega psa Mustelus mustelus *(Linnaeus, 1758). Primerek je meril 1045 mm v dolžino in tehtal 3615 g. Klasperja sta bila različna; desni je bil normalno razvit, kot je značilno za odraslega samca, levi pa manjši, zaokrožen in z veliko odprtino na trebušni strani. Preiskava trebušne votline je pokazala, da primerek nima genitalnega aparata na levi strani, kar verjetno razloži nenavadno obliko levega klasperja. Dolžinsko-masni odnos je pokazal, da je atipični primerek znatno lažji od normalnih primerkov v istem velikostnem razredu.*

Ključne besede: *Mustelus mustelus*, atipičen primerek, masa, stanje, genitalni aparat

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NOTES ON A NEWBORN KITEFIN SHARK, *DALATIAS LICHA*: NEW EVIDENCE ON THE NURSERY OF A RARE DEEP-SEA SHARK IN NORTHEASTERN LEVANT (TURKEY)

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ABSTRACT

On 2 April 2022, a kitefin shark, Dalatias licha *(Bonnaterre, 1788), was incidentally captured by a commercial bottom trawler off Taşucu coast (northeastern Levant), over a mixed mud-sand bottom and at a depth of nearly 550 m. It measured 373 mm in total length and 190 g in undressed weight. The healing birthmark, which was visible on the ventral surface between the pectoral fins, revealed that it was a newborn kitefin shark. Published data suggests that the area may serve as a nursery ground for 15 shark species, including* D. licha*, and the present record of newborn kitefin shark in the region supports this suggestion.*

Key words: *Dalatias*, kitefin shark, pups, vulnerable, conservation

NOTE SU UN NEONATO DI SQUALO ZIGRINO, *DALATIAS LICHA*: NUOVE PROVE SULLA NURSERY DI UNO SQUALO RARO DI ACQUE PROFONDE NEL LEVANTE NORD-ORIENTALE (TURCHIA)

SINTESI

Il 2 aprile 2022, uno squalo zigrino, Dalatias licha *(Bonnaterre, 1788), è stato catturato accidentalmente da un peschereccio commerciale a strascico al largo della costa di Taşucu (Levante nord-orientale), su un fondale misto fango-sabbia, a una profondità di circa 550 m. Misurava 373 mm di lunghezza totale e 190 g di peso. La voglia visibile sulla superficie ventrale tra le pinne pettorali, ha rivelato che si trattava di uno squalo zigrino neonato. I dati pubblicati suggeriscono che l'area può servire da nursery per 15 specie di squali, tra cui* D. licha*, e il presente ritrovamento di squalo zigrino neonato nella regione supporta questa ipotesi.*

Parole chiave: *Dalatias*, squalo zigrino, neonati, vulnerabile, conservazione

INTRODUCTION

The identification and mapping of nursery grounds and other essential fish habitats of exploited stocks is a key requirement for the development of spatial conservation planning aimed at reducing the adverse impact of fishing on exploited populations and ecosystems (Colloca *et al.*, 2015). Castro (1993) defined nursery areas, or simply nurseries, as geographically discrete parts of a species' range where gravid females deliver their young or deposit their eggs and where the young spend their first weeks, months, or years. Since the nurseries of viviparous sharks can be detected by the presence of gravid females, neonates and small juveniles in a given marine area (Castro, 1993), observations of newborn or young-of-the-year (YOY) individuals bearing birthmarks are reliable indications of a possible nursery ground located nearby.

The kitefin shark, *Dalatias licha* (Bonnaterre, 1788), is a sporadically distributed deep-water shark of the outer continental shelf and insular shelves and slopes, found in depths between 37 to at least 1800 m,

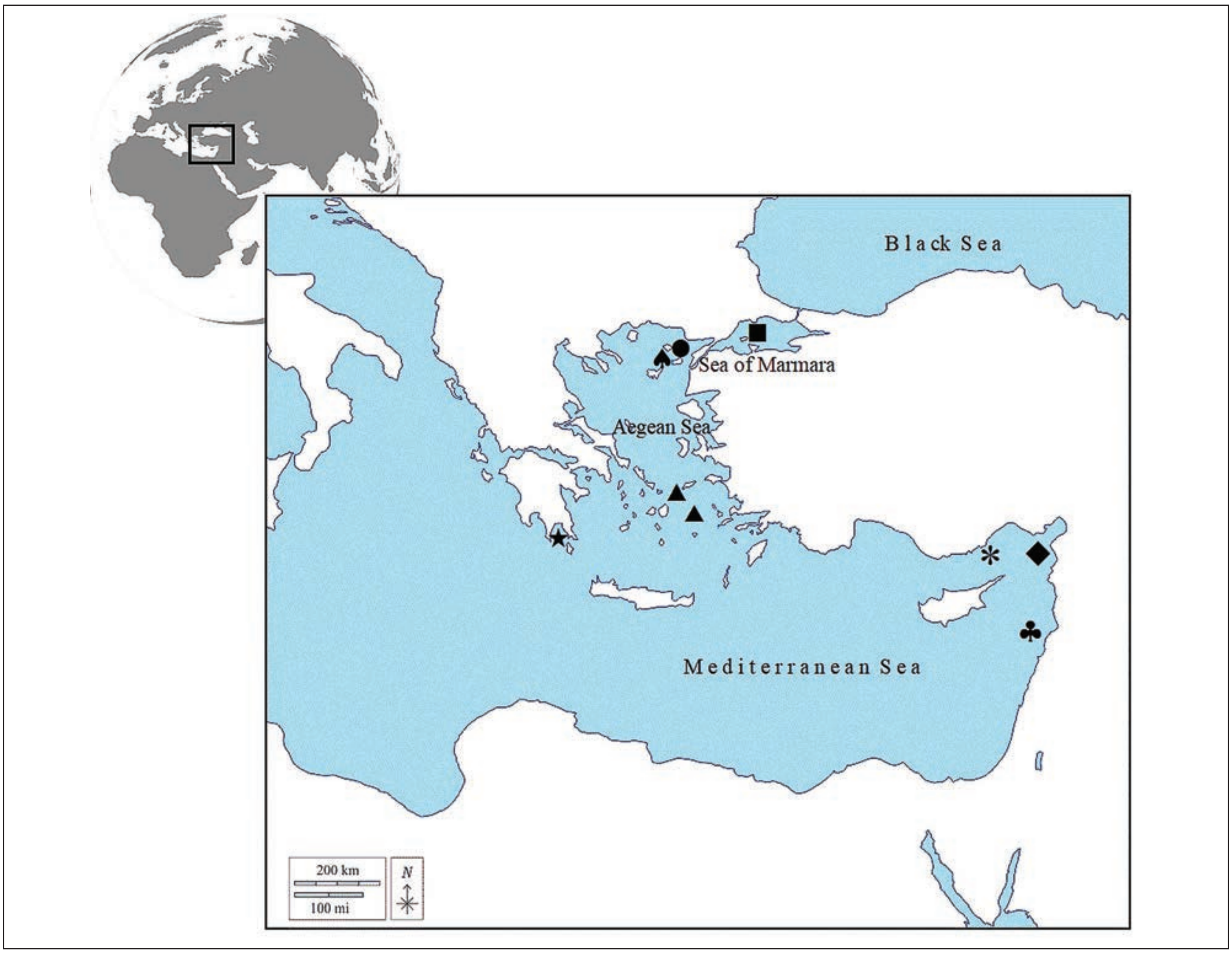

Fig. 1: Approximate locations of capture of** Dalatias licha **specimens reported from the eastern Mediterranean Sea: (*) free-swimming newborn reported in this study; (♣) subadult female kitefin shark reported by Golani (1986); (■) newborn kitefin shark reported by Meriç (1995); (●) newborn kitefin sharks (n=3) reported by Kabasakal & Kabasakal (2002); (♠) specimens (n=5) reported by Gönülal (2016); (♦) adult female kitefin shark reported by Ergüden** et al. **(2017); (★) subadult female reported by Chatzispyrou** et al. **(2018); and (▲) kitefin sharks (n=2) reported by Spyridopoulou** et al. **(2020).

Sl. 1: Približne lokalitete ulova primerkov vrste** Dalatias licha **v vzhodnem Sredozemskem morju: (*) prosto plavajoči primerek mladiča iz pričujoče raziskave; (♣) subadultna samica, o kateri je poročal Golani (1986); (■) komaj skoteni primerek, o katerem je poročal Meriç (1995); (●) komaj skoteni primerki (n=3), o katerih sta poročala Kabasakal & Kabasakal (2002); (♠) primerki (n=5), o katerih je poročal Gönülal (2016); (♦) odrasla samica, o kateri so poročali Ergüden** et al. **(2017); (★) subadultna samica, o kater je poročal Chatzispyrou** et al. **(2018); in (▲) primerka (n=2), o katerih poročajo Spyridopoulou** et al. **(2020).

but most commonly below 200 m (Ebert & Stehmann, 2013). Its distribution range extends from the Atlantic Ocean to the entire Mediterranean Sea, the central and western Pacific, and the Indian Ocean (Serena, 2005; Ebert & Stehmann, 2013). While we know that *D. licha* is a yolk-sac viviparous shark, the information on its reproductive cycle or age at maturity is limited (Ebert & Stehmann, 2013). Recently, Ergüden *et al.* (2022) reported on the capture of an adult female (1180 mm TOT) by a commercial trawler at a depth of 40 m in the northeastern Levant. Although, Ergüden et al. (2022) assumed there was a nursery ground of *D. licha* in the region, the presence of gravid females bearing term embryos alone is not indication enough of a nursery area (Castro, 1993); instead, the occurrence of neonates is required as well. In the present article, authors report on the occurrence of a newborn kitefin shark in the bathyal zone of northeastern Levant, and provide further evidence supporting the possibility of a nursery of *D. licha* in the region. The authors also provide morphometric measurements and biological notes of the examined kitefin shark to contribute to the knowledge of *D. licha* populations in the eastern Mediterranean.

MATERIAL AND METHODS

The examined kitefin shark was incidentally captured on 2 April 2022 by a commercial bottom trawler towing over a mixed sand-mud bottom, at the depth of nearly 550 m, off Taşucu coast (northeastern Levant; Fig. 1). One of the authors of this paper checked whether the animal was alive in order to release it immediately back to the sea in the event it was. Unfortunately, the animal showed no signs of life, thus it was frozen on board for long-term storage and ultimately delivered to the laboratory for further inspection. Following the procedure of Compagno (1984), the total length (TOT) and 46 morphometric measurements were recorded to the nearest 0.05 mm using a vernier caliper. TOT is the distance between the tip of the snout and the tip of the upper caudal lobe, where the caudal fin was depressed to body axis (Compagno, 1984). Morphometric measurements are expressed as percentages of TOT in Table 1. The total weight, where internal organs were not eviscerated, and liver mass were weighed to the nearest gram by means of a precision spring balance (PESOLA Precision scales, Switzerland). Stomach and spiral valve were examined under a binocular dissecting microscope for any remains of food, such as cephalopod beaks or teleostean otoliths. The eviscerated body of the examined kitefin shark was preserved in a 5-percent formalin solution neutralised with borax, and stored in the personal collection of the first author. The present study was supported by the WWF Turkey Wildlife Programme within the scope of the Cartilaginous Fish (Chondrichthyes) Data Generation project.

RESULTS AND DISCUSSION

The female kitefin shark, *Dalatias licha*, which was identified based on the descriptions of Compagno (1984) and Ebert & Stehmann (2013), is depicted in Fig. 2a. The healing birthmark, observed on the ventral surface between the pectoral fins (Fig. 2b), revealed that it was a newborn kitefin shark. The specimen measured 373 mm in TOT; its undressed weight was 190 g, liver weight 30 g (Fig. 2c). Digested remains of a teleost fish were found in the stomach contents; however, due to the level of digestion, it could not be identified at species or genera level.

Data on the size at birth of *Dalatias licha* from different parts of the Mediterranean Sea and the Atlantic Ocean are available in the literature. According to Capapé *et al.* (2008), the size of the smallest free-swimming specimens, caught off the Maghreb coast (south-western Mediterranean), were between 320 and 390 mm TOT, their weight between 256 and 300 g. The TOT of the present newborn kitefin shark (373 mm) coincided with the TOT range given by Capapé *et al.* (2008); however, the weight of the present specimen was clearly lower than that of the smallest free-swimming kitefin shark (320 mm TOT) caught in Maghrebin waters. Kabasakal & Kabasakal (2002) reported the size range of the smallest free-swimming kitefin sharks with birthmarks to be between 338 and 372.5 mm in TOT, with the largest specimen being of similar size to the one in the present study. An unhealed and prominently open umbilical scar was observed on a free-swimming newborn kitefin shark caught in south Atlantic waters (Soto & Mincarone, 2001) and matching the size range of newborn kitefin sharks from the Mediterranean Sea (Kabasakal & Kabasakal, 2002; Capapé *et al.*, 2008; present study). Finally, size of the only kitefin shark that has been reported from the Sea of Marmara to date (345 mm TOT; Meriç, 1995), also matched the TOT range of smallest free-swimming specimens of *D. licha*. The Marmara specimen was captured in commercial trammel-net fishery on the northern slope at a depth of 270 m, on 5 July 1991 (Meriç, 1995).

In the Mediterranean Sea, the depths of capture of newborn specimens of *Dalatias licha* ranged between 200 and 600 m (Kabasakal & Kabasakal, 2002; Capapé *et al.*, 2008; present study); however, the newborn kitefin shark reported by Soto & Mincarone (2001) was collected alive near the surface, and authors interpreted this finding as the expansion of the bathymetrical range of the species from a few meters to 1800 m of depth. The mentioned depths of capture of newborn kitefin sharks in the Mediterranean and in south Atlantic waters raised the question whether gravid females give birth in very shallow waters and then the newborns migrate to deep bathyal grounds or whether encountering a newborn specimen of *D. licha* near the surface was just an unexplainable coincidence.

Tab. 1: Morphometric measurements of kitefin shark* Dalatias licha *carried out in the present study, and previous studies in the Mediterranean Sea.

Tab. 1: Morfometrične meritve na primerku klinoplavutega morskega psa iz pričujoče raziskave in iz prejšnjih raziskav v Sredozemskem morju.

Measurements (mm)	**Present Study**		**Golani (1986)**		**Soto & Mincarone (2001)**		**Kabasakal & Kabasakal (2002)**		**Ergüden *et al.* (2017)**		**Chatzispyrou *et al.* (2018)**	
		% of TOT		% of TOT		% of TOT		% of mean TOT		% of TOT		% of TOT
Total Length (TOT)	373		932		344		338-372.5		1180		990	
Snout tip to												
Outer nostrils	4.15	1.11				2		1.15		2.03		
Eye	11.65	3.12				4.1		3.11		4.06		
Spiracle	35.65	9.56				9.6		9.24		9.59		
Mouth	24.5	6.57				6.1		5.48		6.1		
1st gill opening	65.2	17.48				17.2		16.16		17.15		
3rd gill opening	75.65	20.28						18.72				
5th gill opening	81.85	21.94		20.9		21.2		20.58				21.21
Pectoral origin	82	21.98				21.8		20.69		21.8		
Pelvic origin	200.95	53.87		58.5		54.1		52.73		54.06		62.63
Cloaca	220.5	59.12						57.16				
1st dorsal origin	129.3	34.66		36.8		35.5		34.11		35.46		56.57
2nd dorsal origin	223.15	59.83		62.3		59.9		58.08		59.88		69.7
Dorsal caudal origin	280.1	75.09				75		74.32		75		80.81
Ventral caudal origin	270.05	72.40						71.23				
Distance between bases												
1st and 2nd dorsal fins	78.9	21.15				21.2		20.09		21.22		
2nd and caudal fins	33.25	8.91				10.5		10.67		10.46		
Pectoral and pelvic fins	111.1	29.79				29.1		27.88		29.08		
Nostrils: distance												
Between inner corners	10.65	2.86				2.9		3.34		2.9		
Mouth												
Width	30.4	8.15				7.3		7.42		5.32		
Gill opening lengths												
1st	4.3	1.15				1.5		1.43		1.45		
3rd	5	1.34				1.5		1.34		1.54		
5th	7.15	1.92				1.7		1.69		1.74		
Spiracle: maximum width	7.65	2.05				0.9		1.58		0.87		
Eye												
Horizontal diameter	15.8	4.24				3.5		3.96		3.48		
Vertical diameter	7.2	1.93				1.7		1.97		1.74		
Interorbital width	21.2	5.68				6.1		6.18				
1st dorsal fin												
Overall length	36.65	9.83				9.3		9.65		9.3		
Length base	16.7	4.48				4.1		3.99				
Length posterior margin	12.55	3.36				3.5		4.01				
Height	19.15	5.13				4.1		4.05				
2nd dorsal fin												
Overall length	38.3	10.27				10.2		10.55		9.3		
Length base	21.7	5.82				5.5		5.97				
Length posterior margin	15.1	4.05				4.9		4.82				
Height	16.7	4.48				4.7		4.94				
Pectoral fin												
Length base	16.05	4.30				4.4		4.65				
Length anterior margin	48.25	12.94				12.2		12.23		14.24		
Length distal margin	13.15	3.53						5.56				
Length posterior margin	22.95	6.15				6.1		6.37				
Pelvic fin												
Overall length	49.6	13.30				11		11.65		11.04		
Length base	28.55	7.65				6.4		7.07				
Length anterior margin	33	8.85				8.4		8.24				
Length clasper	---	---				3.8		4.17				
Caudal fin												
Length dorsal lobe	92.2	24.72				25.9		24.43				
Length ventral lobe	42.95	11.51				12.5		11.5				
Dorsal tip to notch	17.1	4.58				5.5		6.01				
Depth notch	15.55	4.17				4.1		4.22				
Trunk at pectoral origin												
Height	40.65	10.9				10.8		9.59		10.75		
Total weight (g)	190											

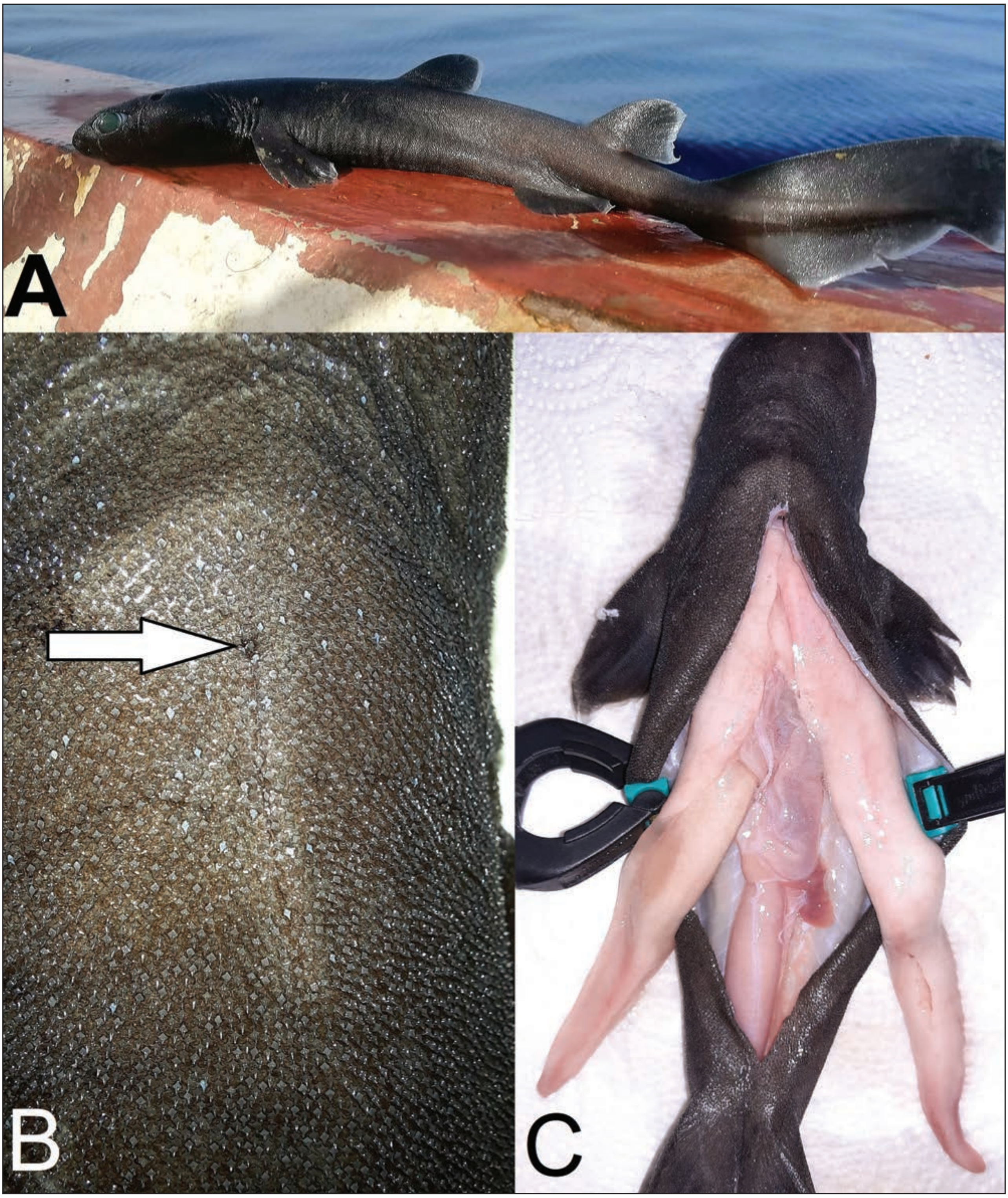

Fig. 2: (a) Lateral view of the newborn kitefin shark,* Dalatias licha*, captured off Taşucu coast, NE Levant; (b) arrow pointing to the healing birthmark on the ventral surface of examined newborn specimen, between the pectoral fins; and (c) internal examination of specimen showing bi-lobed liver and stomach.

Sl. 2: Pogled s strani na komaj skotenega mladiča klinoplavutega morskega psa,* Dalatias licha*, ujetega ob obali Taşucu, SV Levant; (b) puščica označuje poporodno brazgotino na trebušni strani skotenega primerka med prsnimi plavutmi; in (c) notranji pregled primerka z vidnimi dvokrpastimi jetri in želodcem.

Morphometric measurements of the examined kitefin shark, accompanied by previously published morphometric data on *Dalatias licha*, are presented in Table 1. Minor differences were observed between the results of the present study and published morphometrics of *D. licha*, which were statistically insignificant (Table 1; t-test, p>0.10). Although the morphometric ratios of any fish can run between certain minimum and maximum extremes, the condition of the specimen (fresh, preserved, or decomposing in case of stranded specimens), the measurement tool (*e.g.*, an ordinary measurement tape or a vernier caliper) and experience of the measurer etc., can also affect the accuracy of morphometric measurements (Takács *et al.*, 2016).

In the majority of the literature, *Dalatias licha* is considered a rare or data-limited shark (*e.g.,* Capapé *et al.*, 2008; Ergüden *et al.*, 2017; Chatzispyrou *et al.*, 2018; Spyridopoulou *et al.*, 2020). Furthermore, in a recent review of species diversity, taxonomy and distribution of chondrichthyes in the Mediterranean Sea, Serena *et al.* (2020) stated that *D. licha* is not an abundant shark species in any region of its distribution range in the Mediterranean Sea. Serena *et al.* (2020) emphasised that kitefin shark is more frequent in the western basin. However, in two very comprehensive surveys investigating the distribution and abundance of demersal cartilaginous fish in the Mediterranean it was noted that the species is more abundant than expected throughout the investigated region (Baino *et al.*, 2001; Sion *et al.*, 2004). In a MEDITS survey, frequency of occurrence of *D. licha* was 2 percent, with kitefin sharks recorded in 152 out of 6336 bottom trawl hauls (Baino *et al.*, 2001). During a DESEAS survey carried out in three areas of the Mediterranean Sea (Balearic Sea, western and eastern Ionian Sea), *D. licha* specimens were caught in all three areas in the 800–1200 m depth strata (Sion *et al.*, 2004). Moreover, Sion *et al.* (2004) reported that abundance of *D. licha* decreased with depth. Ragonese *et al.* (2013) analysed the data gathered in scientific bottom trawl surveys carried out off the southern coasts of Sicily from 1994 to 2009, and concluded that *D. licha* was common, mainly on the slope. Survey data also indicated an exclusive bathyal presence (376–783 m) for *D. licha* throughout the area of investigation, with a preference for central and eastern grounds and deeper waters (550–783 m) (Ragonese *et al.*, 2013). Last but not least, based on the results of a deep-sea (500–1000 m) long-line survey conducted off the Island of Gökçeada (NE Aegean Sea), Gönülal (2016) stated that *D. licha* is a "frequent" deep-sea shark in the region.

As seen in the map (Fig. 1), the capture localities of free-swimming newborns of *D. licha* in the eastern Mediterranean are widely scattered, suggesting the possibility of multiple nurseries in the region. From the perspective of conservation, the possibility of multiple nurseries of *D. licha* in the eastern Mediterranean could raise the chance of survival and the continuity of the generations; however, this advantageous situation could also pose new challenges in areas where commercial demersal fishery overlaps with those nurseries, as is the case with nurseries of many demersal fishes in the Mediterranean (Colloca *et al.*, 2015). Based on the data reported by Meriç (1995) and Kabasakal & Kabasakal (2002), the suggested nurseries of *D. licha* in the northern Aegean Sea and in the northern slope of the Sea of Marmara (Fig. 1) are overlapped with the fishing zones of commercial trawlers, gill- and trammelnetters, and long-liners. According to Ergüden *et al.* (2022), the Bays of İskenderun and Mersin, which are also important commercial bottom trawling grounds, may serve as nursery grounds of 15 species of sharks, including *D. licha*, and the present record of newborn kitefin shark in the region provides supporting data for this suggestion. *D. licha* is a "vulnerable" shark (Finucci *et al.*, 2018; Serena *et al.*, 2020), and effective conservation of these nursery grounds should also be included among any fishery management measures to be implemented in the vicinity of these areas.

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ZAPIS O NAJDBI SKOTENEGA KLINOPLAVUTEGA MORSKEGA PSA, *DALATIAS LICHA*: NOVI DOKAZ O JASLICAH REDKEGA GLOBOKOMORSKEGA MORSKEGA PSA V SEVEROVZHODNEM LEVANTU (TURČIJA)

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POVZETEK

Dvaindvajsetega aprila 2022 so v bližini obale Taşucu (severovzhodni Levant) na mešanem peščenem muljastem dnu na globini 550 m v pridneno kočo naključno ujeli primerek klinoplavutega morskega psa, Dalatias licha *(Bonnaterre, 1788). Meril je 373 mm v dolžino in očiščen (brez kože) tehtal 190 g. Na podlagi poporodne brazgotine na trebušni strani med prsnimi plavutmi se je izkazalo, da gre za pred kratkim skotenega mladiča klinoplavutega morskega psa. Avtorji na podlagi objavljenih podatkov domnevajo, da bi lahko bilo območje severovzhodnega Levanta vzrejno območje (jaslice) za najmanj 15 vrst morskih psov, vključno s klinoplavutim morskim psom, kar potrjuje tudi pričujoča najdba komaj skotenega mladiča.*

Ključne besede: *Dalatias*, klinoplavuti morski pes, mladič, ranljiva vrsta, varovanje

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DIET COMPOSITION AND FEEDING STRATEGY OF ATLANTIC CHUB MACKEREL *SCOMBER COLIAS* IN THE ATLANTIC COAST OF MOROCCO

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ABSTRACT

*The diet composition and feeding strategy of the Atlantic chub mackerel (*Scomber colias*) were studied in the Atlantic coast of Morocco in the winter of 2017. A total of 330 stomach contents of* S. colias *were examined. The study of the vacuity index indicated high feeding activity of* S. colias *in Safi (SF) (2%), and Laayoune (LA) (6%). However, low feeding activity was shown in El Jadida (JD) (25%) and Agadir (AG) (20%). The analysis of the diet composition of studied populations led to identifying 22 items. The most abundant prey was fish with high importance index, followed by copepods in three localities (AG, SF, and LA), where the dominant preys in El Jadida (JD) were crustaceans and mysids with a high importance index.* S. colias *is a carnivorous fish and a ferocious fish predator. We recorded several cases of cannibalism among the studied populations.*

Key words: Diet, *Scomber colias*, stomach contents, vacuity index, cannibalism

COMPOSIZIONE DELLA DIETA E STRATEGIA ALIMENTARE DELLO SGOMBRO OCCHIONE *SCOMBER COLIAS* LUNGO LA COSTA ATLANTICA DEL MAROCCO

SINTESI

*La composizione della dieta e la strategia alimentare dello sgombro occhione (*Scomber colias*) sono state studiate lungo la costa atlantica del Marocco nell'inverno del 2017. Sono stati esaminati 330 contenuti stomacali di* S. colias. *Lo studio dell'indice di vacuità ha indicato un'elevata attività alimentare di* S. colias *a Safi (SF) (2%) e Laayoune (LA) (6%). Tuttavia, è stata evidenziata una bassa attività alimentare a El Jadida (JD) (25%) e Agadir (AG) (20%). L'analisi della composizione della dieta delle popolazioni studiate ha portato all'identificazione di 22 elementi. La preda più abbondante sono stati i pesci, con un alto indice di importanza, seguiti dai copepodi in tre località (AG, SF e LA), mentre le prede dominanti a El Jadida (JD) sono state i crostacei e i misidi, con un alto indice di importanza.* S. colias *è un pesce carnivoro e un feroce predatore di pesci. Abbiamo registrato diversi casi di cannibalismo tra le popolazioni studiate.*

Parole chiave: dieta, *Scomber colias*, contenuto stomacale, indice di vacuità, cannibalismo

INTRODUCTION

The Atlantic chub mackerel *Scomber colias* (Gmelin, 1789) is an epipelagic to mesopelagic species observed over the continental slope in warm and temperate waters between 0-250 to 300 m (Collette & Nauen, 1983; (Čikeš Kec & Zorica, 2012)). It is widely distributed in the Atlantic Ocean of Northwest Africa including the Eastern Atlantic (the Canary and Azore Islands) to the Bay of Biscay, in the Mediterranean Sea, and the adjacent waters, such as the Black Sea (Collette & Nauen, 1983; Navarro *et al.*, 2012). The Atlantic chub mackerel occupies a key position in the trophic web and is considered to be the link between the primary producers and the higher trophic levels. Thus, it is an important prey for large pelagic fish (tuna, sharks) and marine mammals (dolphins) (Velasco *et al.*, 2011; Machado *et al.*, 2022). The quantity of food available and the interaction between fish using the same food source represent the key factors that influence the size (length-weight) of fish. Hence, the length-weight relationship is an important biological parameter that provides information about the growth, health, habitat conditions, gonad maturity, life history, and fatness of a fish species (Froese, 2006; Froese *et al.*, 2011; Jisr *et al.*, 2018), and is helpful in comparing life histories and morphological aspects of populations inhabiting different habitats (Cherif *et al.*, 2008, Hashemzadeh *et al.*, 2015, Bouzzammit *et al.*, 2019).

The analysis of the composition of stomach contents and dietary patterns can be used to assess habitat preferences, prey selection, effects of ontogenesis, and the development of conservation strategies (Chakraborty *et al.*, 2019; Mishra, 2020). Besides providing important insights into ecological and biological aspects of fish behavior, habitat use, energy intake, and interaction between species in the ecosystem, the study of feeding habits contributes to understanding the ecosystem structure, community composition, and population dynamics (Litvaitis, 2000; Stergiou & Karpouzi, 2002; Zacharia & Abdurahiman, 2004; Ahlbeck *et al.*, 2012; Manko, 2016; Atique & An, 2018; Rahman *et al.*, 2020; Saeed *et al.*, 2020). Also, the feeding habit analysis of aquatic species can yield an understanding of their growth, abundance, and productivity (Nansimole *et al.*, 2014). Therefore, knowledge about dietary patterns and the diet of fish is indispensable in the decision-making process related to the sustainable management of aquatic ecosystems (Garvey & Chipps, 2012).

Several studies have been carried out about the food and feeding habits of fish in general, with many authors discussing in particular the inspection of fish stomach contents (including Hynes, 1950; Windell & Bowen, 1978; Hyslop, 1980; Mohan & Sankaran, 1988; Costello, 1990; Da Silveira *et al.*, 2020), all agreeing that a food item should be counted, weighed, or measured by their volume. Still, the Atlantic chub mackerel (*S. colias*) remains poorly studied and very little is known about their behavioural patterns and feeding strategy in Moroccan waters. As the sustainable management of small pelagic stocks has become a scientific concern in Morocco, a study on the dietary pattern of *S. colias* and its interactions with the ecosystem will contribute to improving the knowledge of this species, especially in terms of stock management.

This study aims to examine the stomach contents composition and to determine the feeding strategy of *S. colias* from four localities in the Atlantic coast of Morocco during winter, in order to provide information on trophic ecology for a good management of this species in Moroccan waters.

MATERIAL AND METHODS

Sampling area

A total of 330 individuals of *Scomber colias* were collected from small-scale boats and purse seiners from four ports in the Atlantic coast of Morocco, located between 33°15′17″ N, -8°30′21″ O and 27°08′30″ N - 13°11′16″ O, namely El Jadida (JD), Safi (SF), Agadir (AG), and Laayoune (LA) (Fig. 1).

Analysis of stomach contents

All samples were measured for total length (TL) to the nearest 1 mm, and total weight (TW) to the nearest 0.1 g. The stomachs were carefully removed from the body, weighed, and preserved in 5% neutralised formalin. The stomachs were opened by making a small cut and the gut fullness was assessed on a visual scale from 0 (empty) to 1.0 (completely full) with intermediate values of 0.25 for 1/4 full, 0.5 for 1/2 full, and 0.75 for 3/4 full. The specimens with full and 3/4 full stomachs were considered to have been feeding actively. The gut contents were transferred into a petri dish. Each stomach content was examined under a compound inverted microscope (X40). All prey items were first identified to the lowest taxonomic level possible using the Boltovskoy (1999) and Rose (1933) identification keys. Diet composition was analysed and evaluated using the following indexes.

The empty stomachs were counted in order to calculate the vacuity index (*VI*), which corresponds to the percentage of empty stomachs (*ES*) in the total number of analysed stomachs (TS):

$$VI\% = ES / TS * 100$$

The importance index indicates the relative importance, and the volumetric analysis index indicates the relative abundance of specific items found in the stomach samples (Lima-Junior & Goitein, 2001). They were used to identify important prey groups in the diet of *S. colias*:

$$\mathbf{AI_i = F_i \cdot * V_i}$$

$$\mathbf{Q = \%F * Cp\%}$$

where F_i = frequency of occurrence, V_i = volumetric analysis index of item (Lima Junior *et al.*, 2001), Q = feeding coefficient, $\%F$ = frequency index of prey i, and $Cp\%$ = percentage of the prey item's volume.

By applying the food coefficient Q and the frequency index F (the Geistdoerfer index [1978]), the prey is divided into three categories, with each further subdivided into two subcategories:

$Q>100$ indicates main prey, which can be preferential ($F>0.30$) or occasional ($F<0.30$); $10<Q<100$ indicates secondary prey, which can be frequent ($F>0.10$) or accessory ($F<0.10$); $Q<10$ indicates complementary prey, which can be first order ($F>0.10$) or second order ($F<0.10$).

While the importance of prey items and feeding strategy were analysed via a graphical method (Amundsen *et al.*, 1996), plots were constructed using a modified Costello method (Amundsen *et al.*, 1996). The graphical analysis of feeding strategy (P_i) is based on a two-dimensional representation of prey-specific

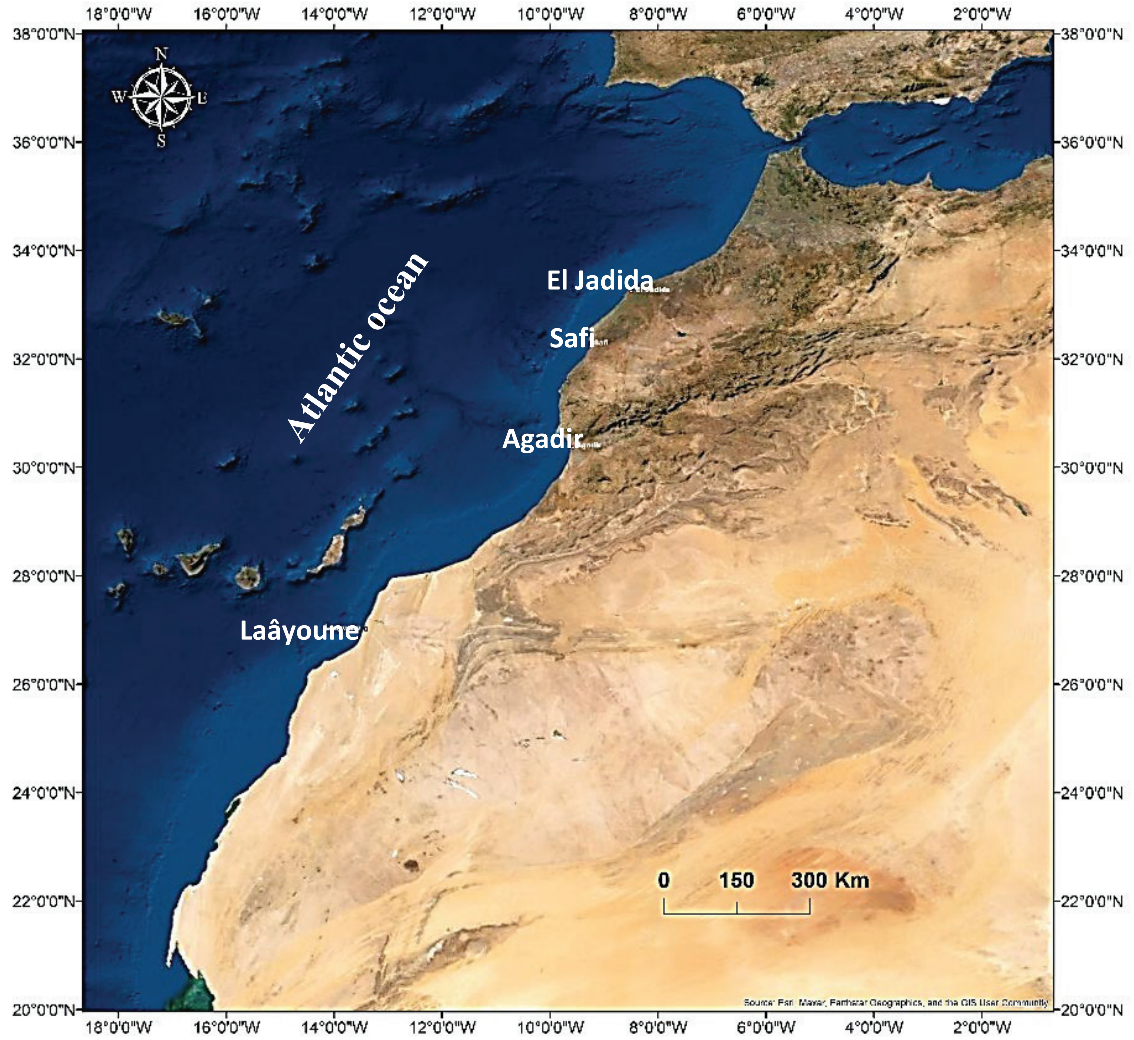

Fig. 1: Sampling areas of *Scomber colias* ***on the Atlantic coast of Morocco.***
Sl. 1: Vzorčevalni predeli, kjer so vzorčili vrsto *Scomber colias* ***ob atlantski obali Maroka.***

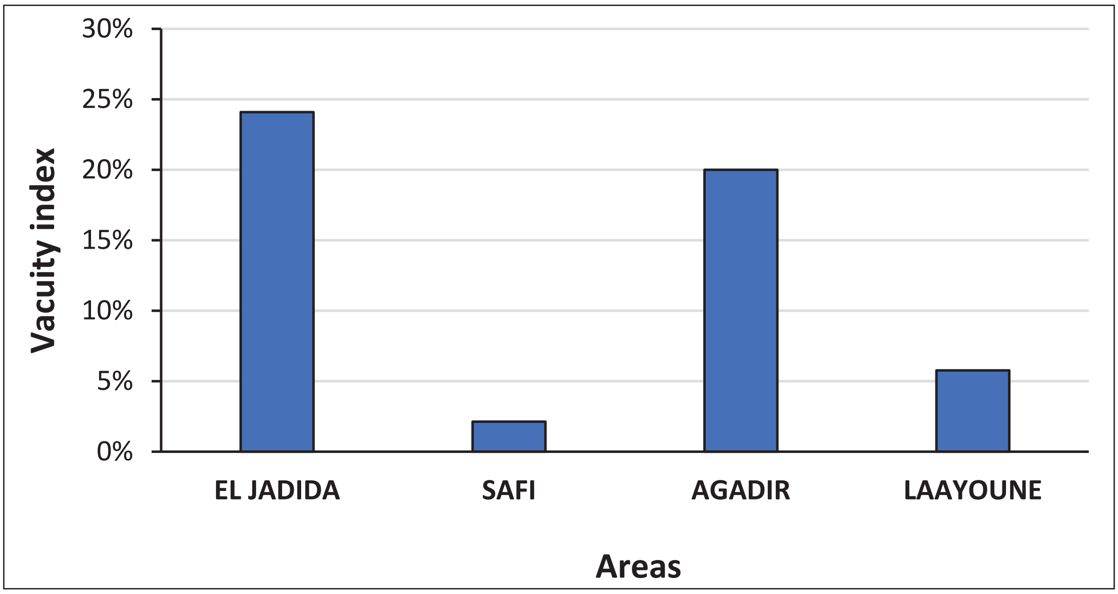

Fig. 2: Variation of vacuity index in the four areas (El Jadida, Safi, Agadir, and Laayoune).
Sl. 2: Variabilnost indeksa praznosti na štirih predelih (El Jadida, Safi, Agadir in Laayoune).

abundance and frequency of occurrence of the different prey types in the diet, and calculated according to the formulae:

$$P_i = (\sum S_i/\sum St_i) * 100$$

$$F_i = 100 * (N_i/N)$$

where S_i is the stomach content (volume, weight, or number) composed by prey i, and St_i is the total stomach content of all stomachs in the entire sample. N_i is the number of predators with prey i in their stomachs, and N is the total number of predators with stomach contents of any kind (Amundsen *et al.*, 1996).

Length-weight relationships and condition factor

The length-weight relationship was studied for different samples collected in the aforementioned areas (EL Jadida, Safi, Agadir, and Laayoune). The body weight was calculated using the equation $\mathbf{Wt = a.TL^b}$, where *Wt* is the total weight, *TL* is the total length, *a* is a coefficient related to body shape, and *b* is an exponent that indicates isometric growth in body proportions if b=3 (Froese 2006). The parameters (*a*, *b*) are important in stock assessment studies (Froese 1998; Froese *et al*., 2011). The relationships between length and weight may also be used for determining the fish condition, comparing fish growth among areas, and as a complement to species-specific reproduction and feeding studies (Koutrakis & Tsikliras, 2003; Froese, 2006; Froese *et al*., 2011).

The condition factor (K) was calculated to compare the change in size based on weight variation: $\mathbf{K= (Wt/TL^3) * 100}$ (Pauly, 1983), where *Wt* is the total body weight in grams, and *TL* is the total length in cm.

Statistical analysis

For statistical analysis, one-way ANOVA was used to test the difference in total length (TL) between four localities. The data were analysed statistically using the SPSS (version 21) statistical software package.

RESULTS

Feeding intensity

Among a total of 330 stomachs of *S. colias* examined, 20 empty stomachs were recorded in the Agadir sample (VI%=20%), 3 empty stomachs were recorded in the Laayoune sample (VI%=6%), 2 empty stomachs in the Safi sample (2%), and 19 empty stomachs in the El Jadida sample (VI%=23%). The highest numbers of empty stomachs were found in the Agadir and El Jadida samples, the lowest in the Safi and Laayoune samples (Fig. 2).

Diet composition and feeding strategy

An analysis of the diet composition of 330 individuals led to the identification of 22 items (Tab. 1), manifesting that the diet of *S. colias* is characterized by a wide spectrum of prey groups and species. The relative importance index showed the most common preys to occur in stomachs of *S. colias* from the different

Tab. 1: Composition of *Scomber colias'* ***stomach contents with Occurrence Frequency (Fi%) and Importance Index (AI) recorded for each food item.***

Tab. 1: Vsebina prehrane lokarde na podlagi frekvence pojavljanja (Fi%) in indeksa pomembnosti (AI) za vsako prehranjevalno kategorijo.

Taxon	Occurrence Frequency				Importance Index			
	Eljadida	Safi	Agadir	Laayoune	Eljadida	Safi	Agadir	Laayoune
Copepoda	52.4	78	40	0	**520**	**689**	**144**	0.1
Shrimp	4.8	0	26.3	0	24	0	0	0
Debris of crustaceans	79.4	1.1	1.3	0	**2567**	0.3	3	0
Crab	3.2	0	0	0	11	0	0	0
Mysids	46	1.1	21.3	0	**1370**	0.1	53	0
Amphipoda	6.4	0	0	0	20	0	0	0
Ostracoda	11.1	3.3	2.5	0	13	1.3	0	0
Cladocera	19	29.4	10	0	45	**100**	1.6	0
Isopod	47.6	1.1	16.3	0	**123**	0.1	33	0
Chaetognathes	33.3	23.9	45	8.2	**185**	49	56	21
Sardina pilchardus	0	35.9	26.3	93.9	0	**731**	**701**	**8767**
Engraulis encrasicolus	0	65.2	27.5	0	0	**2100**	**687**	0
Scomber colias	3.2	21.7	11.3	14.3	5	**390**	**181**	**284**
Debris of fish	4.8	8.7	3.8	0	8	14	0	0
Larvae	19	44.6	1.3	0	79	**321**	0.98	0
Egg	11.1	43.5	3.8	0	42	**248**	0	0
Loligo	0	0	1.3	0	0	0	0.78	0
Annelida	11.1	3.3	0	0	24.2	1.3	0	0
Lammelibranchs	0	0	2.5	0	0	0	0.78	0
Cnidaire	3.2	2.2	0	0	1.3	0.3	0	0
Appendicularia	0	2.2	0	0	0	0.9	0	0
Sand, debris, plastic	3.2	0	2.5	0	3.8	0	2.73	0

studied localities (El Jadida [JD], Safi [SF], and Agadir [AG]) were fish, copepods, crustaceans, chaetognaths, and mysids. However, in Laayoune, the single most important prey recorded was fish, with chaetognaths a distant second.

The statistical analysis revealed a significant difference ($p<0.05$) between the four localities. The Laayoune sample represents the largest sample, followed by Agadir and El Jadida. The Safi sample was the smallest (Fig. 3).

Fish were the predominant prey in AG, SF, and LA because those samples contained a higher number of (adult) mackerel individuals, which prefer to consume fish (sardines, anchovy, and mackerel), compared to smaller individuals (juveniles), which tend to consume zooplankton (copepods, mysids, isopods, amphipods, cladocerans, chaetognaths, and ostracodes). We plotted the prey-specific abundance *Pi* against the frequency of occurrence *Fi* to assess the feeding strategy of *S. colias*. Figures 4 and Figure 5 indicate differences in the feeding strategies of specimens from the four areas (El Jadida, Safi, Agadir, and Laayoune). Many kinds of prey were found in the stomachs of the Atlantic chub mackerel, with fish being the most abundant in three of the four studied populations (Agadir, Safi, and Laayoune)

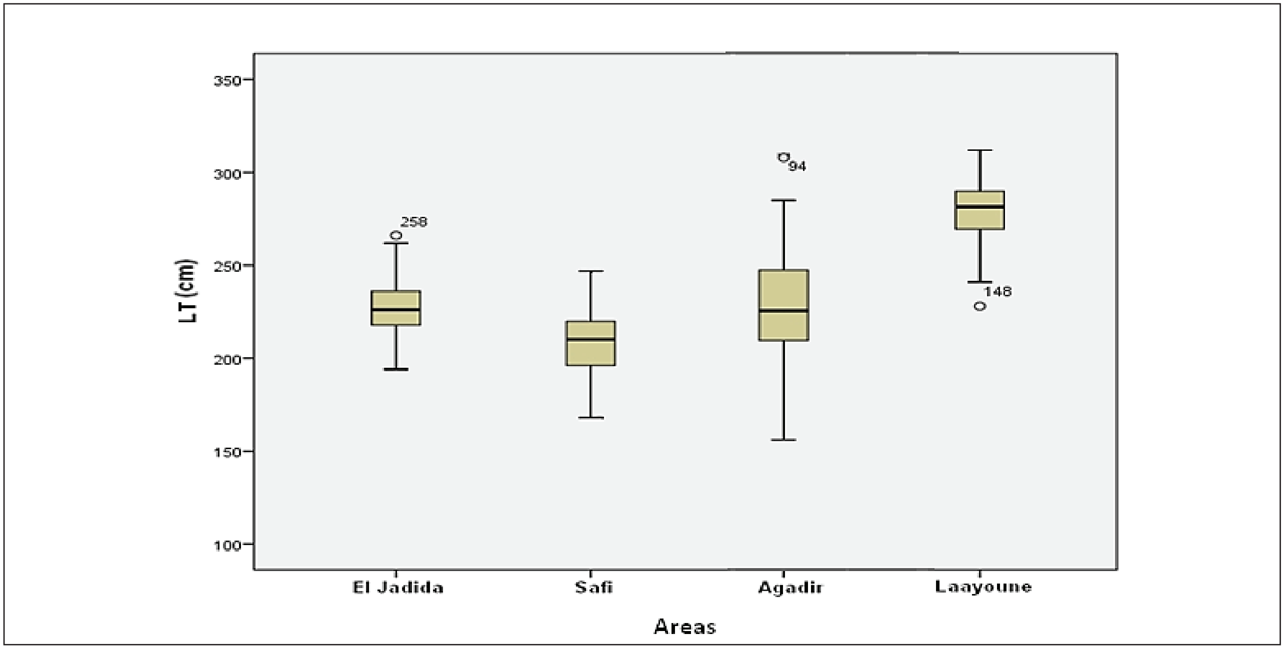

Fig. 3: *Scomber colias* ***total length in the four areas.***
Sl. 3: Celotna dolžina vrste *Scomber colias* ***na štirih predelih.***

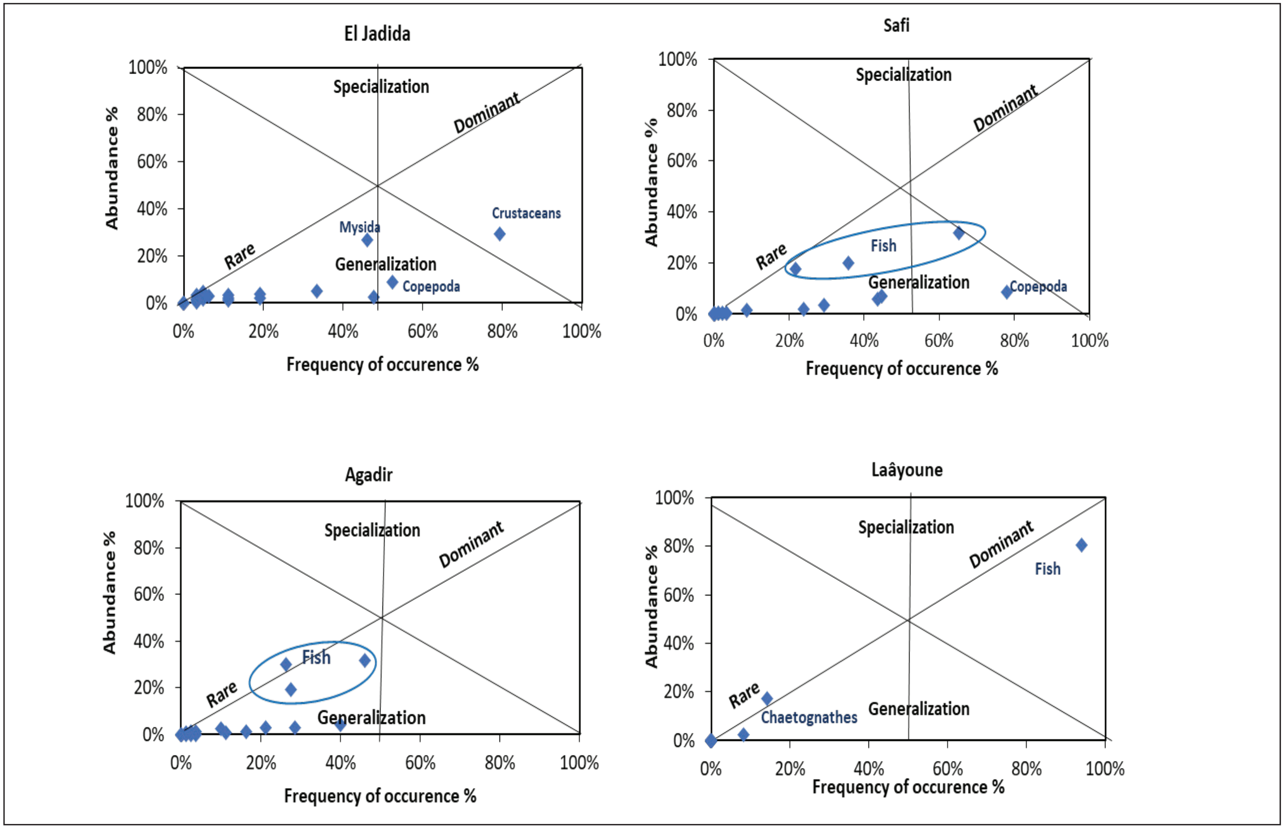

Fig. 4: Graphical explanation of feeding strategy plots of *Scomber colias* ***adapted from Amundsen et al. (1996).***
Sl. 4: Grafična razlaga prehranjevalnih strategij lokarde, prirejena po Amundsenu in sod. (1996).

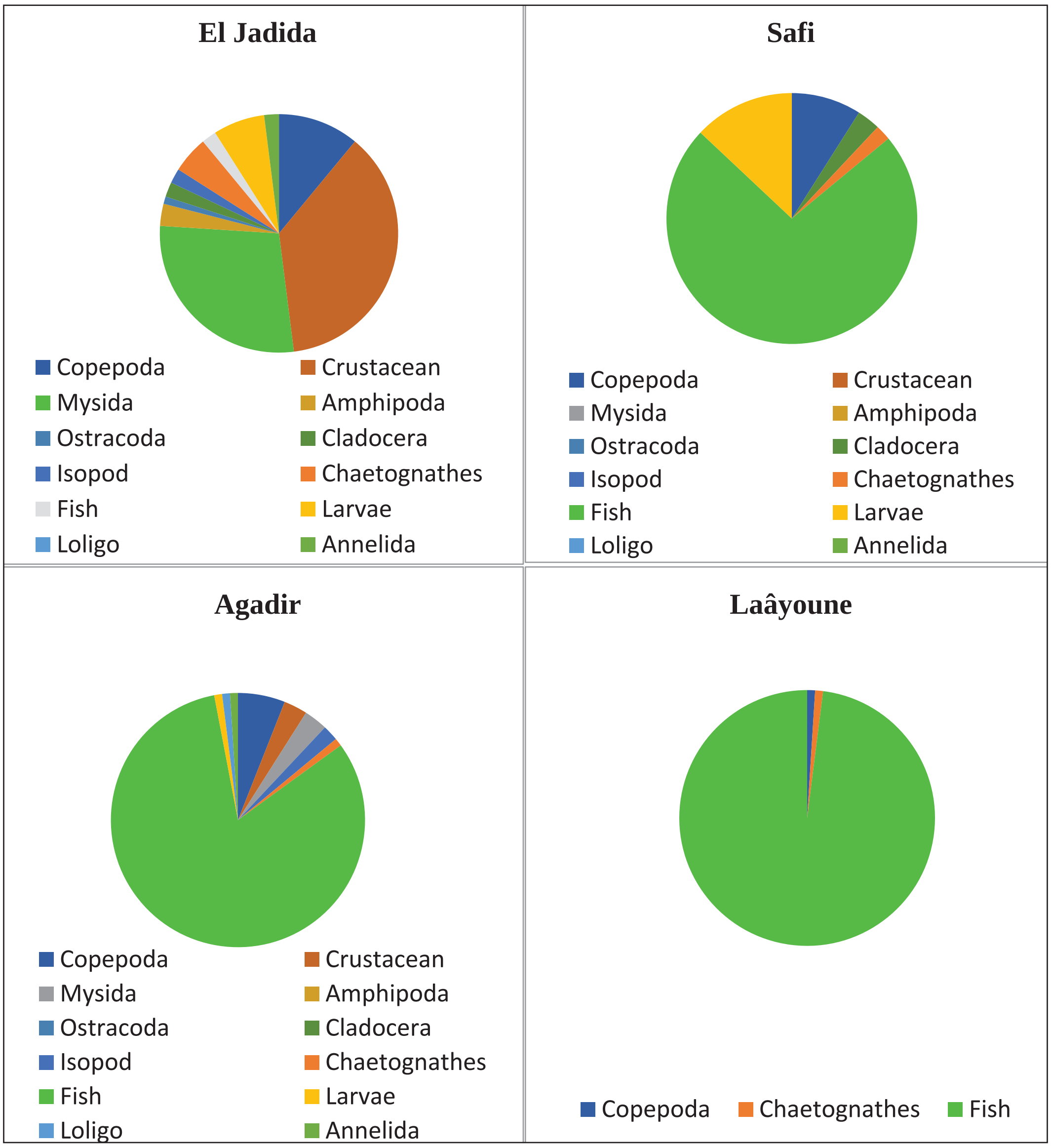

Fig. 5: Distribution of prey abundance among the four areas.
Sl. 5: Porazdelitev številčnosti plena na štirih predelih.

(Fig. 5). The El Jadida prey sample was dominated by crustaceans, such as mysids and fragments of shrimp, followed by copepods (Fig. 5).

The results obtained from the graphical method of Amundsen *et al*. (1996) showed that fish was the most important prey in the diet of *S. colias* from the Atlantic coast, followed by copepods and mysids (Fig. 4).

Estimation of length-weight relationship and condition factor K

The sample size, the length, and the weight characteristics, as well as the estimation of the length-weight relationship parameters *a* and *b*, are presented in Table 2, the length-weight relationships in Figure 6. The Agadir area had the highest number of fish sampled (N=100), with their total lengths ranging from 15 to 34 cm, and weights from 17 and 306 g; Safi ranked second (N=94), with the specimens' total lengths ranging from 14 to 25 cm, and weights from 15 to 100 g; the third largest sample was from the area of El Jadida (N=83), with the specimens' total lengths ranging from19 to 30 cm and total weights from 42 to 187g; the Laayoune sample was the smallest sample (N=53) and only composed of adult fish with the total lengths ranging from 23 to 31 cm and total weight from 75 to 302 g.

Tab. 2: Length-weight relationship parameters (a = intercept of the regression line; b = slope of the regression line; R2 = coefficient of determination; N = number of specimens; TL = total length; Wt = total weight, F = females; M = males; Comb = combined).

Tab. 2: Parametri dolžinsko-masnega odnosa (a = presek regresijske premice; b = naklon regresijske premice; R2 = koeficient determinacije; N = število osebkov; TL = celotna dolžina; Wt = totalna teža, F = samice; M = samci; Comb = kombinirano).

Area	N	TL (cm) (Min-Max)	Wt (g) (Min-Max)	a	b	R^2	K		
							F	M	comb
El Jadida	83	19-30	42-187	0,0023	3,3485	0.8943	0.64	0.64	0.64
Safi	94	14-25	15-100	0,0023	3,3219	0.9221	0.61	0.62	0.62
Agadir	100	15-34	17-306	0,0018	3,4421	0.9206	0.71	0.71	0.71
Laayoune	53	23-31	75-302	0,0009	3,6755	0.9055	0.9	0.9	0.9

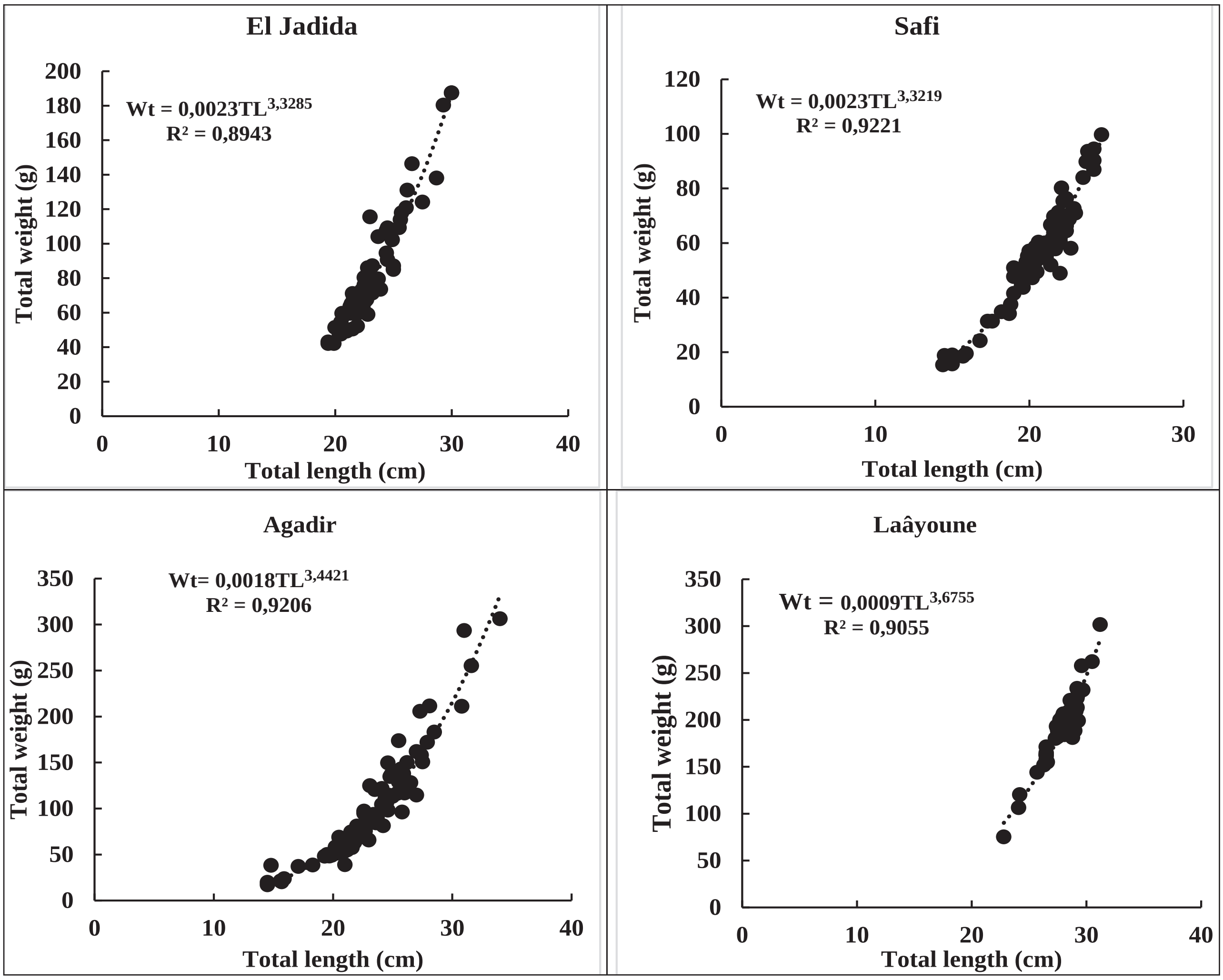

Fig. 6: Plot of length-weight relationships of *Scomber colias* ***from the Atlantic coast of Morocco.***
Sl. 6: Dolžinsko-masni odnos lokarde na atlantski obali Maroka.

The correlation coefficient R2≥0.9 was very important for all areas (Safi, Agadir, Laayoune, and El Jadida). The allometric coefficient for all samples of *S. colias* in total was b>3, whereas the allometric coefficients for El Jadida, Safi, Agadir, and Laayoune separately were b=3.35, b=3.22, b=3.44, and b=3.67, respectively. The pattern observed among the samples is that of positive allometric growth, where the weight gain exceeds the increase in length.

The mean values of condition factor (K) were K=0.64 for El Jadida, K=0.61 for Safi, K=0.71 for Agadir, K=0.87 for Laayoune.

DISCUSSION

All four *S. colias* populations studied (from El Jadida, Safi, Agadir, and Laayoune) exhibited low percentages of specimens with empty stomachs; the slightly higher percentages observed in samples from Agadir (20 %) and El Jadida (23 %) may be due to a reduced availability of food or frequency of feeding activity.

The study was carried out in winter 2017 and the majority of the individuals treated appeared to be in an advanced stage of sexual maturity (mature gonads). The period of sampling thus coincided with the reproduction period of *S. colias* on the Atlantic coast of Morocco, where the spawning of the species takes place between December and March, peaking in January (Techetach *et al.*, 2010; Bouzzammit *et al.*, 2022).

The majority of the examined stomachs contained food, with the prey in different stages of digestion. Nikolsky (1976) mentioned that fish feeding intensity decreases during the spawning season, but his hypothesis that the mackerel fasts during the reproduction period is not applicable to our case. Our suggestion is consistent with that of Hernandez & Ortega (2000) who indicated that the mackerel from the Atlantic coast of northwest Africa feed continuously, even during the breeding season.

The diet composition of the Atlantic chub mackerel from the Atlantic coast of Morocco indicates that fish (sardines, anchovies, mackerel) and zooplankton (copepods, mysids, euphausiids) are two main and preferential prey groups of this species. Preferences vary according to the size of the individual and the availability of prey in their environment. The differences in food preferences between different localities may be due to differences in the size structure of the studied populations or different environmental conditions. The total length across all samples varied from 145 to 340 mm. The total lengths recorded in El Jadida were between 194 and 300 mm, in Safi between 144 and 247 mm, in Agadir between 145 and 340 mm, and in Laayoune between 228 and 312 mm, with the respective averages of 229 ± 2.2 (JD), 206 ± 2.1 (SF), 228±3.5 (AG), and 279 ± 2.1 (LA). The Atlantic chub mackerel is characterised by different food intake strategies: feeding on plankton through filtration in juvenile fish, and predation in large adult fish (Ait Talborjt, 2020). Consequently, the diet composition changes according to the size of the fish, but the switch to larger prey richer in energy may also be prompted by scarcity of the optimum/preferred food source in the environment (Kvaavik *et al.*, 2019). Likewise, Castro (1993) found that in the Canary Islands mackerel fed on different categories of prey, from zooplankton (copepods, mysids, isopods, crustacean larvae), to clupeids as one of the most important prey groups, followed by *Engraulis encrasicolus* and *Scomber colias*. Our results are also in agreement with Angelescu (1979), Angelescu (1980) and Pájaro (1993) with regard to the coasts of Argentina, who mentioned that the diet of the Atlantic chub mackerel was very flexible, both in terms of diversity (20 prey species) and size of prey (ranging from quite small, such as crustaceans, especially copepods, to rather large, such as fish).

The graphical method of Amundsen *et al.* (1996) shows that fish are the main and preferential prey in the diet of *S. colias*, followed by copepods. This result is in agreement with the results of Castro (1991; 1993; 1998), who stated that the diet of the Spanish mackerel was based on fish and copepods. In addition, the populations of *Scomber colias* from the Atlantic coast focus on three types of prey: fish, copepods, and mysids, with the feeding habits changing according to the size of the fish. These form the bulk of the species' diet during the winter. It follows that the Atlantic chub mackerel is an opportunistically feeding carnivorous fish whose selection of prey is based on availability and geographic abundance. This result is similar to the finding of Sever *et al.* (2006) with regard to the Bay of Izmir, indicating that the diet of mackerel is influenced by abundance of prey and availability of food in the environment.

In this study, we also recorded several cases of cannibalism: 22 in the Agadir sample, 18 in the Safi sample, seven in the Laayoune sample, and two in the El Jadida sample. According to Garrido *et al.* (2015), the juveniles of sardines and Atlantic chub mackerel were the main predators of the fish eggs of their species, possibly affecting the mortality rate of their own populations. Furthermore, three cases of Spanish mackerel cannibalism were recorded in the Canary Islands by Castro (1993), while Hunter and Kimbrell (1980), Hernández & Ortega (2000) reported cannibalism in the chub mackerel, associating it with sexual cannibalism where the females kill and consume the males.

The length-weight relationship results indicated positive allometric growth (b>3) for all samples (El Jadida, Safi, Agadir, and Laayoune), with fish weight increasing faster than its length. Coefficient *b* is related to both length and weight. In the sample from Laayoune, for example, which contains large and heavy individuals, the coefficient *b* is expectedly higher and attributable to good environmental conditions and availability of food. The coefficient of determination R^2 for the length-weight relationship was high ($R^2 \geq 0.9$) in all areas (EL Jadida, Safi, Agadir, and Laayoune), indicating that the length increased with the increase in the weight of fish. The differences recorded in condition factor (K) among areas are directly proportional to differences in weight. For example, the condition factor (K) in the Laayoune area was K=0.9, and the weights of specimens ranged between 75 to 306 g, while the condition factor (K) in the Safi area was K=0.62 and the weights ranged between 15 and 100 g. Generally, the condition factor (K) indicates the physiological condition of fish (Getso *et al.*, 2017). The increase in the K value indicates the fatness and gonadal development of fish (Maguire & Mace, 1993). Ujjania *et al*. (2012) also reported that when the value of condition factor (K) is superior to or equals 1, it indicates a good level of feeding and appropriate environmental conditions. The length-weight relationship parameters and the condition factor (K) has been confirmedly affected by feeding intensity, availability of food, fish size, stage of maturation, season, fullness of gut, amount of fat reserves, and life history (Ujjania *et al*., 2012; Gupta & Banerjee, 2015).

CONCLUSIONS

The diet of *S. colias* was characterized by a high diversity of prey groups, including fish (sardines, anchovy, and chub mackerels), copepods, crustaceans (crab, shrimp), mysids, annelids, isopods, chaetognaths, amphipods, larvae, fish eggs, cladocerans, ostracods, and cephalopods. The Atlantic chub mackerel (*S. colias*) is an opportunistic predator that feeds on available food in its habitat. The shift in the diet composition of this species could be interpreted as a result of change in the abundance of prey in its ecosystem. The size of prey targeted by the Atlantic chub mackerel increases in correlation with increase in body size, but the species also predates the smallest prey according to their availability in their habitat. The length-weight relationship parameters and the condition factor (K) are affected by feeding intensity, availability of food, fish size, fullness of gut, and amount of fat reserves.

PREHRANA IN PREHRANJEVALNA STRATEGIJA LOKARDE (*SCOMBER COLIAS)* OB ATLANTSKI OBALI MAROKA

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POVZETEK

*Avtorji so raziskovali sestavo prehrane in prehranjevalno strategijo lokarde (*Scomber colias*) ob atlantski obali Maroka pozimi 2017. Preiskali so skupno 330 vsebin želodcev. Indeks praznosti želodca je pokazal veliko intenziteto hranjenja na lokalitetah Safi (SF) (2%) in Laayoune (LA) (6%), nižjo pa v El Jadida (JD) (25%) in Agadirju (AG) (20%). V preiskavi prehrane so določili 22 prehranjevalnih kategorij. Najbolj številen plen z najvišjim indeksom relativne pomembnosti so bile ribe, sledili so raki ceponožci na treh lokalitetah (AG, SF, and LA), medtem ko so bili na lokaliteti El Jadida (JD) najpomembnejši raki in mizidi.* S. colias *je mesojeda riba in krvoločni plenilec drugih rib. Avtorji so med raziskanimi populacijami zasledili več primerov kanibalizma.*

Ključne besede: prehrana, *Scomber colias*, vsebina želodcev, indeks praznosti, kanibalizem

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LE ORCHIDACEAE DI ALBONA (LABIN, CROAZIA)

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SINTESI

La città di Albona-Labin è situata nell'Istria sud-orientale e il suo territorio si estende su una superficie di circa 71,85 km^2. Il presente lavoro, basato su osservazioni dirette dell'autore, ricerca bibliografica e segnalazioni inedite di vari studiosi, riporta una check-list aggiornata di tutte le Orchidaceae presenti in tale territorio che comprende 37 taxa specifici e infraspecifici e un ibrido. Inoltre è stata eseguita l'analisi corologica da cui risulta la prevalenza dell'elemento Mediterraneo seguito da quello Eurasiatico.

Parole chiave: Albona, Labin, Orchidaceae, check-list, spettro corologico

THE ORCHIDACEAE OF ALBONA (LABIN, CROATIA)

ABSTRACT

The town of Albona-Labin is located in southeastern Istria and covers an area of approximately 71.85 km^2. The present work, based on direct observations of the author, a literature search and unpublished reports of some researchers, contains an updated checklist of all Orchidaceae occurring in this area, including 37 specific and infraspecific taxa and one hybrid. In addition, a chorological analysis was performed, showing that the Mediterranean element is predominant, followed by the Eurasian.

Key words: Albona, Labin, Orchidaceae, check-list, chorological spectrum

INTRODUZIONE

La famiglia delle Orchidaceae Juss. è costituita da circa 27.800 specie ripartite in 880 generi (Givnish *et al.*, 2016) e, dopo le *Asteraceae* Martinov, è la più ricca del mondo vegetale. Essa, pur raggiungendo la maggiore abbondanza e diversità nelle zone tropicali, ha colonizzato con successo quasi ogni bioma terrestre. In Europa e nel bacino del Mediterraneo sono segnalati oltre 600 taxa (Delforge, 2016) e nella penisola istriana 82 (Pezzetta, 2018a). Tale famiglia vegetale suscita un notevole fascino per cui è oggetto di notevoli studi naturalistico-sistematici, è stata assunta a emblema da alcuni comuni italiani e, numerose associazioni e semplici appassionati le ricercano in natura, studiano e coltivano.

La penisola istriana è molto frequentata da appassionati e ricercatori di orchidacee provenienti da diversi stati europei e nonostante i loro studi, si presenta ancora la necessità di approfondirli per descrivere o analizzare qualche ambito poco esplorato o rielaborare le conoscenze esistenti. Una delle aree della penisola istriana ricca di orchidacee è il territorio della Città di Albona (Labin) di cui allo stato attuale non esiste ancora un lavoro monografico completo. Con il presente saggio si vuole colmare questa lacuna e compilare una check-list comprendente le specie, le sottospecie egli ibridi segnalati con le località comunali di presenza.

Inquadramento dell'area d'indagine

Il territorio comunale di Albona (in croato Labin) è situato sulla costa sud-orientale dell'Istria e confina con il Mare Adriatico (est) e i comuni di Kršan (nord), Sveta Nedelja (nord e nord-ovest) e Raša (sud-ovest, sud e sud-est). Esso occupa la superficie di 71,85 km² di una penisola che misura circa 25 km di lunghezza, 13 di larghezza ed è circondato su tre lati dall'acqua: quella del fiume Arsa e dell'omonimo canale a ovest, quella del golfo del Quarnaro a sud e a est. A nord è separata dalla Liburnia dal fiordo di Fianona e dalla val d'Arsa, che fino gli anni Trenta del secolo scorso era ricoperta dall'omonimo lago (De Luca, 2014). Nei suoi confini attuali il territorio comunale della città di Albona è situato in una fascia altitudinale che va dal livello del mare a circa 540 metri d'altitudine. Il suo paesaggio morfologicamente differenziato è costituito da aree più o meno pianeggianti, valli e colline che culminano con le vette dei monti Standar (474 m), Oštri (474m), Goli (539 m), Lutovo (526 m), Studeni Vrh (526 m) e Thiovine (513 m). A sua volta la fascia costiera è lunga 20,2 km ed è caratterizzata dalle baie di Rabac e Prklog, entrambe estensioni di valli torrenticole che iniziano dall'altopiano e scorrono verso il mare seguendo orientamenti diversi.

Nel territorio albonese sono presenti alcune sorgenti d'acqua dolce in cui le acque sono captate e piccoli torrenti che scorrono nei fondivalle. Tra essi il Pećina, il Rabljački potok che nasce presso Podlabin e sfocia nella baia di Rabac; il Carpano (Krapan) che segna parte dei confini comunali e un altro che sfocia nella baia di Duga Luka. In alcuni ambiti del territorio comunale sino al 1937 erano presenti diverse fonti di acqua potabile che si prosciugarono a seguito delle perforazioni minerarie (Šegulja, 1970).

In base al censimento del 2011 la popolazione complessiva dell'intero comune è di 11642 abitanti, mentre la densità media è di circa 162 abitanti per km², un valore notevolmente superiore alla grandezza omonima della contea istriana (73,4 abitanti / km²) e di quella della Repubblica di Croazia (78,1 abitanti / km²). Essa, oltre che nella sede comunale, vive sparsa in 17 diversi insediamenti (naselja): Bartici (Bartići), Becici (Bečići), Cappelletta (Kapelica), Crainzi (Kranjci), Fratta (Presika), Gondali (Gondolići), Glussici (Gora Glušići), Marcegliani (Marceljani), Montagna (Breg), Porto Albona (Rabac), Porto Lungo (Duga Luka), Ripenda Cossi (Ripenda Kosi), Ripenda Carso (Ripenda Kras), Ripenda Verbanzio (Ripenda Verbanci), Rogozzana (Rogočana), Salaco (Salakovci) e Vines (Vinež).

Il centro cittadino di Albona è formato da un nucleo antico, d'origine medioevale situato sulla cima di una collina alta 320 metri s.l.m. e da una area urbanizzata detta Podlabin che si trova ai piedi della città vecchia e si è creata a seguito dello sviluppo minerario dell'area avvenuto negli anni 30 del secolo scorso.

Aspetti geologici

Il territorio comunale di Albona è caratterizzato da tre tipi di formazioni rocciose: rocce calcaree, marnoso-arenacee e depositi alluvionali quaternari. Nell'area sono presenti anche depositi di carbon fossile, bauxite e travertino.

I sedimenti più antichi iniziarono a depositarsi durante il Cretaceo Superiore, continuarono nel Paleogene e nelle epoche successive (Salopek, 1954; Šikić & Polšak, 1973; D'Ambrosi, 1976; Balbo *et al.*, 2004). La maggior parte dei depositi cretacei sono presenti lungo la fascia costiera, la baia di Rabac e in alcune aree interne situate presso i villaggi di Gondolići, Bani, etc. I depositi del Paleogene si rinvengono presso i villaggi di Škrokoni, Majel, Marina, Grpci e Duka Luka. Lungo i torrenti sono presenti i depositi quaternari costituiti da terra rossa, argilla, sabbia e ghiaia.

Il clima

Il territorio albonese si estende dal livello del mare sino a oltre 474 metri d'altitudine, presenta ambiti esposti alle correnti d'aria fredde e, altri esposti a quelle calde e più riparati. Di conseguenza, a causa delle differenze d'esposizione e d'altitudine, al suo interno si registrano diverse tipologie climatiche.

I principali parametri climatici assumono i seguenti valori: precipitazioni annue che oscillano tra 1000 e 1400 mm (Pericin, 2014), temperatura media annua i circa 14 °C, temperatura media del mese più freddo (gennaio) con circa 5,5°C, temperatura media del mese più (luglio) con circa 23,5 °C. La stagione più piovosa è l'autunno, quella più secca è l'estate; il mese più piovoso è novembre e quello meno piovoso luglio. Nel loro complesso i valori di temperatura e precipitazioni riportati sono tipici di un ambito di transizione climatica da mediterraneo a submediterraneo.

Tenendo conto del modello di classificazione climatica di Köppen & Geiger (1954) e dei dati riportati, ad avviso di (Filipčić, 1992) il clima di Albona rientra nel tipo caldo-umido temperato senza stagione secca che è definito "Cfa" ed è caratterizzato dalla temperatura media del mese più caldo che supera 22 °C e le precipitazioni annue comprese tra 700 mm e 1500 mm.

Il paesaggio vegetale

La fisionomia del paesaggio e la sua composizione floristica sono influenzate dal clima, dalle vicende storico-geologiche e dalla pressione antropica attuale e del passato.

Il territorio albonese è abitato dall'epoca preistorica, come dimostrano i vari castellieri presenti (Alberi, 1997). Per diversi millenni, la popolazione del luogo ha operato nel territorio trasformandolo al fine di ricavare legna da ardere, terreni coltivabili, pascoli e materiali da costruzione. Queste pratiche hanno portato alla fondazione di aree urbanizzate, alla riduzione di quelle forestali e alla formazione di terreni aperti, prati sassosi, garighe e lembi di macchia mediterranea. Attorno agli anni 30 del secolo scorso, lo sviluppo minerario della zona portò all'espansione della fascia urbana e dagli anni '60 sono iniziate nuove trasformazioni economico-territoriali quali lo sviluppo delle infrastrutture turistiche e l'abbandono delle pratiche agro-pastorali tradizionali. A causa di questi fattori, ora si osserva la riduzione dei terreni aperti e degli spazi naturali, lo sviluppo di formazioni vegetali arbustive e la ripresa spontanea del processo di riforestazione nei terreni e pascoli abbandonati. Di conseguenza il paesaggio attuale rispetto ad alcuni decenni fa è cambiato ed è caratterizzato da un mosaico che associa strutture turistiche, centri abitati, case sparse, infrastrutture stradali, centri commerciali, radure, terreni coltivati, aree incolte con boschi più o meno estesi, cespuglieti e prati-pascolo. A tal proposito Vragović (2018) ha evidenziato che nel 2012, rispetto al 1980 si sono registrati: l'aumento delle aree incespugliate e dei boschi, la riduzione significativa dei terreni coltivati (-19,6%) e un incremento delle aree dei centri abitati, commerciali, industriali e delle infrastrutture ad esse collegate. In particolare Vragović ha fatto presente che nel 2012 le aree urbane occupavano 3,9 km², le aree industriali 0,1 km², le aree sportive e ricreative 0,3 km², i pascoli 0,8 km², i terreni coltivati 2,2 km², i terreni prevalentemente agricoli 10,2 km², le aree con boschi a foglie caduche 37,5 km², le pinete 2,5 km², i boschi misti 6 km², le aree in cui la foresta si stava espandendo 3,6 km² e i prati naturali 5,6 km². Ora, il territorio della città di Albona si presenta piuttosto boscoso, con qualche appendice brulla, terreni coltivati, pascoli abbandonati, case sparse e centri abitati. In base al diverso uso del suolo, esso si può ripartire in circa 320 ha di terreni incolti e forestali oltre 175 ha di terreni agricoli di cui 39,88 ha destinato a seminativi e giardini, 74,78 ha destinati a pascoli, 4,95 ha a frutteti e 36,42 ha a vigneti (Grad Labin, 2016). Il resto è occupato dalle aree urbanizzate e le infrastrutture a esse annesse.

Nel territorio albonese sono state individuate le seguenti aree protette poiché di alto valore paesaggistico e naturalistico: 1) l'area compresa tra la Baia di Labin-Rabac e Prklog che occupa 1121,50 ha ed è protetta dal 1973; 2) la zona compresa tra Rabac e Labin con la vegetazione di ripido pendio; 3) la collina su cui sorge il centro di Albona; 4) la fascia costiera compresa tra Rabac e Brestova.

Per quanto riguarda la vegetazione, le ricerche di Šegulja (1970) hanno individuato nell'area 20 diverse associazioni caratterizzate ognuna da un proprio corteggio floristico. Questa ricchezza fitosociologia è la conseguenza del fatto che il territorio albonese appartiene a una zona di transizione fitogeografica. Infatti, Šegulja (1970) sostiene che l'ambito in esame si ripartisce tra le zone eumediterranea e submediterranea in cui si registra l'influenza dei reciproci influssi e a causa di ciò, la copertura vegetale è molto varia e insolitamente ricca.

La vegetazione inizia a svilupparsi nella fascia litoranea non sottoposta a una forte pressione turistica e a poca distanza dalla linea di battigia ove si osservano varie associazioni che generalmente comprendono entità xerotermiche capaci di sopravvivere in ambienti molto aridi e con scarsa disponibilità idrica poiché il terreno calcareo e le rocce fessurate non trattengono le precipitazioni. Alcune specie che caratterizzano tale zona sono: *Catapodium loliaceum* (L.) C.E. Hubb., *Parapholis incurva* (L.) C.E. Hubb., *Limonium cancellatum* (Bertol.) Kuntze, *Plantago weldenii* Rchb., *P. holosteum* Scop., *Senecio caroli-malyi* Horvatić, *Silene angustifolia* Poir., *Juncus acutus* L., *Arthrocaulon macrostachyum* (Moric.) Piirainen & G. Kadereit, *Glaucium flavum* Crantz, *Euphorbia segetalis* L. e *Plantago coronopus* L. subsp. *commutata* (Guss.) Pilg.

In diverse parti della fascia costiera non toccate dagli insediamenti turistici e a poche decine di metri dalla linea di battigia sono presenti anche pinete, praterie e il bosco misto mediterraneo *Orno-Quercetum ilicis* H-ić (1939) 1958) che è costituito da essenze arboree a foglie persistenti e da caducifoglie. Esso è diffuso lungo le coste orientali adriatico-ioniche dalla Grecia sino al Golfo di Trieste ove raggiunge il limite settentrionale di distribuzione geografica (Poldini et al. 1980). Alla sua composizione concorrono: *Quercus ilex* L, *Fraxinus ornus* L., *Phyllirea latifolia* L., *Pistacia terebinthus* L., *Asparagus acutifolius* L., *Cyclamen repandum* Sibth & Sm., *Rubia peregrina* L., *Carex distachya* Desf., *Rhamnus alaternus L.*, *Lonicera implexa* Ait., etc.

All'allontanamento dalla linea di battigia, l'aumento dell'altitudine e la maggior esposizione ai venti freddi corrisponde il cambiamento delle formazioni vegetali presenti di cui l'aspetto più vistoso è costituito dalle leccete mediterranee che lasciano gradualmente il posto al bosco submediterraneo, che si sviluppa sia sui terreni marnoso-arenacei sia su quelli calcarei. Alla sua composizione concorrono le seguenti essenze arboree: *Acer monspessulanus*, *A. campestre* L., *Fraxinus ornus* L., *Ostrya carpinifolia* Scop., *Quercus pubescens* Willd, *Cornus mas* L. ed altro.

Le ricerche botaniche effettuate nel territorio albonese dallo scrivente, Pericin (2014), Rottensteiner (2013, 2019), Starmühler (2003, 2010) e Šegulja (1969, 1970) hanno portato alla descrizione di altre formazioni e associazioni vegetali quali:

- prati-pascolo appartenenti a varie associazioni (*Stipo-Salvietum officinalis* H-ić (1956) 1958, *Danthonio-Scorzoneretum villosae* Ht. & H-ić (1956) 1958, *Festuco-Koelerietum splendentis* H-ić 1963, H-ić 1962, *Ononidi-Brometum condensati* H-ić 1962 e *Chrysopogoni-Euphorbietum nicaeensis* H-ić 1962 (Šegulja, 1970);
- arbusteti e formazioni arboreo-arbustive che occupano i pascoli e terreni abbandonati, appartengono a varie associazioni vegetali e alla loro composizione generalmente concorrono: *Asphodelus microcarpus* Viv., *Carpinus orientalis* Mill., *Colutea arborescens* L., *Cornus mas* L., *Cornus sanguínea* L., *Coronilla emerus* L., *Erica arborea* L, *Ligustrum vulgare* L, *Juniperus oxycedrus* L., *Paliurus spina-christi* Mill., *Prunus spinosa* L., *Rosa canina* L, *Rosa sempervirens* L., *Ruscus aculeatus* L., *Smilax aspera* L., *Spartium junceum* L., varie specie dei generi C*istus* L., *Rubus* L.;
- associazioni tipiche degli ambiti pietrosi molto degradati con *Salvia officinalis* L., *Juniperus oxycedrus* L., *Achnatherum bromoides* (L.) P. Beauv., etc.;
- formazioni tipiche degli affioramenti rocciosi con varie specie di *Sedum* L. e altre piante;
- associazioni vegetali tipiche degli ambiti rupestri a cui concorrono: *Alyssum medium* Host., *Asphodeline lutea* (L.) Rchb., *Campanula pyramidalis* L., *Euphorbia fragifera* Jan., etc.;
- associazioni vegetali sinantropiche con composizioni floristiche molto variabili che attecchiscono presso i centri abitati, le abitazioni sparse, i bordi stradali, i campi coltivati e i terreni incolti;
- pinete artificiali di rimboschimento a pino nero;
- formazioni idrofile e igrofile presenti presso gli stagni, le sorgenti e i pochi corsi d'acqua che caratterizzano l'area in cui generalmente si rinvengono: *Callitriche cophocarpa* Sendtn, *Eleocharis palustris* (L.) Roem. & Schult, *Lemna gibba* L., *Myriophyllum spicatum* L., *Phragmites australis* (Cav.) Steud., *Ranunculus peltatus* Schrank, *Ranunculus trycophyllus* Chaix, *Wolffia arrhiza* (L.) Wimm., *Zannichella palustris* L. e varie specie dei generi *Carex* L., *Juncu*s L*., Potamogeton* L., etc. (Pericin, 2014).

In alcune località dell'Albonese sono presenti diverse specie endemiche e rare tra cui: *Carlina fiumensis* Simonk., *Asphodelus microcarpus* Viv., *Aurinia leucadea* (Guss.) K. Koch, *Senecio caroli-malyi* Horvatić.

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

MATERIALI E METODI

L'elenco floristico è stato realizzato tenendo conto delle ricerche sul campo dell'autore e dei dati ricavati dalla bibliografia consultata (Dekker, 2002; Hertel & Hertel, 2002; Grabner, 2009; Griebl, 2009; Kranjčev, 2005; Pericin, 2014, Perko & Kerschbaumsteiner, 2003; Pezzetta, 2018a, Rottensteiner, 2013, 2019; Starmühler, 2003, 2010; Verhart, 2016). Esso comprende le specie, le sottospecie e gli ibridi mentre non sono state prese in considerazione le varietà cromatiche e morfologiche.

Le prime estemporanee e personali osservazioni nell'area iniziarono circa una decina di anni fa e sono continuate con cadenze varie sino al 2019. Negli anni 2020 e 2021 le escursioni si sono interrotte a causa della pandemia. Nel mese di aprile del 2002 esse sono riprese con cadenza settimanale e si sono protratte sino a oltre la metà del mese di giugno.

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

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

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

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

AX: Dekker (2002); AY: Hertel & Hertel (2002); BX: Perko & Kerschbaumsteiner (2003); BY: Starmühler (2003); CX: Kranjčev (2005); CY: Grabner (2009); DX: Griebl (2009); DY: Starmühler (2010); FX: Rottensteiner (2013); FY: Pericin (2014); GX: Verhart (2016); GY: Pezzetta (2018a); HX: Rottensteiner (2019).

Sono state riportate alla voce "Ripenda" tutte le osservazioni fatte a Ripenda Kosi, Ripenda Kras e Ripenda Verbanci.

La bibliografia comprende: 1) i saggi sulla città di Albona di carattere generale, geografico e naturalistico che sono stati consultati; 2) quelli più specifici riguardanti le ricerche floristiche pubblicati dopo il 2000 per evitare citazioni di ritrovamenti non confermati o confermabili a causa delle trasformazioni degli habitat.

RISULTATI E DISCUSSIONE

Elenco floristico

1. *Anacamptis berica* D. Doro – Subendemico. Presika!, Ripenda!, Salakovci!
   OSSERVAZIONI: Il taxon, molto simile a *Anacamptis pyramidalis* da cui si differenzia per vari aspetti morfologici, fenologici e genetici, è stato descritto da Doro (2020) che inizialmente l'ha segnalato sui Colli Berici (Regione Veneto e provincia di Vicenza). In seguito Doro (2021) lo riporta in altre località del Veneto, varie regioni italiane, località istro-croate e una località istro-slovena (Podpeč). Pezzetta tra il 2021e il 2022 ha osservato il taxon nei pressi di Caresana (Provincia di Trieste), nei dintorni di Capodistria (Butari, Brezovica, Belvedur, etc.) e varie località istro-croate. Nei territori albonese *Anacamptis berica* è stata osservata dalla scrivente in piena fioritura il 2 giugno 2022. Successivamente con l'escursione del 12 giugno nelle stesse stazioni, le piante precedentemente osservate ed attribuite a *A. berica* erano sfiorite, mentre erano in piena fioritura altre attribuibili a *A. pyramidalis*. Probabilmente andrebbero attribuite al taxon anche altre segnalazioni storiche assegnate ad *A. pyramidalis* che sono state fatte in Istria.
2. *Anacamptis coriophora* (L.) R.M. Bateman, Pridgeon & M.W. Chase subsp. *fragrans* (Pollini) R.M. Bateman, Pridgeon & M.W. Chase – Eurimediterraneo. (GX, GY). Albona, Rabac, Ripenda!.
3. *Anacamptis laxiflora (*Lam.) R.M. Bateman, Pridgeon & M.W. Chase – Eurimediterraneo. (FY, GX, GY). Ceketov Kol.
4. *Anacamptis morio* subsp. *morio* (L.) R.M. Bateman, Pridgeon & M.W. Chase – Europeo-Caucasico. (AX, AY, DX, GX, GY). Albona!, Bartići!, Gondolići!, Gora Glušići!, Kapelica!, Knapici!, Kranjci!, Presika!, Rabac!, Ripenda!, Salakovci!.
5. *Anacamptis papilionacea* (L.) R.M. Bateman, Pridgeon & M.W. Chase – Eurimediterraneo. (AX, AY, CX, GX, GY). Albona, Kapelica!, Knapici!, Gora Glušići!, Presika!, Salakovci!
6. *Anacamptis pyramidalis* (L.) Rich. subsp. *pyramidalis* – Eurimediterraneo. (AY, FY, GX, GY). Albona!, Bartići!, Gondolići!, Gora Glušići!, Knapici!, Kranjci!, Presika!, Rabac!, Ripenda!. Rogočana!, Salakovci!
7. *Cephalanthera damasonium* (Mill.) Druce – Eurimediterraneo. (AX, AY, GX, GY). Albona, Gora Glušići!, Presika!, Ripenda!, Rogočana!, Salakovci!.
8. *Cephalanthera longifolia* (L.) Fritsch – Eurasiatico. (AX, AY, GX, GY). Albona, Kranići!, Presika!, Ripenda!, Salakovci.
9. *Epipactis helleborine* subsp. *helleborine* (L.) Crantz – Paleotemperato. (AX, GX, GY). Albona, Presika, Rabac.
10. *Epipactis microphylla* (Ehrh.) Sw. – Europeo-Caucasico. (GX, GY). Albona, Rabac.
11. *Epipactis muelleri* Godfery – Centro-Europeo. (AY). Kranjci!, Rabac, Ripenda, Salakovci.
12. *Gymnadenia conopsea* (L.) R. Br. in W.T. Aiton susbp. *conopsea* – Eurasiatico. (GY). Albona.
13. *Himantoglossum adriaticum* H. Baumann – Eurimediterraneo. (GX, GY). Albona!, Kranjci! Presika!, Ripenda!, Salakovci!.
14. *Limodorum abortivum* (L.) Sw. – Eurimediterraneo. (AY, BY, DX, GX, GY). Albona, Gondolići!, Gora Glušići!, Kranjci!, Rabac, Ripenda!, Salakovci!.

15.*Neotinea maculata* (Desf.) Stearn – Mediterraneo-Atlantico. (CY). Albona, Salakovci.

16.*Neotinea tridentata* (Scop.) R.M. Bateman, Pridgeon & M.W. Chase – Eurimediterraneo. (AX, AY, DX, GX, GY). Albona, Bartići!, Gora Glušići!, Kranjci!, Presika!, Rabac, Ripenda!, Rogočana!, Salakovci!.

17.*Neottia ovata* (L.) Bluff & Fingerh. – Eurasiatico. (AY). Salakovci.

18.*Neottia nidus-avis* (L.) Rich. – Eurasiatico. (GX, GY). Albona.

19.*Ophrys apifera* Huds. – Eurimediterraneo. (AY, BY, DX, GX, GY). Albona, Bartići!, Gondolići!, Gora Glušići!, Kranjci!, Presika!, Rabac, Ripenda!, Salakovci!

20.*Ophrys holosericea* (Burm. f.) Greuter subsp. *tetraloniae* (W.P. Teschner) Kreutz – Appennino-Balcanico. (AY, FY, GY). Albona, Kranjci!, Presika!, Rabac, Ripenda, Rogočana. Salakovci!.

21.*Ophrys holosericea* (Burm. f.) Greuter *subsp. untchjii (*M. Schulze) Kreutz– Subendemico. (AY, FY, GX, GY). Albona, Gondolići!, Kranjci!, Presika!, Rabac, Ripenda!, Rogočana!, Salakovci.

22.*Ophrys incubacea* Bianca subsp. *incubacea* – Stenomediterraneo. (GX, GY). Albona, Rabac, Salakovci!

23.*Ophrys insectifera* L. – Europeo. (AX, GX, GY). Albona, Kranjci!, Presika!.

24.*Ophrys sphegodes* subsp. *sphegodes* Mill. – Eurimediterraneo. (AX, AY, DX, GY). Albona, Bartići!, Gora Glušići!, Kranjci!, Presika!, Rabac, Ripenda!, Salakovci!

25.*Ophrys sphegodes* subsp. *tommasinii (*Vis.) Soó – Appennino-Balcanico. (AX, AY, CY. GY). Albona, Gora Glušići!, Presika!, Rogočana. Salakovci.

26.*Ophrys sulcata*. Devillers-Tersch. & P. Devillers – Mediterraneo-Occidentale. (AY, GY). Albona, Salakovci!

27.*Ophrys zinsmeisteri* A. Fuchs & Ziegenspeck (pro hybr.) – Endemico. (BX, DX, GX, GY). Albona, Gondolići, Knapici!, Kranjci!, Rabac, Salakovci!.

28.*Orchis mascula* (L.) L. subsp. *mascula* – Europeo. (GX, GY). Albona

29.*Orchis militaris* L. – Eurasiatico. (CX, DY, GX, GY). Albona, Rabac.

30.*Orchis pauciflora* Ten. – Stenomediterraneo. (AY, CX, FX, GY, HX). Albona, Kranjci!, Rabac, Ripenda!, Salakovci.

31.*Orchis provincialis* Balb. Ex Lam. – Stenomediterraneo. (AY, CY, GY). Albona, Salakovci.

32.*Orchis purpurea* Huds. – Eurasiatico. (AX, CX, CY, FY, GX, GY). Albona!, Bartići!, Gora Glušići!, Knapici!, Kranjci!, Mikoti, Presika!, Rabac, Ripenda!, Rogočana!, Salakovci!,

33.*Orchis simia* Lam. – Eurimediterraneo. (GY). Albona.

34.*Platanthera bifolia* (L.) Rchb. subsp. *bifolia* – Paleotemperato. (AX, AY, GX, GY). Albona, Gondolići!, Gora Glušići!, Kranjci!, Presika!, Rabac, Ripenda!, Salakovci!.

35.*Platanthera chlorantha* (Custer) Rchb. – Eurosiberiano. (AY, GX, GY). Albona, Bartići, Rabac, Ripenda!, Salakovci!.

36.*Serapias vomeracea* (Burm.f.) Briq. subsp. *vomeracea* – Eurimediterraneo. (GX, GY). Albona, Gondolići!, Kranjci!, Presika!, Rabac, Ripenda!.

37.*Spiranthes spiralis* (L.) Chevall. – Europeo-Caucasico. (CX, GY). Albona, Duga Luka!, Rabac!, Ripenda.

Ibridi

1. *Anacamptis* x*gennarii* (Rchb. f.) Nazzaro & La Valva. (AY, GY). Albona, Kapelica!, Knapici!, Ripenda, Salakovci!

L'elenco floristico comprende 37 taxa infraspecifici. Tale numero costituisce il 45 % delle Orchidacee presenti nella Penisola Istriana e circa il 20 % della Repubblica di Croazia. A tale insieme si aggiunge un ibrido per cui l'ammontare complessivo delle entità presenti è di 38, un valore numerico che tenendo conto di quanto riportato in Pezzetta (2018a), colloca il territorio della città di Albona tra i comuni istriani più ricchi di orchidacee.

Nel territorio di Albona, Pezzetta (2018a), segnalava a presenza di 29 taxa infraspecifici e un ibrido. Di conseguenza con tale saggio, l'ambito

Tab. 1: Biodiversità dei generi delle Orchidaceae di Albona.
Tab. 1: Pestrost rodov kukavičevk na območju Labina.

Genere	Numero taxa	Genere	Numero taxa
Anacamptis	6	*Neottia*	2
Cephalanthera	2	*Ophrys*	9
Epipactis	3	*Orchis*	6
Gymnadenia	1	*Platanthera*	2
Himantoglossum	1	*Serapias*	1
Limodorum	1	*Spiranthes*	1
Neotinea	2		

Tab. 2: Località di Albona con presenza di Orchidaceae.
Tab. 2: Lokalitete na območju Labina z označenimi ugotovljenimi taksoni kukavičevk.

Località	Taxa totali	Località	Taxa totali
Albona (Labin)	35	*Kranjci*	17
Bartići	7	*Micoti*	1
Ceketov Kol	1	*Presika*	17
Duga Luka	1	*Rabac*	21
Gondolići	8	*Ripenda*	21
Gora Glušići	10	*Rogočana*	7
Kapelica	3	Salakovci	27
Knapići	6		

di studio si arricchisce di 8 taxa. Inoltre nell'elenco floristico sono riportate molte segnalazioni di località e stazioni inedite che contribuiscono ad allargare l'areale di diffusione dei singoli taxa nella penisola istriana

Dalla Tabella 1 emerge come varie entità si ripartiscono in 13 generi tra cui il più rappresentato è il genere *Ophrys* con 9 taxa. Seguono i generi: *Anacamptis* e *Orchis* con 6 taxa ciascuno, *Epipactis* con 3; *Cephalanthera*, *Neotinea* e *Neottia* con 2 taxa ciascuno; *Gymnadenia*, *Himantoglossum*, *Limodorum*, *Serapias* e *Spiranthes* con un solo taxon.

I taxa più diffusi sono i seguenti: *Anacamptis morio* subsp. *morio* e *Orchis purpurea* che sono segnalati in 11 località; *Anacamptis pyramidalis* con 10 segnalazioni; *Neotinea tridentata* e *Ophrys apifera* con 9 segnalazioni; *Ophrys holosericea subsp. untchjii, O. sphegodes* subsp. *sphegodes* e *Platanthera bifolia* subsp. *bifolia* che sono segnalate in 8 località.

Le specie più rare del territorio albonese che sono presenti in un'unica località sono le seguenti: *Anacamptis laxiflora, Gymnadenia conopsea, Neottia ovata, N. nidus-avis, Orchis mascula* subsp. *mascula* e *O. simia*.

La Tabella 2 mostra che l'insieme dei taxa è presente in 15 località. Il maggior numero di segnalazioni si registra nei dintorni della città di Albona. Molte segnalazioni riguardanti "Albona" sono ricavate dalla bibliografia consultata e non sono state confermate dalle ricerche dello scrivente. Di conseguenza è molto probabile che esse possano riferirsi ad altre località del territorio comunale che poiché non conosciute nella loro denominazione corretta, sono state ricondotte alla voce "Albona".

Tab. 3: Corotipi delle Orchidaceae del comune di Albona. Nella tabella i contingenti geografici sono segnati in grassetto.
Tab. 3: Horotipi kukavičevk na območju Labina. Geografski kontingenti so označeni z mastnim tiskom.

Contingenti Geografici e Corotipi (1)	Numero taxa	%
Endemico	**3**	**8,11**
Endemico	1	
Subendemico	2	
Mediterraneo	**16**	**43,25**
Eurimediterraneo	12	
Stenomediterraneo	3	
Mediteraneo-Occidentale	1	
Eurasiatico	**12**	**32,43**
Eurasiatico s. s.	6	
Europeo-Caucasico	3	
Eurosiberiano	1	
Paleotemperato	2	
Europeo	**5**	**13,51**
Europeo s. s.	2	
Centro-Europeo	1	
Appennino-Balcanico	2	
Mediterraneo-Atlantico	**1**	**2,7**
Mediterraneo-Atlantico	1	
Totale	**37**	**100**

La Tabella 3 riporta i risultati dell'analisi corologica, con la ripartizione percentuale dei vari contingenti geografici. Si può osservare che domina il contingente Mediterraneo con 16 taxa (43,24%) ripartiti nei corotipi Eurimediterraneo (12 taxa), Stenomediterraneo (3) e Mediteraneo-Occidentale (1 taxon). Esso è seguito dai contingenti: Eurasiatico (12 taxa), Europeo (5), Endemico (3) e Mediterraneo-Atlantico (1 taxon).

CONCLUSIONI

I dati riportati dimostrano come il territorio di Albona sia molto interessante per il popolamento di orchidacee poiché vi attecchiscono specie rare per la penisola istriana e per tutta la Repubblica di Croazia. Il numero rilevato è un indicatore della sua buona qualità ambientale poiché le entità di tale famiglia attecchiscono su terreni che non sono alterati da dissodamenti, concimazioni e largo uso di diserbanti e insetticidi. È tuttavia possibile che a causa della diffusione delle aree urbane, delle infrastrutture turistiche, dell'espansione delle aree forestali e dell'abbandono delle pratiche agro-pastorali tradizionali seguano delle trasformazioni di habitat che potrebbero portare ad una diversa ripartizione delle varie specie con alcune in fase espansione e altre in contrazione o addirittura a rischio di estinzione.

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POVZETEK

Labin leži v jugovzhodnem delu Istre in pokriva površino približno 71,85 km^2. Avtor poroča o seznamu vrst kukavičevk, ki temelji na podlagi lastnih vzorčenj, razpoložljive strokovne literature in neobjavljenih podatkov različnih raziskovalcev, in vključuje 37 vrst, intraspecifičnih taksonov in križancev. Obenem je opravil horološko analizo, ki kaže na prevlado sredozemskih elementov, tem pa sledijo evrazijski elementi.

Ključne besede: Labin, Albona, Orchidaceae, seznam vrst, horološki spekter

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THE MAUVE STINGER, *PELAGIA NOCTILUCA*, HAS EXPANDED ITS RANGE TO THE SEA OF MARMARA

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ABSTRACT

A single individual of Pelagia noctiluca *(Forsskål, 1775) with an approximate bell diameter of 10 cm was observed and photographed from Paşalimanı Island on 12 December 2021, located at the south of Sea of Marmara. The species was hitherto known only from the Aegean and Levantine coasts of Turkey and the present record significantly expands its distribution range. There are currently no signs of an established* P. noctiluca *population, but monitoring studies are certainly required to detect any possible further records from the region.*

Key words: *Pelagia noctiluca*, Sea of Marmara, Scyphozoa, range expansion

LA MEDUSA LUMINOSA, *PELAGIA NOCTILUCA*, HA ESTESO IL SUO AREALE AL MAR DI MARMARA

SINTESI

Un singolo individuo di Pelagia noctiluca *(Forsskål, 1775) con un diametro dell'ombrello di circa 10 cm è stato osservato e fotografato il 12 dicembre 2021 dall'isola di Paşalimanı, situata a sud del Mar di Marmara. La specie era finora nota solo per le coste egee e levantine della Turchia e il presente ritrovamento ne amplia significativamente l'areale di distribuzione. Al momento non ci sono segni di una popolazione consolidata di* P. noctiluca*, ma sono certamente necessari studi di monitoraggio per individuare eventuali ulteriori segnalazioni nella regione.*

Parole chiave: Pelagia noctiluca, Mar di Marmara, Scyphozoa, espansione dell'areale

INTRODUCTION

In their comprehensive checklist, Çinar *et al*. (2014) has listed five scyphozoan species from the Sea of Marmara, namely, *Aurelia aurita* (Linnaeus, 1758), *Chrysaora hysoscella* (Linnaeus, 1767), *Rhizostoma pulmo* (Macri, 1778), *Periphylla periphylla* (Péron & Lesueur, 1810) and *Paraphyllina ransoni* Russell, 1956. The local inventory has prominently increased since then by newly recorded species, as an indication of the complex changes in hydrography and bioecology of the region. Occurrences of four additional species were documented lately (*Discomedusa lobata* Claus, 1877 – İşinibilir *et al*. 2015; *Cotylorhiza tuberculata* (Macri, 1778) – İşinibilir *et al*., 2021; *Mawia benovici* (Piraino, Aglieri, Scorrano & Boero, 2014) and *Drymonema dalmatinum* Haeckel, 1880 – İşinibilir *et al*., 2022), corresponding to 80% increase in Scyphozoa diversity of Sea of Marmara just within the past eight years.

The mauve stinger, *Pelagia noctiluca* (Forsskål, 1775), is a small-sized warm-temperate holoplanktonic jellyfish occurring in tropical and subtropical regions of the world as far as the North Sea (Mariottini *et al*., 2008), which is also widely distributed across the Mediterranean Sea (Boero, 2013). Periodical blooms of this species in the western Mediterranean have been reported, causing adverse effects on human health, fisheries, and pelagic ecosystems (Axiak & Civili, 1991). In Turkey, the distribution of the species is restricted to the Aegean and Levantine coasts (Çinar *et al*. 2014), in which the northern limit of the species is the entrance of Çanakkale Strait (Alpaslan, 2001). Despite its noteworthy abundance in the Mediterranean Sea, published information on the species from Turkey is quite limited and only a single outbreak from the northeastern Levant has recently been documented (Çinar & Dağlı, in press).

In this paper, we are recording the first occurrence of *P. noctiluca* from the Marmara Archipelago (Sea of Marmara) ecosystem, representing a significant expansion from its documented distribution range. Due to its characteristic coloration and distinct morphology, we assume its range expansion to the region as a recent event.

MATERIAL AND METHODS

A scientific survey on board the research vessel K. Piri Reis was organized at Marmara Archipelago (south of the Sea of Marmara) during December 2021 within the scope of the MarIAS project (Addressing Invasive Alien Species Threats at Key Marine Biodiversity Areas Project) to assess the composition and distribution of certain alien species through scuba dives and bottom trawlings. Since the region has recently undergone a catastrophic mucilage event between late 2020 and summer 2021, we also tracked a wide range of organisms other than those targeted within the project. On 12 December 2021, a single individual of *Pelagia noctiluca* was sighted and photographed (Fig. 1) at the southern tip of Paşalimanı Island (Fig. 2., 40°26′42.67″N – 27°39′21.87″E), at a depth of 10 m where the seawater temperature was 13°C. Although the collection of the specimen was not possible at that time, several underwater photographs enabled us to carry out a positive identification. Photographs were taken with a digital compact Olympus TG-6 camera.

RESULTS AND DISCUSSION

The single individual observed had a bell diameter of about 10 cm, characterized by a hemispherical umbrella, four oral arms (longer than the bell diameter) around the mouth, eight relatively thick tentacles (> 25 cm) arising between successive lappets, mauve-colored exumbrella, oral arms and tentacles, rounded warts scattered on the exumbrellar dome, and reddish (female) to purple (male) gonads, conforming to the diagnostic features of *P. noctiluca* (Piraino *et al*., 2014). The closely related confamilial species *Mawia benovici* is clearly distinguished from *P. noctiluca* by having horse-shoe shaped milky white outwardly convex gonads, white transparent color of tentacles, manubrium and oral arms, and rounded to arrow-pointed exumbrellar cnidocyst warts (Piraino *et al*., 2014). Considering the bell diameter >8.5 cm (Malej & Malej, 2004) and the purple-colored gonad (Fig. 1), we may assume the present finding of *P. noctiluca* from the Sea of Marmara denotes a mature male individual. Since the study locality (Marmara Archipelago) is regularly being surveyed on a seasonal basis since September 2020 where more than 100 scuba dives were performed, the occurrence of *P. noctiluca* in the region is probably a recent event, currently with no signs of an established population.

The Sea of Marmara is the focus of attention in Turkey, especially due to the drastic ecosystem changes and environmental catastrophes it has experienced during the past few decades. Not only the seawater temperatures showed a significant increase from 15.1 °C during the 1970-1979 period to 16.8 °C during the 2011-2021 period (TSMS, 2021), but also extreme blooms of algae are being observed since 2007, likely to be triggered by the combined effects of human-induced pressures such as domestic and industrial wastes, insufficient treatment levels and overfishing, along with the climate change (Balkıs-Özdelice *et al*., 2021). Such cumulative effects have been indicated

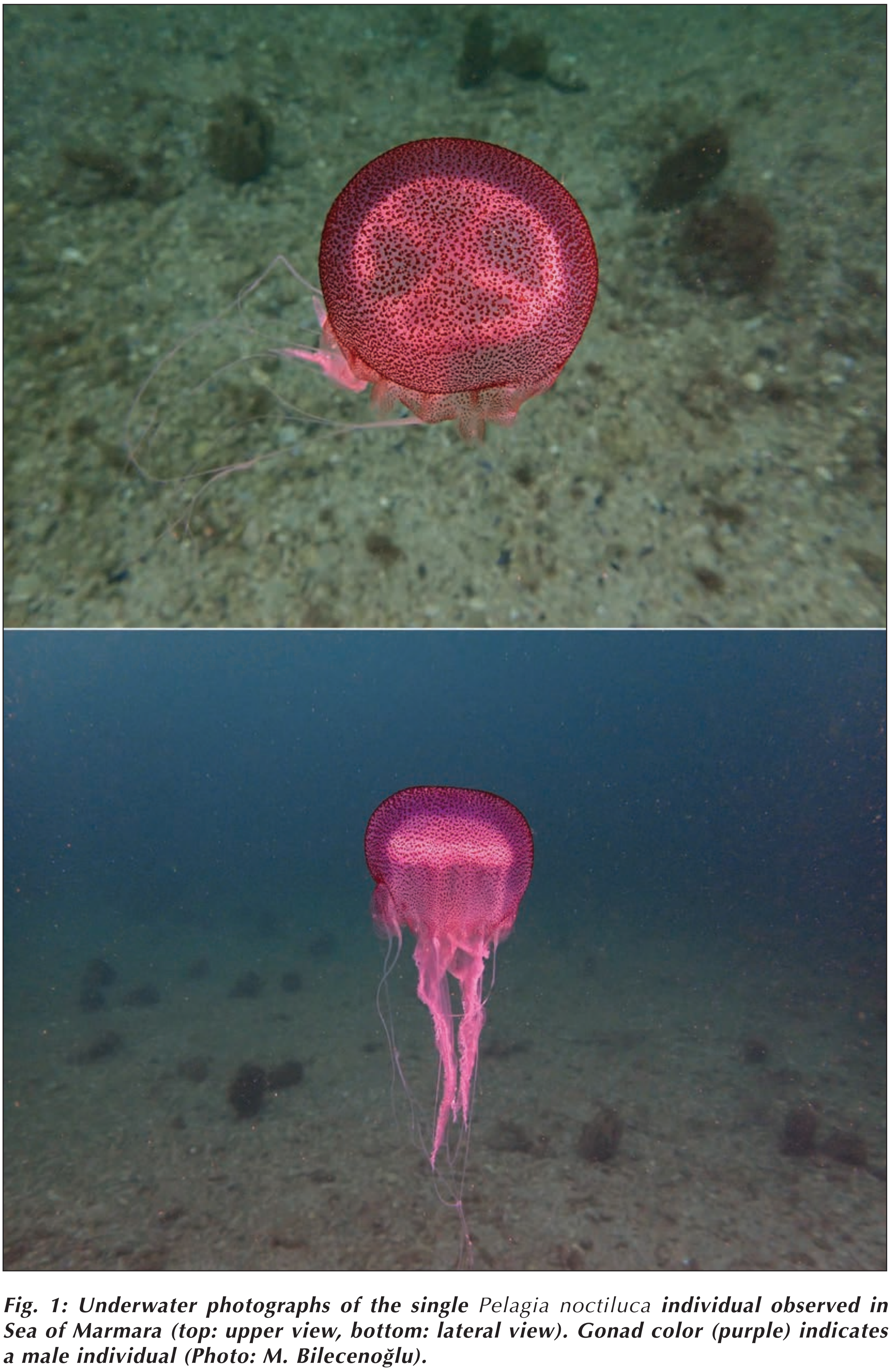

Fig. 1: Underwater photographs of the single *Pelagia noctiluca* ***individual observed in Sea of Marmara (top: upper view, bottom: lateral view). Gonad color (purple) indicates a male individual (Photo: M. Bilecenoğlu).***
Sl. 1: Podvodni fotografiji primerka mesečinke *(Pelagia noctiluca)****, opaženega v Marmarskem morju (zgoraj: pogled z vrha; spodaj: pogled s strani). Barva gonad (vijolična) kaže, da gre za samca (Foto: M. Bilecenoğlu).***

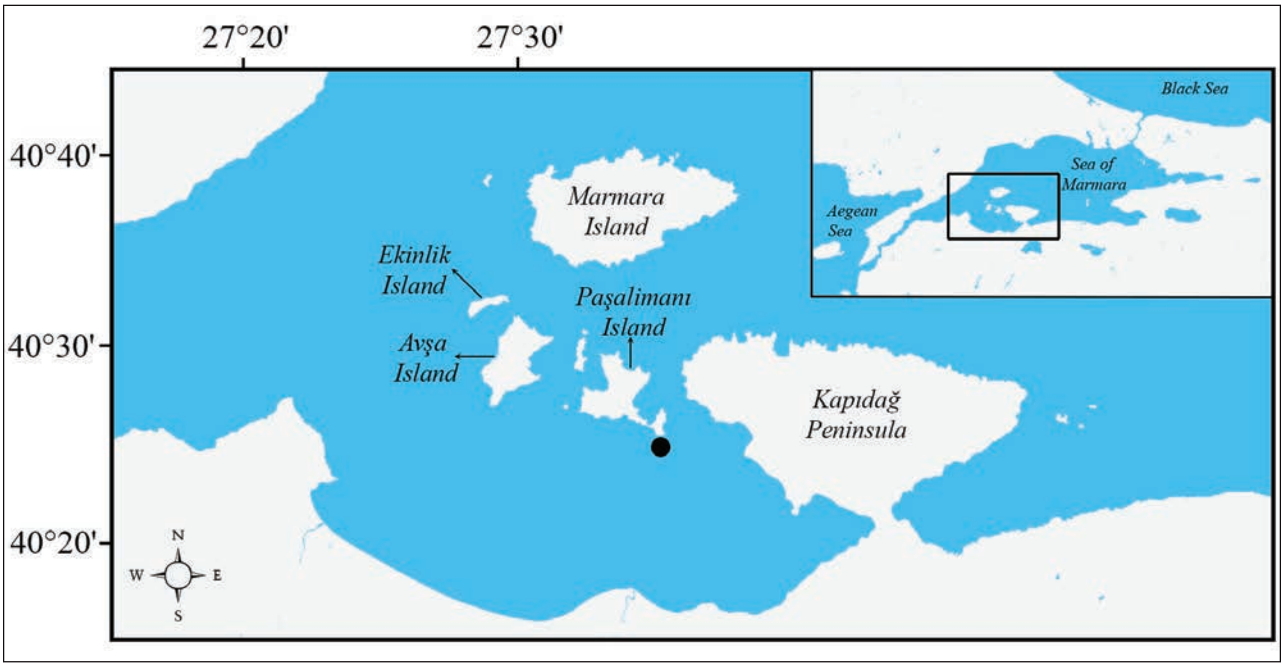

Fig. 2: Map of the observation locality of* Pelagia noctiluca *(indicated by a full dot) in the Sea of Marmara.
Sl. 2: Zemljevid z lokaliteto, kjer je bil opažen primerek mesečinke* (Pelagia noctiluca) *(črn krogec) v Marmarskem morju.

to be involved in the mechanisms which can promote the increase of jellyfish occurrence (Mills, 2001; Boero, 2013). In addition to the above-mentioned stressors, *P. noctiluca* has been identified as prey of some apex Mediterranean predators, including tuna (*Thunnus thynnus*) and swordfish (*Xiphias gladius*) (Cardona *et al.*, 2012), which have disappeared from the Sea of Marmara simply due to overfishing (Ulman *et al.*, 2020), and massive removal of top-predator fishes could open up food resources for jellyfish (Mills, 2001). It is worth mentioning that our *P. noctiluca* observation from the Sea of Marmara is followed by the recent mucilage event (November 2020 to mid-2021) that has intensely impacted the region to an unimaginable extent, corresponding to the most vulnerable ecosystem state where mass mortalities and/or severe declines of several taxa such as the endangered *Pinna nobilis* (Çinar *et al.*, 2021a; also see the dead individuals in the background of Fig.1) and the vulnerable *Paramuricea clavata* (Topçu & Öztürk, 2021) were observed.

The Aegean Sea is connected to the Sea of Marmara through the Çanakkale Strait, which is a very important biological corridor characterized by a two-layered current system, facilitating not only the penetration of thermophilic native species, such as *P. noctulica*, but also many alien species originating from the Red Sea that have formed viable populations (Çinar *et al.*, 2021b). To assess and understand the changes that these species will trigger in the fragile ecosystems of the Sea of Marmara, long-term monitoring studies are required.

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MESEČINKA (*PELAGIA NOCTILUCA*) JE RAZŠIRILA SVOJ AREAL DO MARMARSKEGA MORJA

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Primerek mesečinke, Pelagia noctiluca (Forsskål, 1775) s premerom klobuka približno 10 cm so 12 decembra 2021 opazovali in fotografirali blizu otoka Paşalimanı v južnem Marmarskem morju. Do zdaj so to vrsto poznali le z egejske in levantske obale Turčije. Pričujoči zapis o pojavljanju potrjuje, da se je njen areal znatno razširil. Za zdaj ni znakov, da bi mesečinka vzpostavila svojo populacijo, je pa smiseln redni monitoring, ki bi obelodanil možne nove zapise o pojavljanju te vrste v regiji.

Ključne vrste: *Pelagia noctiluca*, Marmarsko morje, Scyphozoa, širjenje areala

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DYNAMICS OF MESOZOOPLANKTON ALONG THE EASTERN COAST OF THE SOUTH ADRIATIC SEA

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ABSTRACT

Temporal and spatial variability of the mesozooplankton community was studied along the eastern coast of the south Adriatic Sea on a monthly basis from October 2012 to September 2013. Samples were collected at three stations using a 200 μm mesh Nansen net by vertical hauls at two depth layers. A total of 141 holoplanktonic taxa were identified, of which copepods were the dominant group. Total abundances showed high temporal variation (from 181 ind.m^{-3} *in October to 1923 ind.m*$^{-3}$ *in May). The mesozooplankton community differed significantly between the investigated layers and seasons. Deeper layers as well as the winter period were characterized by a subsurface and mesopelagic fauna, while over the warmer months the dominance of typically coastal Adriatic species was recorded. Comparing our results with studies carried out in the middle of the last century, it can be concluded that the eastern coast of the southern Adriatic hosts a stable mesozooplankton community, less affected by global changes.*

Key words: copepods, seasonal variations, zooplankton, Mediterranean Sea

DINAMICA DEL MESOZOOPLANCTON LUNGO LA COSTA ORIENTALE DEL MARE ADRIATICO MERIDIONALE

SINTESI

La variabilità temporale e spaziale della comunità di mesozooplancton è stata studiata lungo la costa orientale dell'Adriatico meridionale su base mensile da ottobre 2012 a settembre 2013. I campioni sono stati raccolti in tre stazioni utilizzando una rete Nansen con maglie da 200 μm, con retate verticali a due strati di profondità. Sono stati identificati 141 taxa oloplanctonici, di cui i copepodi erano il gruppo dominante. Le abbondanze totali hanno mostrato un'elevata variazione temporale (da 181 ind.m^{-3} *in ottobre a 1923 ind.m*$^{-3}$ *in maggio). La comunità di mesozooplancton differiva significativamente tra gli strati e le stagioni analizzate. Gli strati più profondi e il periodo invernale sono stati caratterizzati da una fauna mesopelagica e sub-superficiale, mentre nei mesi più caldi si è registrata la dominanza di specie tipicamente costiere dell'Adriatico. Confrontando i nostri risultati con studi condotti a metà del secolo scorso, si può concludere che la costa orientale dell'Adriatico meridionale ospita una comunità di mesozooplancton stabile, meno influenzata dai cambiamenti globali.*

Parole chiave: copepodi, variazioni stagionali, zooplancton, Mediterraneo

INTRODUCTION

The mesozooplankton occupy an essential position in pelagic carbon-flux processes since they serve as links between phytoplankton and higher pelagic trophic levels, such as larval and juvenile fishes, and interact with the benthic community. They are important indicators of climate change impact on marine and estuarine systems (Hays *et al*., 2005; Hsiao *et al*., 2011; Edwards *et al*., 2013; Menéndez *et al*., 2014; Varkitzi *et al*., 2018). Data on spatial and temporal population variability and food-web interactions of zooplankton can be a valuable index of trophic dynamics and the ability of marine ecosystems to support marine fisheries.

The size range of the mesozooplankton (0.2-20 mm) corresponds almost exactly to the size range of copepodites and adult copepods, which are generally the dominant zooplankton group. Other members of the mesozooplankton include small hydromedusae, ctenophores, chaetognaths, appendicularians, doliolids, fish eggs and larvae, together with the older stages of crustacean plankton and meroplanktonic larvae. Different copepod species in various developmental stages may ingest a wide variety of prey and are mostly omnivorous, i.e., they are able to switch between suspension feeding on phytoplankton and ambush feeding on motile prey (Kiørboe, 1997) depending on the relative abundance of the different types of prey in the environment. Furthermore, small-sized copepods (<1 mm in length) are able to efficiently utilize components of the microbial food web (Turner, 2004). The occurrence of other taxa, such as cladocerans and gelatinous tunicates (appendicularians and doliolids) is more seasonal and characterized by high growth rates (Hopcroft & Roff, 1995; Rose, 2004).

Zooplankton respond rapidly to ecosystem disturbances and there is a strong correlation between environmental changes and plankton dynamics (Roemmich & McGowan, 1995). Temperature and salinity can directly influence growth rate and usually become dominant factors in determining the spatial and seasonal distribution of mesozooplankton (Badylak & Philps, 2008). Moreover, biotic interactions, including competition and predation, are also considered to control populations of mesozooplankton (Verity & Smetacek, 1996). In contrast to the offshore, the estuarine and coastal areas are systems with strong spatio-temporal variability in hydrobiological factors. Physical processes such as changes in water circulation patterns, variations in land inputs (sewage discharges, rivers, etc.) associated with coastline configurations, and bottom topography may also account for a significant part of the temporal variation in zooplankton community structure (Kurt & Polat, 2013). Therefore, studies of spatial and temporal variability of coastal zooplankton are important for a better understanding of the functioning of coastal ecosystems, but also with respect to fisheries.

Seasonal variability of zooplankton has been studied in different coastal regions of the Mediterranean (Mazzocchi & Ribera d'Alcala, 1995; Siokou-Frangou, 1996; Siokou-Frangou *et al*., 1998; Christou, 1998; Fernández de Puelles *et al*., 2003, 2004, 2014; Jamet *et al*., 2001, 2005; Zakaria, 2006; Mazzocchi *et al*., 2011; Kurt & Polat, 2013; Vidjak *et al*., 2019). Investigations of the zooplankton of the Adriatic coast have mostly focused on its productive northern part (Cataletto *et al*., 1995; Fonda Umani *et al*., 2005; Kamburska & Fonda Umani, 2006; Mackas *et al*., 2012; Mozetič *et al*., 2012; Bernardi Aubry *et al*., 2012; Bojanić Varezić *et al*., 2015; Pierson *et al*., 2020). With regard to the eastern Adriatic coast, the copepod fauna of the Kvarner region was analyzed in the work of Hure *et al*. (1979), with several papers describing zooplankton communities in the coastal areas of the central Adriatic (Regner, 1985; Vidjak *et al*., 2006, 2009, 2012). Zooplankton investigations of the southern shallow neritic areas have mostly focused on the more productive enclosed areas such as Mali Ston Bay (Benović & Onofri, 1982; Lučić & Kršinić, 1988; Lučić & Onofri, 1990;), Neretva Channel (Vidjak *et al*., 2007, 2012), Mljet Lakes (Benović *et al*., 2000; Miloslavić *et al*., 2015) or inshore waters near Dubrovnik (Benović *et al*., 1978). However, little information and data are available on species composition and seasonal variation of the zooplankton in the Dubrovnik offshore waters. Information on the current area mostly forms part of broader surveys of the open waters of the southern Adriatic. For example, Benović *et al*. (2004) presented data on medusae over the spring period in the central and southern Adriatic Sea. Additionally, a station near Dubrovnik has recently been involved in two investigations: studies of mesozooplankton over two transects in the southern Adriatic during winter, and presentation of copepod fauna in pre- and post-winter conditions in the southern Adriatic (Hure *at al*., 2018, 2020, 2022).

However, this is the first comprehensive study of the zooplankton of the coastal waters surrounding Dubrovnik, including their taxonomic composition and annual pattern of abundance and diversity. The present study focuses on identifying the dominant environmental factors that drive species-specific spatial and temporal variability.

MATERIAL AND METHODS

Study area

The southern Adriatic is a relatively deep (up to 1250 m) oligotrophic circular basin. Interaction with the main body of the Mediterranean Sea includes inflow of Levantine Intermediate Water and Ionian

Surface Water northward along the eastern Adriatic coastline, and outflow southward along the western coast (Zore-Armanda, 1969; Orlić *et al.*, 1992; Gačić *et al.*, 2002). The intensity of the inflow varies depending on climatic oscillations and on the mechanism of the Bimodal Oscillating System that changes the circulation of the North Ionian Gyre from cyclonic to anticyclonic and vice versa, on a decadal time scale (Gačić *et al.*, 2010).

The study area, located near the city of Dubrovnik, is strongly influenced by currents originating from the eastern Mediterranean (Zore-Armanda, 1969; Gačić *et al.*, 2010). Furthermore, in such coastal areas, land runoff and inshore waters often interact with complex dynamics on a variety of temporal and spatial scales, and fluctuations in ecological parameters can be quite complex.

Sample collection and processing

Sampling was carried out during 11 monthly oceanographic surveys (from October 2012 to September 2013) at 3 stations: S1, S2 and S3. Instead of the one sampling in March, two were conducted in April (at the beginning and end of the month). The stations were located along the eastern part of the southern Adriatic coast at a bottom depth of 100 m (Fig. 1). Due to difficult weather conditions, samples could not be collected at S3 in February 2013. Temperature, salinity and dissolved oxygen (DO) were measured using a SeaBird OC25 probe. Seawater samples (500 mL) for chlorophyll-a (Chl *a*) measurements were collected from depths of 0, 5, 10, 20, 50, 70 and 100 m using a Niskin bottle. For Chl *a*, seawater was filtered through Whatman GF/C glass-fiber filters. The filters were then homogenized in 90% aqueous acetone and the extract measured in a spectrophotometer according to the method described by Strickland & Parsons (1972).

A total of 64 mesozooplankton samples were collected from two depth layers (0-50 m, 50-100 m) using a vertically towed version of a modified open-closed Nansen net (1.13 m diameter; mesh size 200 µm). Samples were collected in daylight and immediately preserved with buffered formaldehyde (4% final concentration). Sample processing and species identifica-

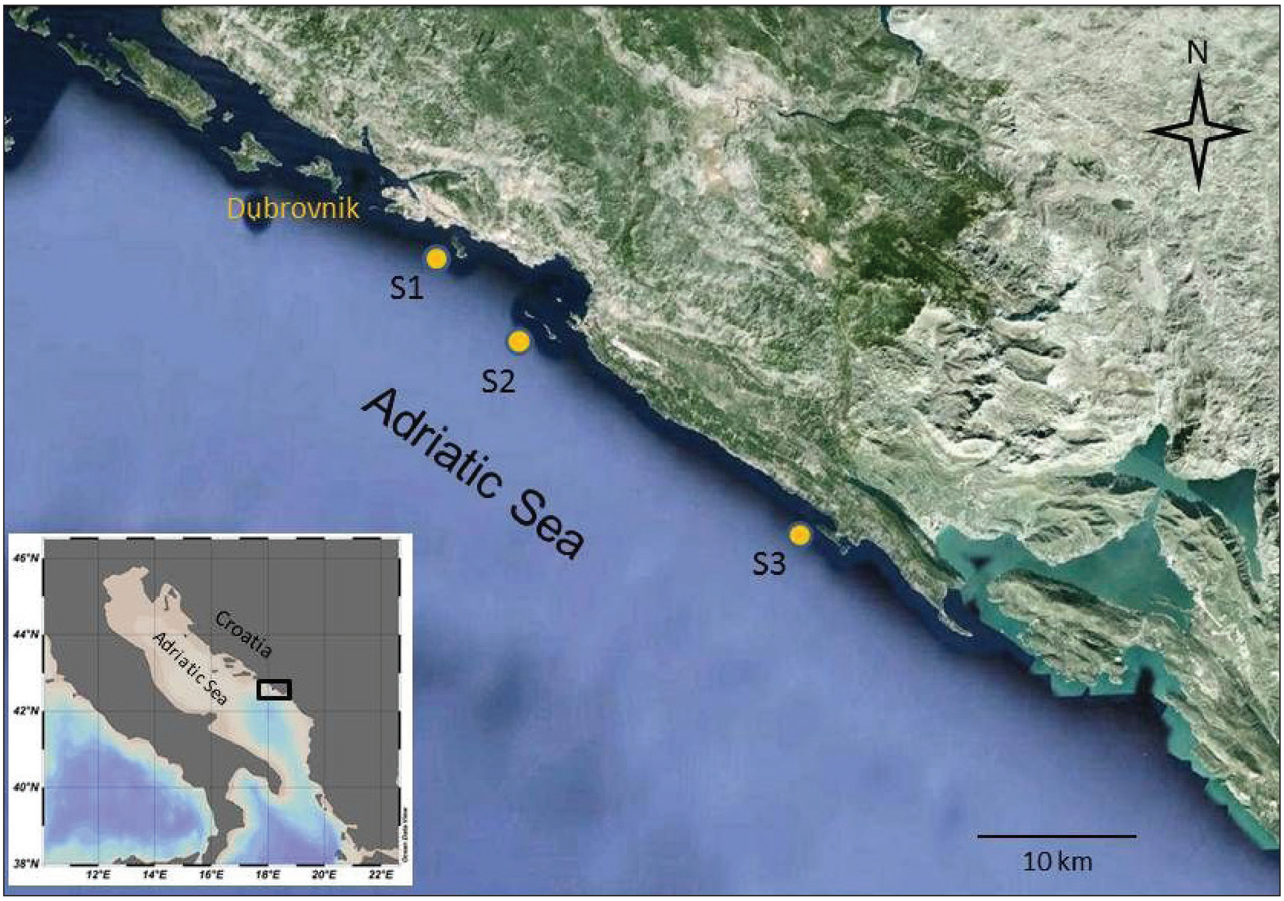

Fig 1: Study area with the sampling stations.
Sl. 1: Zemljevid obravnavanega območja z vzorčevalnimi postajami.

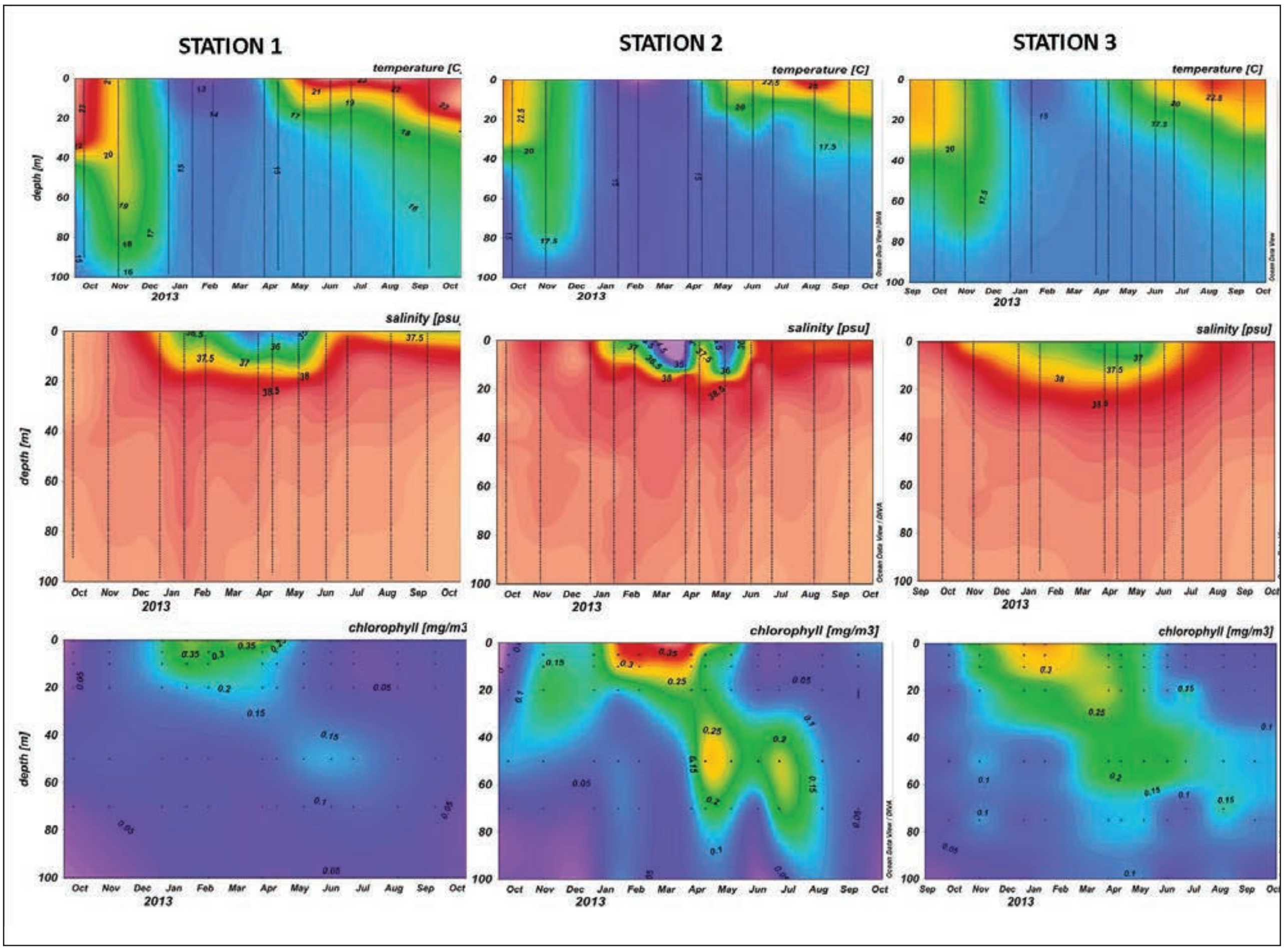

Fig. 2: Annual variability of temperature, salinity and Chl a in the South Adriatic.
Sl. 2: Letna variabilnost temperature, slanosti in Chl a v južnem Jadranu.

tion were conducted at the laboratory according to standard zooplankton methodology (Harris *et al.*, 2000), using an Olympus SZX16 stereomicroscope for counting and detailed observations. Each sample was examined in its entirety for rare species. Taxonomic identification was performed at the lowest possible taxonomical level: most of holoplankters were identified at the species level while some zooplankton were grouped in larger taxonomic groups (e.g., copepodite stages, copepod families Oncaeidae, Corycaeidae, Sapphirinidae, amphipods, ostracods, mysids, euphausids, doliolids). Abundance was expressed as individuals per cubic meter (ind.m^{-3}).

Data analyses

For univariate biodiversity measures, the Margalef species richness (d) and Shannon-Wiener diversity index (H′) were calculated for each sample to analyze seasonal diversity changes. The Margalef formula (Margalef, 1968) compares the number of taxa in a sample and the total number of organisms comprising those taxa. The Margalef species richness index is given by the equation: $d = (S-1)/ \ln N$, where S is the number of taxa in the sample and N is the total number of individuals. The Shannon-Wiener index (Shannon & Wiener, 1963) evaluates how individuals are distributed among taxa and is determined by the equation: $H' = \text{å}-\Sigma i\ Pi \ln Pi$, where Pi is the proportion that the i-th taxa represent to the total number of individuals in the sample space.

One-way analysis of similarity (ANOSIM) was used to test whether the community structure differed significantly between groups: investigated sites, layers and seasons (winter: J, F, spring: A, M, J, summer: J, A, S, Autumn: O, N). ANOSIM generated a test statistic, R, and the magnitude of R is the indicator of the degree of separation between groups, with the score of 1 indicating complete separation and 0 indicating no separation (Clarke & Green, 1988; Clarke, 1993).

Tab. 1: Average dissolved oxygen (DO) concentrations (ml/L) of each investigated layer at stations S1, S2 and S3.
Tab. 1: Povprečna koncentracija raztopljenega kisika (DO; v ml/L) na raziskanih slojih na postajah S1, S2 in S3.

Month	Layer	STATION		
		S1	S2	S3
OCT	0 - 50 m	4.97	5.03	5.03
	50 - 100 m	4.87	4.91	4.73
NOV	0 - 50 m	4.97	4.96	4.87
	50 - 100 m	5.05	5.15	4.70
JAN	0 - 50 m	5.21	5.17	5.21
	50 - 100 m	4.95	4.93	4.90
FEB	0 - 50 m	5.36	5.33	
	50 - 100 m	5.24	5.25	
APR	0 - 50 m	5.41	5.39	5.43
	50 - 100 m	5.20	5.21	4.90
APR	0 - 50 m	5.36	5.44	5.45
	50 - 100 m	5.12	5.14	5.21
MAY	0 - 50 m	5.38	5.48	5.49
	50 - 100 m	5.13	5.11	5.17
JUNE	0 - 50 m	5.26	5.25	5.21
	50 - 100 m	4.86	4.93	4.93
JULY	0 - 50 m	5.44	5.45	5.34
	50 - 100 m	4.85	4.99	5.02
AUG	0 - 50 m	5.66	5.58	5.36
	50 - 100 m	5.13	5.06	4.92
SEP	0 - 50 m	5.12	5.14	4.99
	50 - 100 m	4.95	4.82	4.84

The PRIMER 5 software package for Windows (Clarke & Gorley, 2001) was used to obtain diversity indices and conduct the ANOSIM analysis.

To identify taxa representative of the different layers and seasons, we employed Indicator Species Analysis (ISA; Dufrene & Legendre, 1997). This method combines information on the concentration of species abundance in a particular group and the consistency of occurrence of a species in a particular group. It generates an indicator value (IndVal) for each taxon, ranging from 0 (no indication) to 100 (perfect indication). The statistical significance of each taxa IndVal was determined by the Monte Carlo method, in which sample units were randomly reassigned 1000 times to test if the IndVal value was higher than expected by chance (Dufrene & Legendre, 1997). Taxa with IndVal>25 and p<0.1 were considered characteristic of the groups.

Non-metric multidimensional scaling (NMDS) ordination was used to detect relationships between major zooplankton taxa (>3% contribution) and environmental variables (temperature, salinity, Chl *a* and DO). Prior to the analyses, the data were log-transformed to normalize the variance while maintaining the distances between low values. The final matrix consisted of 64 samples and 19 taxa. The Bray-Curtis measure was used. Dimensionality was determined through evaluation of the standard residual sum of squares (STRESS; Mather, 1976). STRESS values of less than 20 indicate a stable solution (McCune & Grace, 2002). The ISA and NMDS analyses were performed using PC-ORD v. 5.32 (McCune & Mefford, 2006).

RESULTS

Environmental conditions

The annual variations in temperature, salinity and Chl *a* are shown in Fig. 2. The greatest temperature fluctuations were recorded at the surface, particularly at S2, where a minimum of 12.6 °C (February) and a maximum of 25.7 °C (August) were recorded. A period of isothermal conditions occurred from December to April at all stations. Sea surface temperature increased from the end of April, with the strongest thermal stratification in August between 10 and 20 m depth.

The vertical salinity distribution shows that the largest fluctuations occurred in the upper 20 m, due to lateral advection of fresh water from the coast. This was most evident at station S2, where a sharp halocline was detected in spring (minimum of 34.6 recorded at the surface in April). Layers below 20 m are characterized by high salinity values (>38.5) with a maximum of 39.0 noticed at the S3, in October at 30 m depth.

During the study period, the water column was well oxygenated (Tab. 1), with DO concentrations ranging from 4.4 ml/L (S3; October; bottom layers) to 5.9 ml/L (S1; August; 25 m depth).

The highest variations in Chl *a* concentration were recorded at S1, from a minimum of 0.01 $mg.m^{-3}$, recorded in the bottom layer in October 2012 to 0.64 $mg.m^{-3}$ found at the surface in April. Generally, the highest values were recorded in the surface layers of S2 during spring, with a maximum of 0.36 $mg.m^{-3}$.

Mesozooplankton abundance and distribution

Zooplankton abundances in the surface layers (0-50 m) ranged between 346 $ind.m^{-3}$ in October (S1) and 2357 $ind.m^{-3}$ in August (S1) with an average value of 983±553 $ind.m^{-3}$ (Figs. 3 a, b, c). The bottom layers (50-100 m) generally had lower zooplankton abundance than the upper, with an average density of 517±329 $ind.m^{-3}$. The minimum (181 $ind.m^{-3}$) was also found in October at S1 (Fig. 3d), and the maximum (1013 $ind.m^{-3}$) was recorded in April at S3 (Fig. 3f). The increased abundances were generally recorded in spring, following the trend of the copepods as the dominant group com-

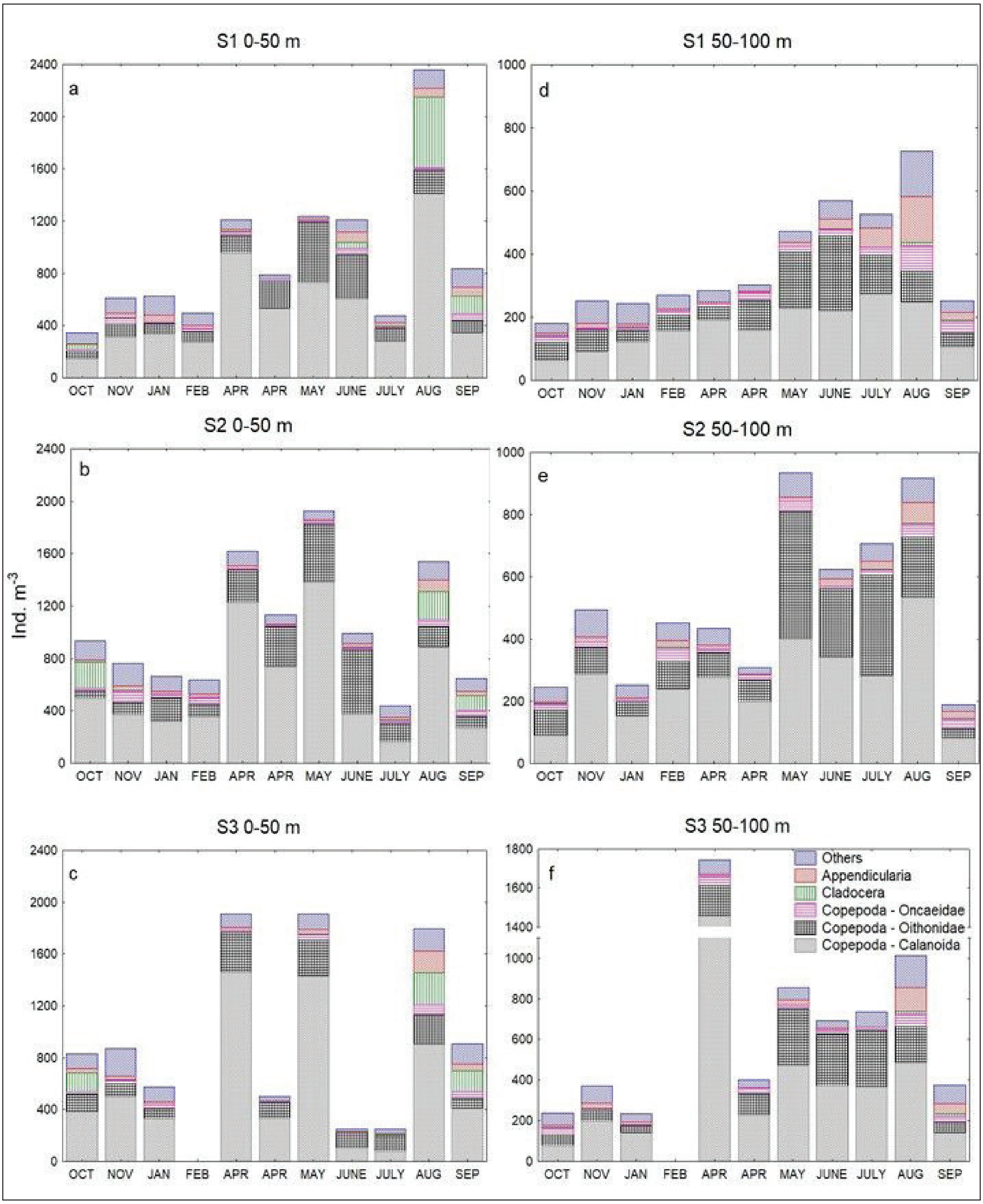

Fig. 3: Annual distribution of the abundances of all mesozooplankton and the dominant mesozooplankton groups at stations S1, S2 and S3 in the upper layer (a, b, c) and in the bottom layer (d, e, f).

Sl. 3: Letna porazdelitev abundance celotnega mezozooplanktona in prevladujočih mezozooplanktonskih skupin, na postajah S1, S2 in S3 v zgornjem sloju (a, b, c) in v spodnjem sloju (d, e, f).

prising from 60 to 98% (mean: 82%) of the total. On average, copepods were more numerous in the upper layer (796±490 ind.m^{-3}) than in the lower (427±310 ind.m^{-3}). Calanoids were the dominant group and their copepodites were more abundant than adults, representing on average 67% of the total of calanoids at all stations. Oithonidae were more numerous only in spring in the layer below 50 m (stations S1 and S2). Oncaeidae were more abundant in the bottom layer during the summer, especially at S1.

Appendicularians were the second most important mesozooplankton group with the highest abundances in August (up to 145 ind.m^{-3}), especially in the layers below 50 m depth. Cladocerans were found mainly in the surface layers and were relatively important from August to October, contributing 17% on average. Of the other invertebrates, doliolods were relatively more abundant, especially in the bottom layer, where they reached a maximum average abundance of 112 ind.m^{-3} in August. Chaethognats were more abundant in the upper layer (16±10 ind.m^{-3}) than in the layer below (6±5 ind.m^{-3}). Meroplanktonic groups fluctuated significantly in time and space (total average of 36±10 ind.m^{-3}) with bivalvia larvae being the most abundant taxon.

Mesozooplankton diversity and community structure

A total of 141 holoplanktonic taxa were identified (Appendix 1). Copepods were the most important group in terms of diversity with 71 taxa found, followed by hydromedusae (18), appendicularians (14) and siphonophores (13). The annual trend of diversity showed a clear seasonal pattern, with the lowest values registered in spring and increasing over winter (Fig. 4). Generally, higher diversity was found in the 50–100 m layer (average d=9.0; H′= 2.9) than in the upper 50 m (d= 8.4; H′= 2.8).

The most abundant and regular adult copepods were calanoids and cyclopoids, including *Oithona similis* (average contribution 8.2%), *Ctenocalanus vanus* (4.2%), *Acartia (Acartiura) clausi* (4.1%), Oncaeidae (3.4%) and *Oithona nana* (3.0%). Harpacticoid density was low, mainly due to the variability of the most important species of the group – *Euterpina acutifrons* (average contribution 0.3%). Apart from copepods, a larger contribution to the entire community was noted for Cladocera *Penilia avirostris* (3.4%), the doliolids (1.4%) and Appendicularia *Oikopleura longicauda* (1.1%).

ANOSIM analyses showed no statistically significant difference between sampling stations (ANOSIM global R=-0.026, P>0.01), while significant differences were observed between sampling layers (global R=0.265, P<0.01) and seasons (global R=0.591, P<0.01). When considering seasons, significant differences were noted between spring/ autumn samples (R=0.738), attributable to different zooplankton composition, while the least differences were observed between summer and autumn samples (R=0.368).

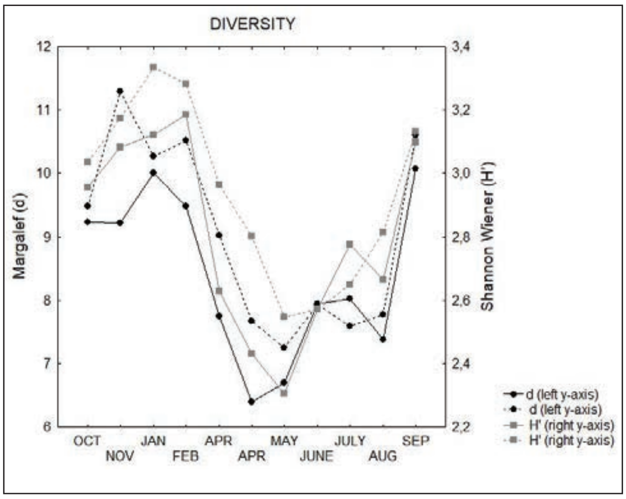

Fig. 4: Annual diversity distribution in the upper layer (full line) and in the bottom layer (dotted line). H' = Shannon's diversity index, D = Margalef's species richness index.

Sl. 4: Letna porazdelitev diverzitete v zgornjem (neprekinjena črta) in globinskem sloju (prekinjena črta). H' = Shannonov diverzitetni indeks, D = Margalefov indeks vrstne pestrosti.

Indicative taxa (IndVal>25; p<0.1), with their abundances and the contribution of each layer and season are shown in Table 2. Most of the mesozooplankton that characterized the upper layer were coastal or warm water taxa (e.g., Corycaeidae). By contrast, the deeper layers were occupied by subsurface and mesopelagic copepods (e.g., *Lucicutia flavicornis*, *Haloptilus longicornis*, genus *Pleuromamma*). In winter, the most important taxa were also copepod species that are generally found in open waters (e.g., *L. clausi*, *P. abdominalis*). In spring, cyclopoids of the genus *Oithona* showed the highest abundances while *Paracalanus parvus* showed the highest IndVal. The pteropod *Limacina trochiformis*, doliolids, the appendicularian species *Fritillaria pellucida* and *Oikopleura fusiformis*, the cladoceran *P. avirostris* and the calanoid genus *Centropages* (*C. typicus* and *C. kroyeri*) characterized the summer period along the southeastern Adriatic coast. In autumn, only five mesozooplankton taxa displayed IndVal>25 and were composed of highly heterogenic members, including copepod genus *Calocalanus*, dinoflagellate *Noctiluca scintillans*, ostracods, and hydromedusae *Liriope tetraphylla*.

Tab. 2: Mesozooplankton taxa characterizing each depth layer and seasons with their indicator values (IndVal), average abundance (N - ind. m-3) and average contribution (%).
Tab. 2: Mezozooplanktonski taksoni, značilni za oba sloja in sezone z njihovimi indikatorskimi vrednostmi (IndVal), povprečno abundanco (N - os.m-3) in povprečnim deležem (%).

	IndVal	**N**	**%**		**IndVal**	**N**	**%**
Upper layer (0-50 m)				**Bottom layer (50-100 m)**			
Corycaeidae	77.9	18.3	2.2	*Tomopteris* spp.	67.1	0.6	0.1
Temora stylifera	77.4	7.4	0.8	Lucicutia flavicornis	63.8	1.8	0.6
Flaccisagitta enflata	71.8	1.8	0.2	Diaixis pygmaea	61.4	1.7	0.3
Acartia (Acartiura) clausi	68.8	58.1	4.2	Clausocalanus paululus	60.3	5.0	1.4
Muggiaea kochii	63.5	1.4	0.2	Haloptilus longicornis	46.8	2.9	1.0
Aglaura hemistoma	62.9	1.4	0.2	Pleuromamma gracilis	43.0	0.5	0.2
Creseis spp.	62.2	5.1	0.7	Pleuromamma abdominalis	37.5	0.2	0.1
Euterpina accutifrons	61.5	3.4	0.4	Scolecithricella dentata	36.8	0.3	0.1
Evadne spinifera	57.5	7.0	0.7				
Isias clavipes	44.1	1.7	0.1				
Pseudevadne tergestina	28.1	2.8	0.2				
Winter				**Spring**			
Euterpina accutifrons	63.1	6.3	1.2	Paracalanus parvus	58.0	14.6	1.4
Haloptilus longicornis	55.9	4.3	1.7	Hyperiidae	57.1	3.5	0.6
Lucicutia clausi	52.6	2.3	0.7	Ctenocalanus vanus	55.8	55.4	5.6
Pleuromamma abdominalis	44.9	0.6	0.3	Acartia (Acartiura) clausi	55.3	56.4	4.3
Lucicutia flavicornis	46.0	2.3	0.9	Oithona similis	54.8	108.8	12.9
Euchaeta marina	37.9	0.4	0.1	Calanus helgolandicus	54.6	3.9	0.5
Neocalanus gracilis	39.6	0.4	0.1	Oithona nana	53.4	39.7	4.4
				Serratosagitta serratodentata	31.4	0.1	<0.1
Summer				**Autumn**			
Limacina trochiformis	66.6	4.7	0.8	Ostracoda	58.6	14.4	3.7
Doliolida	64.4	25.4	2.8	Calolacalnus styliremis	52.0	8.5	1.5
Fritillaria pellucida	59.2	14.8	2.1	Calocalanus elongatus	50.0	0.5	0.1
Centropages typicus	58.0	14.7	1.3	Noctiluca scintillans	49.1	18.2	3.6
Oikopleura (Coecaria) fusiformis	55.9	11.2	1.5	Liriope tetraphylla	41.7	0.1	<0.1
Penilia avirostris	53.8	61.5	4.6				
Lizzia blondina	38.9	0.2	<0.1				
Centropages kroyeri	32.5	1.9	0.1				

The ordination of the major taxa, with the highest IndVal and an overall contribution of >3% related to environmental factors, is shown in Fig 5. A 2D NMDS ordination solution was chosen based on the final moderate stress value of 15.6 and the final instability <0.000001. The ordination cumulatively represented 80.6% of the community variance. Axis 1 represented 38.8% of the variance and was related to temperature variation (r=0.737). Thus, this axis distinguished summer from winter samples. The cladoceran *Penilia avirostris* was strongly associated with summer high-temperature samples, while the copepod *Clausocalanus paululus* displayed the opposite pattern. Axis 2 explained 41.8% of the remaining variance and was positively correlated with DO (r=0.462) and negatively with salinity (r=-0.436). Distribution of samples (grouped by season) along the second axes confirmed the strong separation between spring and winter/autumn samples where the spring samples were grouped with higher DO values.

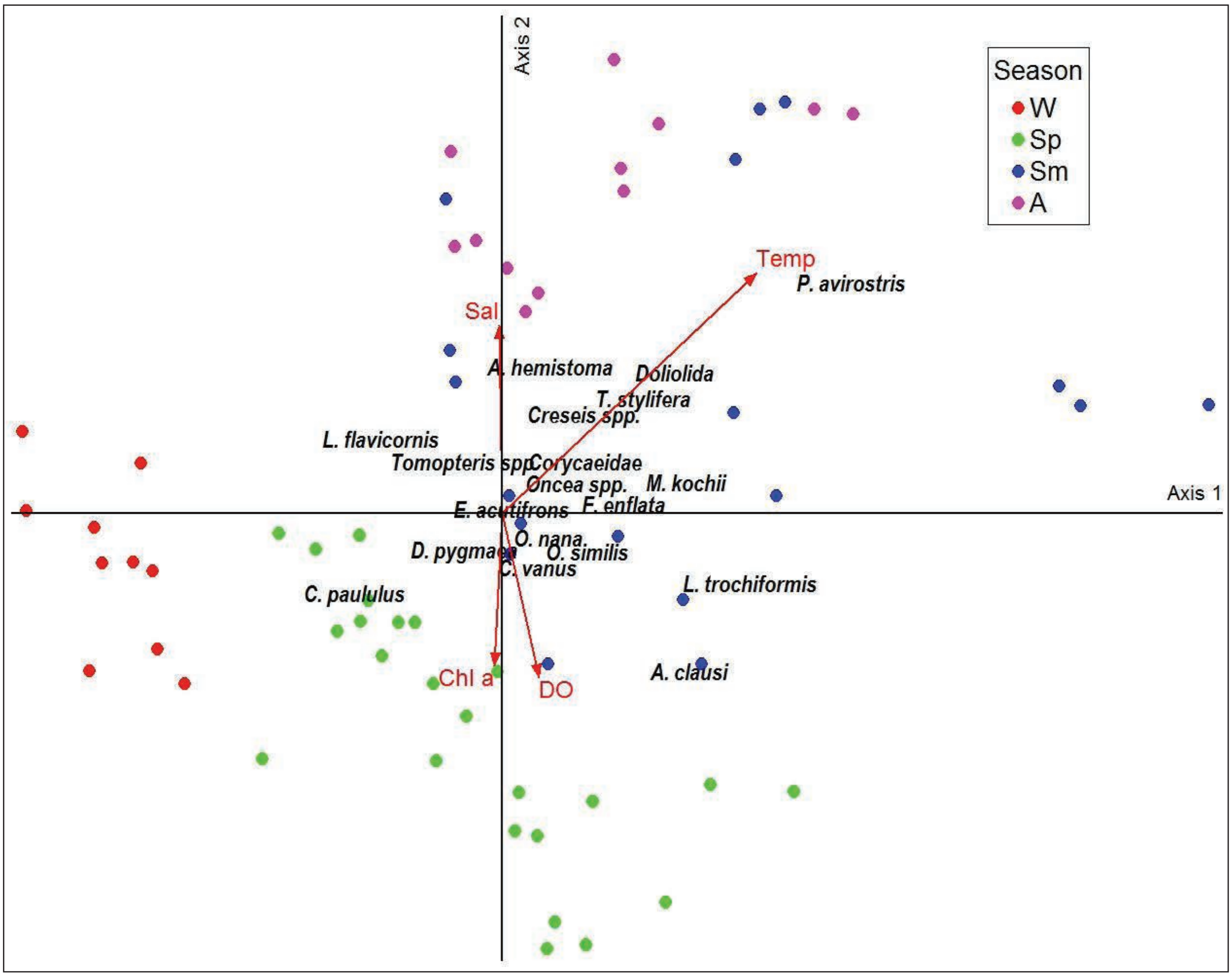

Fig. 5: Ordination joint plot with results of nonmetric multidimensional scaling (NMDS) with the position of the most important taxa and the related environmental variables overlaid as vectors (Temp-temperature, Sal – salinity, Chl a, DO). Vector length and direction indicate relative strength of the correlation with axes. Samples were grouped by season (W - winter, Sp - spring, Sm - summer, A - autumn).

Sl. 5: Ordinacijski diagram z rezultati nemetričnega večdimenzionalnega skaliranja (NMDS) s položajem najpomembnejših taksonov in povezanimi okoljskimi spremenljivkami kot vektorji (Temp - temperatura, Sal - slanost, Chl a, DO). Dolžina in smer vektorja označujeta relativno moč korelacije z osmi. Vzorci so bili razvrščeni po sezonah (W - zima, Sp - pomlad, Sm - poletje, A - jesen).

DISCUSSION

In this study, the annual distribution of mesozooplankton in the coastal area of the Dubrovnik region was investigated with the aim of providing detailed information on their composition, biodiversity and relationship with environmental parameters.

Total mesozooplankton values were considerably lower compared to other coastal Mediterranean regions (Siokou-Frangou, 1996; Fernández de Puelles *et al.*, 2003; Ribera d'Alcala *et al.*, 2004; Kurt & Polat, 2013) or other eastern Adriatic coastal sites (Hure *et al.*, 1979; Vidjak *et al.*, 2007, 2012; Miloslavić *et al.*, 2015). Similar abundance ranges were found in the open surface waters of southern Adriatic (Hure *et al.*, 2018), indicating low productivity, negligible human impact and a high influence of the open sea. Despite the proximity of the mouth of a stream whose freshwater discharge causes lower surface salinities in spring (affecting station S2 the most) Chl *a* values also remain low, analogous to those found in offshore waters (Benović *et al.*, 2004; Hure *et al.*, 2018, 2020), confirming the oligotrophic nature of the study sites.

In Mediterranean coastal areas, zooplankton abundance generally follows the phytoplankton bloom that takes place in late winter, with increased values in spring/summer (Siokou-Frangou, 1996; Ribera d'Alcala *et al.*, 2004; Morabito *et al.*, 2018) and/or bimodal distribution with a second peak in autumn (Scotto di Carlo & Ianora, 1983; Morabito *et al.*, 2018). Generally, our results show higher values during spring and summer. Unlike more eutrophic coastal Mediterranean sites, where cladocerans (mostly *Penilia avirostris*) dominate during the summer (Siokou-Frangou, 1996; Calbet *et al.*, 2001; Vidjak *et al.*, 2007; Isari *et al.*, 2007; Camatti *et al.*, 2008; Piontkovski *et al.*, 2012; Bernardi Aubry *et al.,* 2012; Peirson *et al.*, 2020) and have a great influence on total mesozooplankton densities, our total abundances in the surface layers followed copepod densities even during the August/September. Thus, the lack of seasonal predominance of cladocerans indicates a negligible coastal influence in the study area. In the bottom layers, the summer peak was associated with the higher densities of doliolids and appendicularians, which were found to be the most important group after copepods. Their temperature-dependent seasonality has been frequently documented (Lučić & Onofri, 1990; Vidjak *et al.*, 2007; Isari *et al.*, 2007; Miloslavić *et al.*, 2015). Compared to other more productive surrounding areas where cyclopoids (Oithonidae) prevail over copepod fauna during summer (Lučić & Kršinić, 1998; Vidjak *et al.*, 2007; Miloslavić *et al.*, 2015), calanoids remained dominant in our study for almost the entire period of investigation.

All the species identified during this research have already been recorded in the Adriatic Sea (Hure *et al.*, 1980; Benović *et al.*, 2004; Batistić *et al.*, 2004; Hure *et al.*, 2018). The most abundant copepod taxa, such as *Oithona similis*, *Ctenocalanus vanus*, *Acartia (Acartiura) clausi*, *Oithona nana* and Oncaeidae, are similar to those reported for other coastal Adriatic areas (Hure *et al.*, 1979; Hure & Kršinić, 1998; Vidjak *et al.*, 2012; Miloslavić *et al.*, 2015), confirming a relative uniformity of the copepod community in coastal Adriatic waters. Even so, their numbers over the investigated sampling sites were considerably lower than in other coastal areas.

The studied area is characterized by a high influence of open-water intrusion, including inflowing Ionian currents (Gačić *et al.*, 2002), which have a great impact on the distribution of zooplankton species (Hure *et al.*, 2018). It should be emphasized here that some taxonomic groups, whose members show high species-specific differences, were not determined at species level but at family level (e.g., Corycaeidae, Oncaeidae, Ostracoda). Although station S2 was under a greater influence of low salinity water inflow, i.e., terrestrial runoff, than the other two investigated stations, this influence seems to have a negligible effect on the mesozooplankton community, which did not differ between stations. Moderate differences were found in the vertical levels, where neritic species occupied the surface layer, while mainly subsurface (*Tomopteris* spp., *Clausocalanus paululus*, *Lucicutia flavicornis*, *Pleuromamma gracilis*) and mesopelagic (*Pleuromamma abdominalis*, *Haloptilus longicornis*, *Scolecithricella dentata*) taxa were indicative of the bottom layer.

In general, seasonality was a major factor influencing the distribution of zooplankton in the study area. The NMDS analysis revealed that seasonal temperature changes were the main environmental gradient responsible for the formation of the first axis. It is well known that temperature is an important factor regulating the distribution of zooplankton (Siokou-Frangou *et al.*, 2004; Vidjak *et al.*, 2007, 2012; Miloslavić *et al.*, 2015). There is a strong separation of winter samples from all others along this axis, with mid-temperature (*C. paululus*) and termophilic (*P. avirostris*, *T. stylifera*, Doliolids) taxa also being distinguished. The winter period along the southern Adriatic coast was characterized by low densities and presence of characteristic offshore species, with the exception of *E. acutifrons* at the surface. *E. acutifrons* also peaked in winter in the Neretva Channel (Vidjak *et al.*, 2007), and in even greater numbers. The spread of subsurface and intermediate copepod species from southern and central Adriatic along the eastern coast winter isotherm has already been reported (Regner, 1985; Hure & Kršinić, 1998; Vidjak *et al.*, 2007). This is related to the eastern Adriatic circulation pattern, which is characterized by an increased inflow enhancing currents along the eastern coast (Zore-Armanda *et al.*, 1999; Boicourt *et al.*, 2020). The annual diversity pattern over the study period also confirmed this condition.

The most significant differences in the zooplankton community were found between spring and autumn samples, as displayed by the results of the NMDS analysis along the second axis. The environmental traits characterizing the spring samples, on the other hand, are low salinity and higher Chl *a* and DO values. Typical coastal copepods (*Paracalanus parvus, Acartia* (*Acartiura*) *clausi*) were conspicuous, as were species of the genus *Oithona*, whose dominance over the warmer part of the year has already been reported in the eastern Adriatic coast (Vidjak *et al.*, 2007; Miloslavić *et al.*, 2015).

Autumn was distinguished by cold water taxa, such as the copepod genus *Calocalanus* and ostracods, which are an important element of the southern Adriatic winter zooplankton community (Hure & Kršinić, 1998; Brautović *et al.*, 2006). Dinoflagellates of the species *Noctiluca scintilans* also showed higher abundances in this part of the year, although their blooms normally occur in the spring-summer period (Fonda Umani, 2004; Mikaelyan *et al.*, 2014).

During summer, in addition to the copepod genus *Centropages*, other zooplankton groups and taxa were conspicuous, including the pteropod *Limacina trochiformis* or appendicularians *Fritillaria pellucida* and *Oikopleura fusiformis*. These species usually peak in spring or summer (Siokou-Frangou, 1996; Calbet, 2001; Ribera d'Alcala *et al*., 2004; Miloslavić *et al*., 2015).

CONCLUSIONS

It can be concluded that the mesozooplankton fauna of the investigated area is marked by high dynamics and a high degree of temporal variability due to the particular hydrographic regime and occurrence of characteristic taxa in the annual cycle. The low values of Chl *a* and total abundance of mesozooplankton pointed to the oligotrophic character of the studied area, indicating a negligible influence of the nearby freshwater source or the Boka Kotorska system located further south. In the warmer months, higher neritic zooplankton abundances were recorded in the upper layers. In winter, strong and persistent physical forces maintain the homogeneity of the water column and therewith higher salinity, promoting the presence of species characteristic of the open sea, greater diversity, and decrease in overall densities. There are several studies confirming significant changes in the composition and abundance of mesozooplankton in the Adriatic Sea as a result of global warming and introduction of non-native species, especially in its northern region (Conversi *et al*., 2009; Bernardi Aubry *et al*., 2012; Mozetič *et al*., 2012; Pierson *et al*., 2020). Overall, the authors found that the species preferring cold water decreased while species with a preference for warm water expanded their residence and migrated northwards. This was mostly related to summer–autumn increases in sea surface temperature.

This investigation could be of particular importance as a database for future monitoring of the planktonic communities of the Adriatic Sea, representing a baseline study of the zooplankton biodiversity of the eastern Adriatic coastal system, fundamental for future considerations about the possible measures to mitigate to the effects of climate change and anthropogenic activities.

However, a major limitation in describing the annual cycles is the remarkable complexity and interannual variability of environmental factors and plankton responses. This is particularly evident in oligotrophic waters, where short-term and/or small-scale patchiness may be of greater importance. More frequent sampling and multi-year surveys are therefore needed to cover all phases of an annual cycle and to distinguish regular patterns from occasional and exceptional events in this variable system.

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Appendix 1: List of determined zooplankton taxa found in the eastern coast of the south Adriatic in 2012/2013. An Asterisk indicates presence in investigated layer and season (W-winter, Sp-spring, Sm-summer, A-Autumn).
Priloga 1: Seznam določenih taksonov zooplanktona, najdenih na vzhodni obali južnega Jadrana v letih 2012/2013. Zvezdica označuje prisotnost v preiskovanem sloju in sezoni (W-zima, Sp-pomlad, Sm-poletje, A-jesen).

	Layer		**Season**			
Taxon	**0-50 m**	**50-100 m**	**W**	**Sp**	**Sm**	**A**
HOLOPLANKTON						
Cnidaria Hydrozoa						
Order Anthoathecata						
Podocorynoides minima	*	*	*		*	
Lizzia blondina	*	*			*	
Podocoryna areolata		*			*	
Odessia maeotica	*				*	
Euphysa aurata		*		*	*	
Turritopsis dohrnii	*					*
Eucodonium brownei	*					*
Order Leptothecata						
Obelia spp.	*	*	*	*	*	
Clytia hemisphaerica	*	*	*	*	*	*
Helgicirrha cari	*	*			*	
Eutima gracilis	*				*	
Order Trachymedusae						
Rhopalonema velatum	*	*	*	*	*	*
Aglaura hemistoma	*	*	*	*	*	*
Persa incolorata	*	*	*	*	*	*
Order Limnomedusae						
Liriope tetraphylla	*	*			*	*
Order Narcomedusae						
Solmissus albescens		*			*	*
Solmaris leucostyla		*			*	*
Solmundella bitentaculata	*	*	*		*	
Order Siphonophorae (Calycophorae)						
Sulculeolaria chuni	*				*	
Sulculeolaria quadrivalvis	*		*			
Lensia campanella	*	*	*			*
Lensia fowleri		*		*		
Lensia multicristata		*	*			
Lensia subtilis	*	*	*	*	*	*
Muggiaea atlantica	*	*	*	*	*	*
Muggiaea kochii	*	*	*	*	*	*
Chelophyes appendiculata	*	*			*	
Eudoxoides spiralis	*	*	*	*	*	*
Sphaeronectes irregularis		*			*	
Sphaeronectes koellikeri	*	*	*	*	*	*

Bassia bassensis	*	*	*		*	*
Ctenophora	*	*			*	*
Mollusca Gastropoda						
Order Littorinimorpha						
Atlanta peronii	*	*	*		*	*
Order Thecosomata						
Limacina sp.	*					*
Limacina trochiformis	*	*	*	*	*	*
Heliconoides inflatus	*	*	*	*	*	*
Creseis spp.	*	*	*	*	*	*
Annelida (Polychaeta)						
Tomopteris spp.	*	*	*	*	*	*
Chaetognatha Sagittoidea						
Flaccisagitta enflata	*	*	*	*	*	
Mesosagitta minima	*	*		*		*
Parasagitta setosa	*	*	*	*	*	*
Serratosagitta serratodentata	*	*		*	*	
Decipisagitta descipiens	*	*	*	*		
Arthropoda Crustacea						
Superorder Cladocera						
Penilia avirostris	*	*		*	*	*
Evadne spinfera	*	*	*	*	*	*
Evadne nordmanni	*			*	*	*
Pseudevadne tergestina	*				*	*
Pleopis polyphemoides	*	*	*	*	*	*
Podon intermedius	*			*	*	
Class Ostracoda	*	*	*	*	*	*
Subclass Copepoda						
Calanus helgolandicus	*	*	*	*	*	*
Mesocalanus tenuicornis	*	*	*	*	*	*
Nannocalanus minor	*	*	*	*	*	*
Neocalanus gracilis	*	*	*	*	*	*
Pareucalanus attenuatus	*	*	*	*	*	*
Paracalanus parvus	*	*	*	*	*	*
Paracalanus denudatus	*	*	*	*	*	*
Calocalanus pavo	*	*	*	*	*	*
Calocalanus contractus	*	*	*	*	*	*
Calocalanus styliremis	*	*	*	*	*	*
Calocalanus elongatus	*	*	*		*	*
Mecynocera clausi	*	*	*	*	*	*
Clausocalanus arcuicornis	*	*	*	*	*	*
Clausocalanus jobei	*	*	*	*	*	*
Clausocalanus furcatus	*	*	*	*	*	*
Clausocalanus pergens	*	*	*	*	*	*
Clausocalanus parapergens	*	*		*	*	*

Clausocalanus lividus	*	*	*	*	*	*
Clausocalanus mastigophorus	*	*	*	*	*	*
Clausocalanus paulusus	*	*	*	*	*	*
Ctenocalanus vanus	*	*	*	*	*	*
Pseudocalanus elongatus	*	*		*	*	*
Aetideus armatus	*	*	*	*	*	*
Aetideus giesbrechti	*	*	*	*		
Paraeuchaeta hebes	*	*	*	*	*	*
Euchaeta marina	*	*	*	*		*
Xanthocalanus agilis		*	*	*		
Spinocalanus longicornis		*				*
Scaphocalanus curtus	*	*	*	*	*	*
Scolecithricella dentata	*	*	*	*	*	*
Scolecithrix bradyi	*	*	*	*	*	*
Diaixis pygmaea	*	*	*	*	*	*
Centropages typicus	*	*	*	*	*	*
Centropages kroyeri	*			*	*	*
Centropages violaceus	*					*
Isias clavipes	*	*	*	*	*	*
Temora stylifera	*	*	*	*	*	*
Temora longicornis	*				*	
Pleuromamma abdominalis		*	*	*	*	*
Pleuromamma gracilis	*	*	*	*	*	*
Labidocera wollostoni		*		*		
Lucicutia flavicornis	*	*	*	*	*	*
Lucicutia ovalis	*	*	*	*	*	*
Lucicutia clausi	*	*	*	*	*	
Lucicutia gemina		*		*		
Heterorhabdus papilliger	*	*	*	*		*
Heterorhabdus abyssalis		*		*		
Heterorhabdus spinifrons		*	*			
Haloptilus longicornis	*	*	*	*	*	*
Candacia giesbrechti	*	*	*	*	*	*
Candacia bipinata		*	*			
Phaenna spinifera	*	*	*			*
Acartia (Acartiura) clausi	*	*	*	*	*	*
Acartia(Acartiura) longirermis	*	*	*		*	*
Acartia (Acartia)negligens	*		*			
Oithona nana	*	*	*	*	*	*
Oithona plumifera	*	*	*	*	*	*
Oithona similis	*	*	*	*	*	*
Oithona setigera	*	*	*	*	*	*
Oithona atlantica	*	*		*	*	
Oithona linearis	*	*			*	*
Oncea spp.	*	*	*	*	*	*

Euterpina acutifrons	*	*	*	*	*	*
Microsetella norvegica	*	*	*		*	*
Macrosetella gracilis	*	*	*	*	*	*
Corycaeidae	*	*	*	*	*	*
Goniopsillus clausi	*	*	*	*	*	*
Lubbockia squillimana	*	*	*	*	*	*
Copilia spp.	*	*	*			
Sapphirina spp.	*	*	*	*	*	*
Monstrilla longiremis	*			*	*	
Order Euphausiacea	*	*	*	*	*	*
Order Mysida	*	*		*	*	
Order Isopoda	*	*			*	*
Order Amphipoda Hyperiidea	*	*	*	*	*	*
Chordata Thaliacae						
Order Doliolida	*	*	*	*	*	*
Chordata Appendicularia						
Oikopleura (Vexillaria)albicans	*		*			
Oikopleura (Vexillaria)dioica	*	*	*	*	*	*
Oikopleura (Coecaria) longicauda	*	*	*	*	*	*
Oikopleura cophocerca		*	*	*		
Oikopleura (Coecaria) fusiformis	*	*	*	*	*	*
Appendicularia sicula	*	*			*	
Mesoikopleura haranti		*			*	
Fritillaria borealis	*	*	*	*	*	*
Fritillaria pellucida	*	*	*	*	*	*
Fritillaria haplostoma	*	*	*	*	*	*
Fritillaria formica	*	*		*	*	
Fritillaria megachile	*		*			
Stegosoma magnum		*				*
Kowalevskia tenuis	*				*	
MEROPLANKTON						
Decapoda	*	*	*	*	*	*
Bivalvia	*	*	*	*	*	*
Phoronida	*	*	*	*	*	*
Gastropoda	*	*	*	*	*	*
Polychaeta	*	*	*	*	*	*
Cirripedia	*	*		*	*	
Echinodermata Bipinnaria	*	*	*	*	*	*
Echinodermata Ophiopluteus	*	*	*	*	*	*
Echinodermata Auricularia	*	*	*	*	*	*
Pisces	*	*	*	*	*	*
Branchiostoma lanceolatum juv.	*	*			*	*

DINAMIKA MEZOZOOPLANKTONA VZDOLŽ VZHODNE OBALE JUŽNEGA JADRANA

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POVZETEK

Avtorji so raziksovali časovno in prostorsko dinamiko mezozooplanktonske združbe vzdolž vzhodne obale južnega Jadranskega morja enkrat mesečno od oktobra 2012 do septembra 2013. Vzorce so pobirali z navpičnimi dvigi na dveh globinskih slojih treh postaj z uporabo Nansenove 200 µm planktonske mreže. Določili so skupno 141 holoplanktonskih taksonov, med katerimi so prevladovali raki ceponožci. Zaznali so velika nihanja celokupne abundance v časovni skali (od 181 os.m^{-3} *oktobra do 1923 os.m*$^{-3}$ *v maju). Združba mezozooplanktona se je v raziskanih slojih in sezonah značilno razlikovala. V globljih slojih in v zimskem času je prevladovala podpovršinska in mezopelagična favna, v toplejših mesecih pa so prevladovale značilne obalne jadranske vrste. Na podlagi primerjave z raziskavami s polovice prejšnjega stoletja so avtorji zaključili, da se v južnem Jadranu pojavlja stabilna mezozooplanktonska združba, na katero globalne spremembe manj vplivajo.*

Ključne besede: raki ceponožci, sezonska nihanja, zooplankton, Sredozemsko morje

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POPULATION DYNAMICS OF THE COCKLE *CERASTODERMA GLAUCUM* (MOLLUSCA: BIVALVIA) IN THE GULF OF GABES (TUNISIA)

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ABSTRACT

The cockle Cerastoderma glaucum *is one of the most abundant shellfish species in the southern Tunisian waters. Its current exploitation status and management are becoming a major concern for fishing industry in Tunisia. This study is the first attempt to investigate its population dynamics including the population structure, growth, mortality, and exploitation status of two populations. Cockles were collected from Sfax (site A) and Gabes (site B) during a one-year period. Length frequency data were analyzed for estimation of population parameters to evaluate the stock. Recruitment was continuous and showed two major pulses in the two sites. The data presented herein are essential for the appropriate fisheries management and conservation for cockles.*

Key words: *Cerastoderma glaucum*, population dynamics, mortality, recruitment, south of Tunisia

DINAMICA DI POPOLAZIONE DEL CUORE DI LAGUNA *CERASTODERMA GLAUCUM* (MOLLUSCA: BIVALVIA) NEL GOLFO DI GABES (TUNISIA)

SINTESI

Il cuore di laguna Cerastoderma glaucum *è una delle specie di molluschi più abbondanti nelle acque della Tunisia meridionale. Il suo attuale stato di sfruttamento e la sua gestione stanno diventando una delle principali preoccupazioni per l'industria della pesca in Tunisia. Questo studio è il primo tentativo di indagare le dinamiche di popolazione, tra cui la struttura della popolazione, la crescita, la mortalità e lo stato di sfruttamento di due popolazioni. Gli esemplari sono stati raccolti a Sfax (sito A) e a Gabes (sito B) durante il periodo di un anno. I dati sulla frequenza delle lunghezze sono stati analizzati per stimare i parametri della popolazione e valutare lo stock. Il reclutamento è stato continuo e ha mostrato due impulsi principali nei due siti. I dati qui presentati sono essenziali per un'adeguata gestione e conservazione della pesca della specie.*

Parole chiave: *Cerastoderma glaucum*, dinamiche di popolazione, mortalità, reclutamento, sud della Tunisia

INTRODUCTION

Cerastoderma glaucum (Poiret, 1789) is a benthic species of bivalve mollusk which is very common in the Mediterranean Sea and southern Europe, preferentially dwells on muddy bottoms of lagoons and estuaries. It has been recorded from the coasts of Tunisia, Egypt, Turkey, Sardinia, Italy, Greece, Portugal, Spain, France, the Netherlands, the British Isles, Denmark, Finland, Norway and in the Wadden Sea, Adriatic Sea, Red Sea, Aegean Sea and Caspian Sea (Derbali, 2011; Malham *et al*., 2012; Derbali *et al*. 2012, 2014).

The cockle *C. glaucum* lives in a wide range of salinity and thermal characteristics (Rygg, 1970). This makes *C. glaucum* an interesting subject for cultivation and/or reducing the environmental impact of organic loading in estuaries' systems (Trotta & Cordisco, 1998). Cockles have an important role in the nutrient cycle because they establish a connection between trophic levels - feeding on primary producers and being prey of several invertebrates and vertebrates (including humans). Accordingly, *C. glaucum* is important within the macrobenthos that contribute to regulating the benthic fauna ecosystem in its habitat (El-Shabrawy, 2001; Fishar, 2005). In southern Tunisia, cockles represent one of the dominant species of macrozoobenthos (Machreki-Ajmi *et al*., 2008; Derbali, 2011) and so are important for ecological functioning. Previous findings have shown that the cockle's abundance was highly variable according to location. In southern Tunisian waters, the highest mean density has been estimated as 270 inds.m^{-2} (Derbali *et al*., 2012, 2014). Several studies of *C. glaucum* were also undertaken from other Tunisian sites, e.g., Bougrara Lagoon (Derbali *et al*., 2009).

Previous surveys have highlighted the high divergence between cockle populations in southern Tunisian waters (Derbali, 2011), that could be related to the environmental and ecological conditions of the Gulf of Gabes. Such studies could be important for investigating the populations' dynamics as a result to their potential adaptations since several environmental characteristics (e.g., climate, temperature, salinity, wave action, available substrate, species composition, species interactions, and food sources) vary considerably.

Despite this species prevalence in the literature, no empirical work has rigorously investigated the cockles' dynamics in the south of Tunisia. The commercial importance of *C. glaucum* increases as a candidate species for Tunisian food, research on its population parameters will be of considerable necessity for future economic valorization and sustainable management of this resource in Tunisian waters. In this context and considering the absence of information on cockles' dynamics, the present study is the first attempt to estimate the population structure, growth, mortality, exploitation rates and recruitment pattern of *C. glaucum* populations in the Gulf of Gabes.

MATERIAL AND METHODS

Study area

Sampling sites are located in southern Tunisian waters. Both sites are wide tidal flats. Specimens were sampled from Site A (34°35′17″N, 10°37′00″E) and Site B (34°20′44″N, 10°12′40″E) chosen with respect to environmental conditions and cockle densities (Fig. 1). In the first sector, the substratum is mud and detrital organic matter with high cover of the marine seagrasses *Cymodocea nodosa* (Ascherson, 1870) and *Zostera noltei* (Hornemann, 1832). In contrast, the second sector is characterized by a muddy-sand substratum and the anthropogenic activities resulting from receiving runoff and discharge of pollutants from drainage water (Derbali, 2011).

Sampling and laboratory procedures

In the two sites, systematic surveys were carried out during one year from January to December 2017. Approximately 200 individuals were collected each month by quadrats (0.25 m^2) using a shovel (up to 1 m depth). The sediments were washed out carefully in situ through one mm mesh size sieve. Large specimens were collected by hand and the small were taken by the sieve. The materials retained by the sieve were kept in labeled containers filled with 7% formaldehyde-seawater solution. Seawater temperature and salinity were recorded at the same time as the cockle collections.

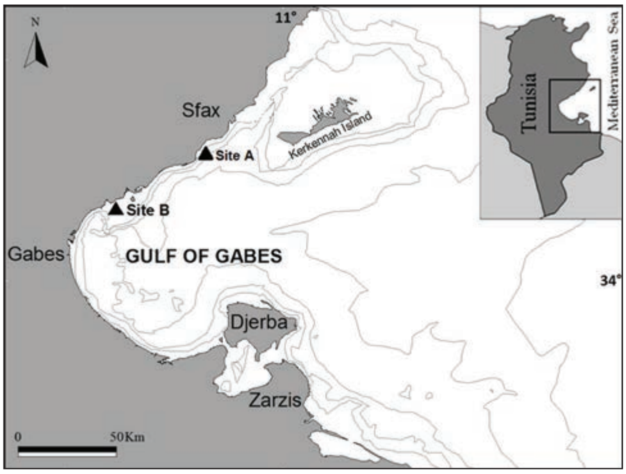

Fig. 1: Geographical position of sampling sites of** Cerastoderma glaucum **in the Gulf of Gabes (Tunisia).
Sl. 1: Geografski položaj vzorčevalnih postaj za nabiranje navadnih srčank v Gabeškem zalivu (Tunizija).

In the laboratory, shell length (maximum distance on the anterior-posterior axis, SL) of each cockle was measured to the nearest 0.1 mm using a digital caliper. Length measurements were used to produce length-frequency distribution for each sample collected from the two sites using class intervals of 1 mm size. Total fresh weights (TW) of adult cockles were measured using top-loading digital balance (precision of 0.0001 g).

Data analysis

Length-weight relationships

The relationship between total weight (TW) and anterior-posterior shell length (SL, mm) was described by the following allometric equation:

$$\log TW = \log a + b \log SL$$

where log *a* and *b* are intercept (initial growth coefficient) and slope (relative growth rate of variables) of the linear regression line, respectively. The deviation of the *b* value of the regression function from the isometric hypothetical value ($b = 3$) was analyzed by means of a Student's *t*-test. A significance deviation indicates a negative ($b < 3$) or positive ($b > 3$) allometric relationship. Statistical analyses were carried out using MINITAB software (version 13, 2000). Statistical significance was considered when $p < 0.05$.

Von Bertalanffy growth parameters

Length-frequency data were analyzed using the FiSAT II software as explained in detail by Gayanilo *et al*. (2005). The asymptotic shell length (L∞, mm) and the growth coefficient (K, yr^{1}) of the von Bertalanffy Growth Function (VBGF) were estimated from these data by means of ELEFAN-I (Electronic Length Frequency Analysis; Pauly & David, 1981; Pauly & Morgan, 1987). The VBGF is defined by the equation:

$$L_t = L_\infty [1 - e^{-K(t-t_0)}]$$

where L_t = mean length at age t, L_∞ = asymptotic shell length, K = growth coefficient, t = age, and t_0, the hypothetical age at which the length is zero (Pauly & David, 1981), here $t_0 = 0$.

L∞ and K were used to calculate the growth performance index Φ' (Pauly & Munro, 1984) using the equation:

$$\Phi` = \log(K) + 2\log(L\infty)$$

Growth performance indices are calculated to compare between our two sampling sites and with other populations of *C. glaucum*. The inverse von Bertalanffy growth equation was used to find the lengths of *C. glaucum* at various ages. The theoretical maximum age (T_{max}) was calculated for each population by solving for t in the von Bertalanffy equation by setting Lt = L∞, using the following equation constructed by Michaelson & Neves (1995):

$$T_{max} = \frac{\ln L_\infty + Kt_o}{K}$$

Mortality and exploitation rate

Total mortality (Z, yr^{1}) was estimated by length-converted catch curve method (Pauly, 1990). FiSAT calculates Z as well as the 95% confidence intervals surrounding Z based on the goodness-of-fit of the regression. Natural mortality rate (M, yr^{1}) was estimated using the empirical relationship of Pauly (1980):

$$\text{Log}_{10} M = -0.0066 - 0.279\,\text{Log}_{10} L\infty + 0.6543\,\text{Log}_{10} K + 0.4634\,\text{Log}_{10} T$$

where T = is the mean annual temperature (°C). Once Z and M were obtained, then fishing mortality (F, yr^{1}) was estimated using the relationship: F = Z – M. The exploitation rate (E) was obtained with the relationship proposed by Gulland (1971):

$$E = F/Z = F/(M+F)$$

Recruitment pattern

The routine in FiSAT reconstructs the recruitment pulses from a time series of length-frequency data to determine the number of pulses per year and the relative strength of each pulse, using the VBGF parameters (Moreau & Cuende, 1991). Normal distribution of the % of recruits was determined by NORMSEP (Pauly & Caddy, 1985) in FiSAT.

RESULTS

Shell length-weight relationships

Relationships between logarithmically transformed data of total weight (TW.) and shell length (SL, mm) of *C. glaucum* collected from site A and site B are shown in Table 1. In site A, isometric growth patterns were recorded for *C. glaucum*. On the other hand, slope values (*b*) significantly deviated from 3 ($p < 0.05$) indicating negative allometric growth patterns for *C. glaucum* at site B.

Population structure

Overall, 2256 and 2340 individuals of *C. glaucum* were measured and their population structure studied for site A and site B, respectively (Fig. 2). The shell length ranged between 6–31 and 10–35

Tab. 1: Regression parameters (log a and b) of shell length (SL, mm) and total weight (TW, g.) relationships of *Cerastoderma glaucum* ***collected from two sites in Tunisia. t: values of Student's t-test; p: level of significance from isometric value of the slope; r2: coefficient of determination; F: variance ratio; N: number of individuals; SD: standard deviation.***

Tab. 1: Regresijski parametri (log a in b) odnosa med dolžino lupine (totalna dolžina, mm) in maso (g) navadne srčanke iz dveh tunizijskih lokalitet. Legenda: T= vrednost Studentovega testa, p: interval zaupanja izometrične vrednosti naklona; r2: koeficient determinacije; F: delež variance; N: število primerkov; SD: standardna deviacija.

Length-Weight relationship									
Sites	**Log *a* ± S.D.**	***b* ± S.D.**	***t***	***p***	**r^2**	***F***	**SL range**	**TW range**	**N**
Site A	-3.34 ± 0.04	2.86 ± 0.03	4.66	$p > 0.05$	0.937	8189.46	12.0-31.4	0.55-9.532	550
Site B	-3.31 ± 0.05	2.48 ± 0.03	17.33	$p < 0.05$	0.929	7023.47	12.4-32.4	0.584-9.532	541

mm for the two sites, respectively. Two peaks were observed corresponding to individuals with 20 and 25 mm shell length in site A and with 20 and 26 mm shell length in site B. Large individuals (> 25 mm) represent 31 and 53% of total collected samples from site A and site B, respectively.

Growth and age

Estimated asymptotic length (L∞) and growth coefficient (K) of the von Bertalanffy Growth Function (VBGF) by ELEFAN-I were 32.55 mm and 0.48 yr^{-1} and 36.75 mm and 0.42 yr^{-1} for the cockles collected from site A and site B, respectively. Figure 3 showed length frequency distribution and the superimposed growth curves estimated by ELEFAN-I for *C. glaucum* from the two sites, respectively. Growth performance indices (Φ') were 2.71 and 2.75 in sites A and B, respectively (Tab. 2). Also, the theoretical maximum age (T_{max}) was higher in site B (T_{max} = 8.58 yr^{-1}) than in site A (T_{max} = 7.25 yr^{-1}).

Mortality and exploitation rate

Length-converted catch curve analysis produced total mortality (Z) for *C. glaucum* was 1.25 yr^{-1} (confidence interval; CI = -2.13 – 4.63) and 0.90 yr^{-1} (CI

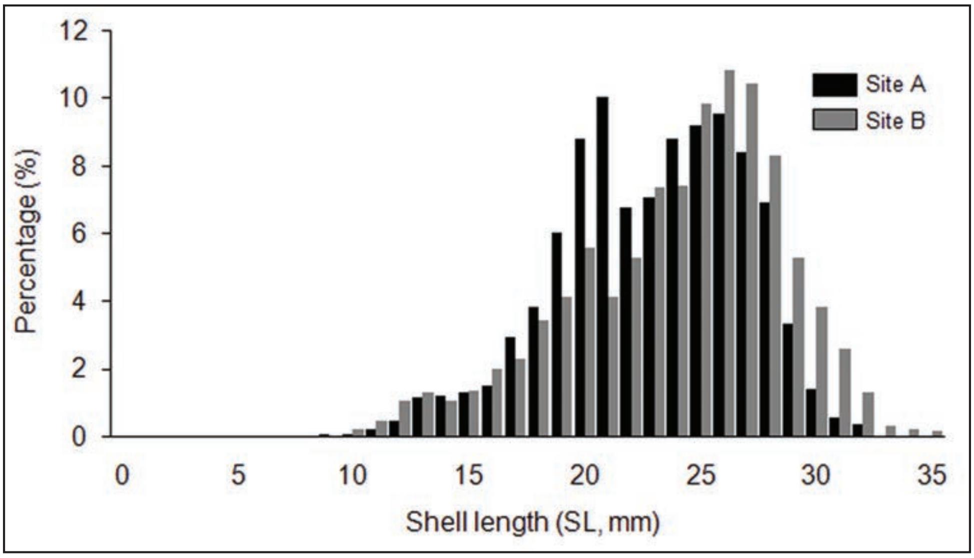

Fig. 2: Variations in the percentage occurrence of the different size classes of *Cerastoderma glaucum* ***collected from sites A and B throughout the study period.***

Sl. 2: Spremembe v deležu pojavljanja posameznih velikostnih razredov primerkov navadne srčanke, pobranih na lokalitetah A in B v obravnavanem obdobju.

Tab. 2: Population parameters of *Cerastoderma glaucum* ***in the south of Tunisia.***
Tab. 2: Populacijski parametri navadne srčanke iz juga Tunizije.

Population parameters	Site A	Site B
Asymptotic length ($L_{\infty,}$ mm)	32.55	36.75
Growth co-efficient (K) yr^{-1}	0.48	0.42
Growth performance index (Φ)	2.71	2.75
The theoretical maximum age (T_{max}) yr^{-1}	7.3	8.6
Natural mortality (M) yr^{-1}	0.90	0.81
Fishing mortality (F) yr^{-1}	0.35	0.09
Total mortality (Z) yr^{-1}	1.25	0.90
Exploitation rate (E)	0.28	0.10
Shell length (SL) range (mm)	6.5 – 31.60	10.00 – 35.00
Sample number (N)	2256	2340

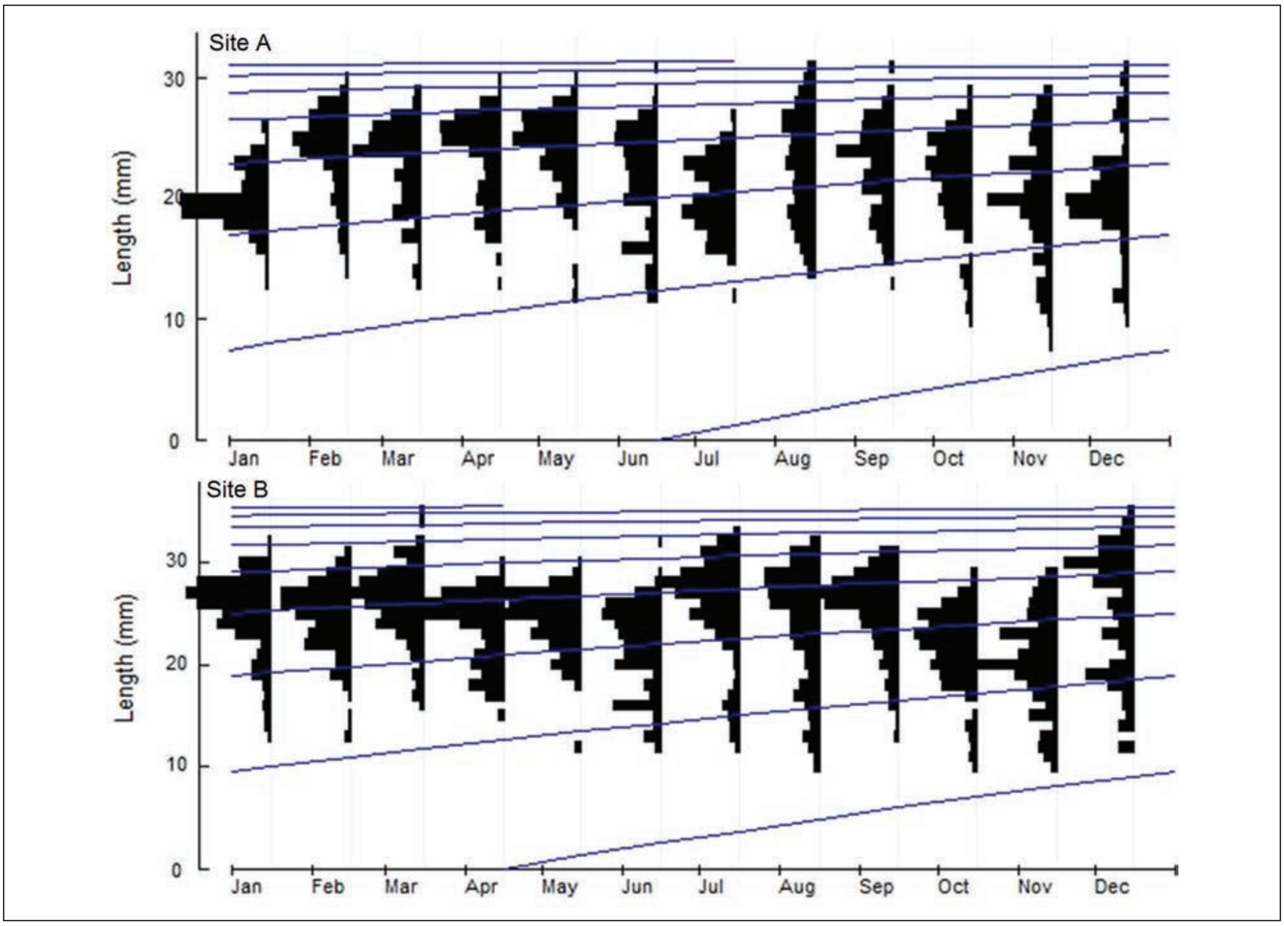

Fig. 3: Von Bertalanffy growth curves superimposed on length frequency histograms of *Cerastoderma glaucum* ***at site A (L∞ = 32.55 mm and K= 0.48 yr^{-1}) and site B (L∞ = 36.75 mm and K= 0.42 yr^{-1}) using ELEFAN 1.***
Sl. 3: Von Bertalanffijeve rastne krivulje in velikostni histogrami primerkov navadne srčanke na lokalitetah A (L∞ = 32.55 mm in K= 0.48 $leto^{-1}$) in B (L∞ = 36.75 mm in K= 0.42 $leto^{-1}$) z uporabo ELEFAN 1.

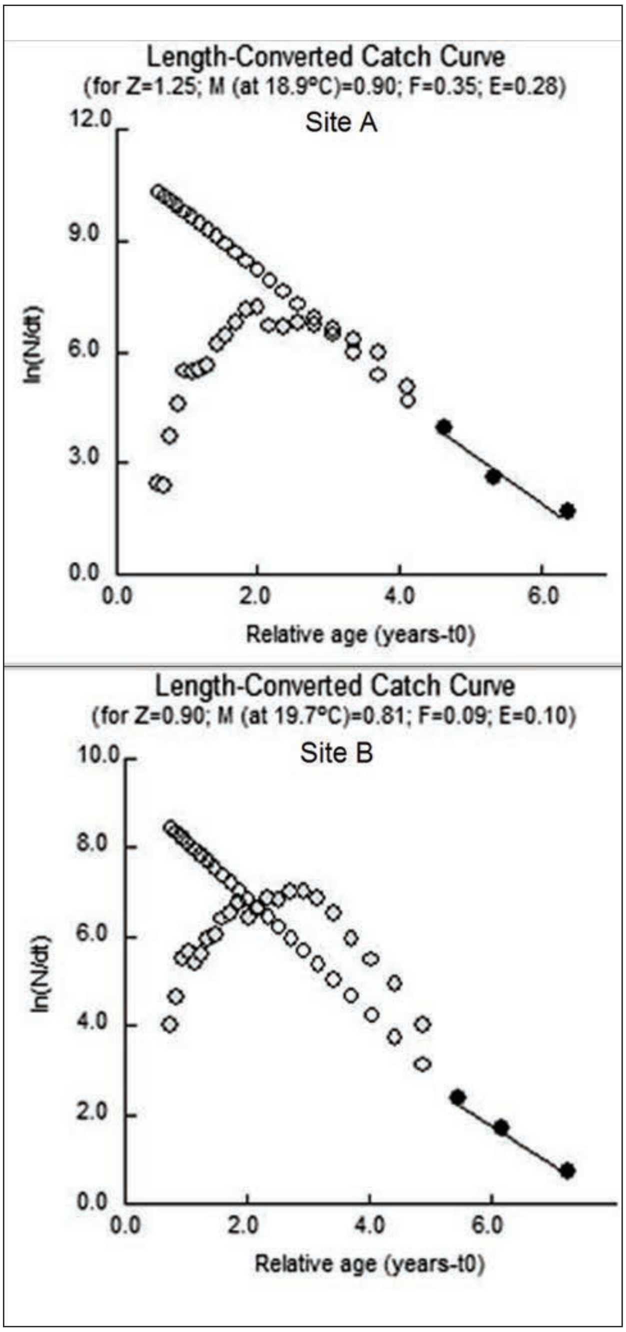

Fig. 4: Length converted catch curve of *Cerastoderma glaucum* **at sites A and B. Solid dots are those used in calculating the parameters of the straight line, the slope of which is an estimate of Z. Open dots represent cockles not used in mortality estimation.**

Sl. 4: Krivulja ulova navadne srčanke, preračunanega na dolžino, na lokacijah A in B. Polni krogci so tisti, ki so bili uporabljeni pri izračunu parametrov premice, katere naklon je ocenjena Z vrednost. Prazni krogci predstavljajo primerke, ki niso bili upoštevani v oceni smrtnosti.

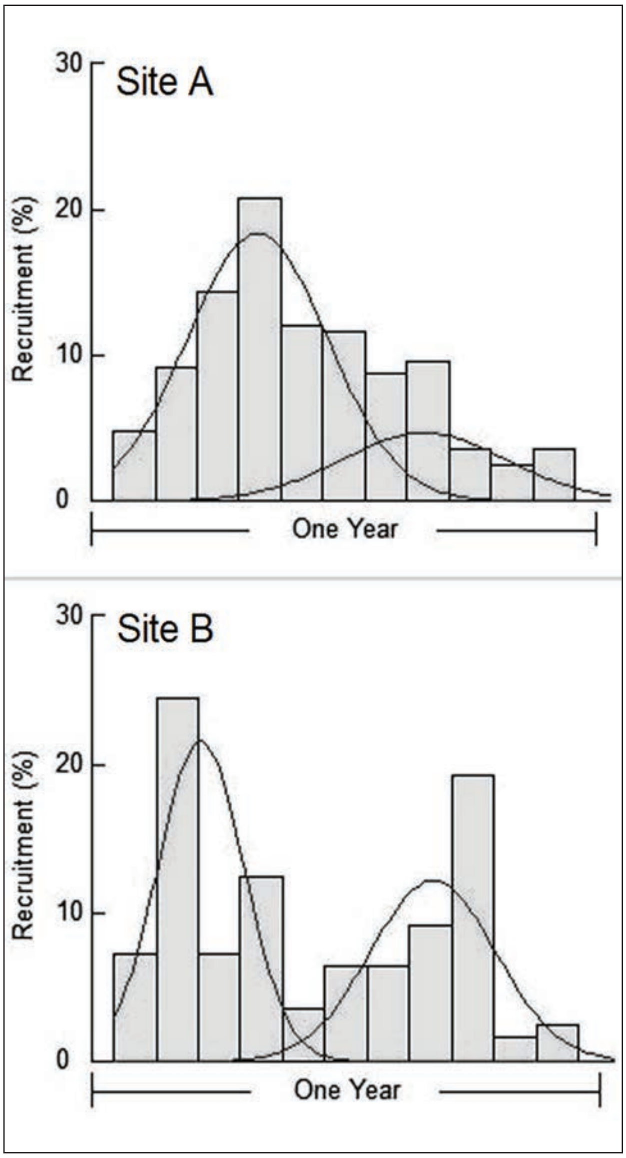

Fig. 5: Recruitment pattern of *Cerastoderma glaucum* **at sites A and B showing two major recruitment pulses within a year.**

Sl. 5: Rekrutacija primerkov navadne srčanke na lokalitetah A in B kaže dva letna viška.

= 0.80 – 1.00) for site A and site B, respectively. The catch curves used in the estimation of Z are represented in Figure 4 for the two sites, respectively. The darkened circles represent the points used in calculating Z through least square regression analysis. Estimated value of natural mortality (M) from Pauly's empirical formula is relatively higher (0.90 yr^{-1}) in site A than in site B (0.81 yr^{-1}). Fishing mortality (F) was estimated to be 0.35 and 0.09 yr^{-1} for the two sites, respectively. The rate of exploitation (E) was estimated at 0.28 for site A and 0.10 for site B (Tab. 2).

Tab. 3: Values of von Bertalanffy growth parameters (K and L∞) and growth performance indices (ϕ,) of** Cerastoderma glaucum **and its congeneric** Cerastoderma edule **in different localities. Legend: ϕ, = log K + 2 log L∞. *: Mean value for males and females.

Tab. 3: Vrednosti von Bertalanffijevih rastnih parametrov (K in L∞) in indeks uspešnosti rasti (ϕ,) navadne srčanke (**Cerastoderma glaucum**) in njene sorodnice, užitne srčanke (**Cerastoderma edule**) v različnih lokalitetah. Legenda: ϕ, = log K + 2 log L∞. *: Srednja vrednost za samce in samice.

Species	K yr $^{-1}$	L∞ (mm)	Φ`	Location	Source
C. glaucum	0.48	32.55	2.71	Gargour, Tunisia	Present study
C. glaucum	0.42	36.75	2.75	Akarit, Tunisia	Present study
C. glaucum	0.45	28.35	2.56	Lake Qarun, Fayoum Depression, Egypt	Kandeel *et al*. (2017)
C. glaucum	0.28	33.60	2.50	Lake Timsah, Suez Canal, Egypt	Kandeel *et al*. (2017)
C. glaucum	0.22* 0.26*	38.07* 39.31*	2.49 2.59	Lake Timsah, Suez Canal, Egypt	Mohammed *et al*. (2006)
C. edule	0.600	40.00	2.98	South Bull, Dublin Bay, Irish Sea	West *et al*. (1979)
C. edule	1.609	26.50	3.05	Rias Atlas, North Spain	Catoria *et al*. (1984)
C. edule	0.640	34.36	2.88	Bay of Saint-Brieuc, North coast of Britany	Ponsero *et al*. (2009)
C. edule	0.404	40.00	2.81	Wadden Sea, German	Ramon (2003)
C. edule	0.026	28.27	1.32	Mundaca estuary, north Spain	Iglesias & Navarro (1990)
C. edule	0.180	36.00	2.37	Algeciras Bay, South Spain	Guevara & Niell (1989)
C. edule	0.640	36.00	2.92	Banc d'Arguin, French	Magalhaes *et al*. (2016)
C. edule	1.300 1.330	31.00 38.00	3.10 3.30	Merja Zerga, Moroccan Atlantic Coast Arcachon Bay, French Atlantic Coast	Gam *et al*. (2010)

In both sites, the salinity remains almost stable throughout the year, i.e. 28–48 in site A and 36–48 in site B. Temperature of the seawater recorded in the whole study area showed an annual fluctuation between 11°C (winter) and 28°C (summer).

Recruitment patterns

Relative strength of recruitment pulses generated by FiSAT for *C. glaucum* among the two sites was continuous throughout the year with two major pulses in June and November. For site A, the relative strength of these pulses was 10.3 and 17.4 % recruitment, respectively. For site B, the relative strength of the pulses was 7.8 and 15.7 % recruitment, respectively. Also, a minor pulse (4.4 and 10.5 % recruitment; respectively) was recorded in August (Fig. 5).

DISCUSSION

The present study provided new information about the population structure, growth, mortality, and exploitation rates and recruitment pattern of cockles' populations at two different sites in southern Tunisian waters. The strong correlation between shell length and weight for *C. glaucum* in this study and in earlier studies (Leontarakis *et al.*, 2009; Derbali *et al.*, 2012; Kandeel *et al.*, 2017) is similar to that reported for other bivalves (Gaspar *et al.*, 2001; Zeinalipour *et al.*, 2015).

Previous surveys highlighted several estimations of the growth parameters for *C. glaucum* and its congeneric *C. edule* (Tab. 3). On comparison, our findings were not in agreement with those recorded from Egypt by Mohammed *et al.* (2006) and later by Kandeel *et al.* (2017). Saeedi *et al.* (2010) have suggested several key factors affecting growth at the local scale in bivalves inhabiting the northern Persian Gulf including individual's difference, climate, latitude, and longitude.

Asymptotic shell length (L∞) derived from site A population (32.55 mm) proved to be smaller compared to site B population (36.75 mm) due to the lack of bigger sizes. The negative correlation between asymptotic shell length (L∞) and growth coefficient (K) invalidates comparison based on individual parameters (Pauly & Munro, 1984). As a result, comparison of the growth performance of bivalve populations is better fitted by the growth index phi prime (Φ'). This criterion was used to characterize not only similar species (Pauly & Munro, 1984), but also related species as in the case of scallops (Del Norte, 1988). The value of (Φ') obtained in the present study (2.75) is consistent with those previously calculated for other studies (Table 3). Values ranged from 2.49 to 2.75 and from 1.32 to 3.05 for *C. glaucum* and *C. edule*, respectively.

Total mortality rate of *C. glaucum* population was significantly higher at site A ($Z = 1.25\ yr^{-1}$) than at site B ($Z = 0.90\ yr^{-1}$). Natural mortality ($M = 0.81\ yr^{-1}$) and total mortality ($Z = 0.90\ yr^{-1}$) of the cockles in site B have nearly the same value as there is no fishery in the study area (Gayanilo & Pauly, 1997). A similar observation was recorded for the same species in Lake Qarun, Egypt (Kandeel *et al.*, 2017) and for the clam *Barbatia trapezina (= Barbatia decussata)* (Lamarck, 1819) in the northern Persian Gulf, Iran (Zeinalipour *et al.*, 2014). Mortality of *C. glaucum* is generally natural and may occasionally be caused by anthropogenic activities (e.g., habitat modification and habitat degradation). Habitat degradation resulting from receiving runoff and discharge of pollutants from drainage water may be the major reason underlying the relatively high natural mortality ($0.81\ yr^{-1}$) for *C. glaucum* in site B. However, commercial harvesting of the venerids, *Ruditapes decussatus* (Linnaeus, 1758) causes disturbances and higher mortality for the cockle *C. glaucum* in site A. Thus, fishing mortality of *C. glaucum* in site A ($0.35\ yr^{-1}$) was much higher than that recorded in site B ($0.09\ yr^{-1}$). Earlier studies have shown that commercial harvesting can reduce the fitness of bivalves leading to their higher mortality. Robinson & Richardson, 1998 found that undersized *Ensis magnus* (Schumacher, 1817) (= *Ensis arcuatus*) individuals returned to the seabed were slow to re-bury, becoming highly vulnerable to predation by crabs.

Population dynamics of cockles are controlled also by abiotic factors such as salinity, temperature, immersion time, water velocity and sediment dynamics (Malham *et al.*, 2012). Salinity may be the main factor affecting macrobenthos abundance. Rygg (1970) tested the tolerance of *C. glaucum* in a range from 3 to 60 and found that this species lived in a wide range of salinities from 5 to 45. In the present study, we have found that cockles lived in a wide range of salinities between 28 and 48. Boyden (1972) stated that maximum age of the cockle *C. glaucum* is reduced within hypersaline environments. Therefore, salinity increase may interpret the high representation of large sizes (31% and 53%) in populations of site A and site B, respectively. Accordingly, the theoretical maximum age (T_{max}) was lower in site A ($7.3\ yr^{-1}$) than in site B ($8.6\ yr^{-1}$).

Reproduction of *C. glaucum* in the two sites occurred throughout the year (Derbali, 2011). Recruitment pattern was continuous during the study period and two major peaks were observed during June and November. Also, one minor peak was recorded in August. This pattern of recruitment is typical for tropical bivalves, which are fast-growing and short-lived species (Del Norte-Campos, 2004).

The cockle *C. glaucum* has a bi-phasic life cycle with a pelagic larva and a benthic postlarval stage which can also be pelagic before settling on the sediment and becoming benthic adults (Malham *et al.*, 2012). Reduction in cockle recruitment success by high predation rates and the presence of high densities of adult macrofauna led to recruitment failures (André & Rosenberg, 1991; Beukema & Dekker, 2005; Flach, 2003). Predation of larval cockles by adult cockles through larviphagy can lead to reductions of up to 40% of the population (Malham *et al.*, 2012). The same sequence of events has been reported for *C. edule* from Sweden (André *et al.*, 1993). Authors stated that survival of settling larvae decreased drastically with increasing adult density and reported that inhalation of settling larvae by populations of resident suspension feeders may cause a significant decrease in settlement on a larger scale.

The present paper is the first report on population structure, growth, mortality, and exploitation status of *C. glaucum* from southern Tunisian waters. This study will help to accurately monitor the population dynamics of cockles and introduce measures of appropriate fisheries management. The data may help to determine future quantitative changes indicating trends in Tunisian waters that are exposed to various factors of environmental conditions and human activities.

Further work is required to explore the association between spawning and recruitment for *C. glaucum* with environmental variables to accurately monitor its exploitation. The adoption and implementation of rules, such as limiting the size of cockles, will be required to protect this new exploitable fishery resource similar to *R. decussatus* natural populations.

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POPULACIJSKA DINAMIKA NAVADNE SRČANKE *CERASTODERMA GLAUCUM* (MOLLUSCA: BIVALVIA) V GABEŠKEM ZALIVU (TUNIZIJA)

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POVZETEK

*Navadna srčanka (*Cerastoderma glaucum*) je ena od najštevilčnejših školjk v južnih tunizijskih vodah. Status izkoriščanja in menedžment te vrste v ribištvu v Tuniziji postajata zaskrbljujoča. Ta študija je prvi poskus raziskovanja populacijske dinamike te vrste, upoštevaje strukturo populacije, rast, smrtnost in status izkoriščenosti dveh populacij. Srčanke so v enoletnem obdobju pobirali v Sfaxu (lokalitete A) in Gabesu (lokaliteta B). Da bi ocenili populacijske parametre za opredelitev staleža, so analizirali velikostno porazdelitev. Rekrutiranje, ki je bilo kontinuirano, je pokazalo dva glavna viška na obeh lokalitetah. Predstavljeni podatki so ključnega pomena za primeren menedžment navadne srčanke in njeno ohranitev.*

Ključne besede: *Cerastoderma glaucum*, populacijska dinamika, smrtnost, rekrutiranje, jug Tunizije

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TRACING DOLPHIN-FISHERY INTERACTION IN EARLY GREEK FISHERIES

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ABSTRACT

An exhaustive review of anecdotal references related to dolphin-fishery information in the Greek seas during the early phase of fishery development (1900-1975) was conducted. In that period fishers perceived dolphins as competitors and would intentionally kill them in retaliation for the loss that the dolphins caused by obstructing fishing operations and damaging fishing gear. This review highlights that dolphin-fishery interaction has been a major cause of concern to Greek fishers since the early 20th century, escalating with the way of life of modern society.

Key words: historical accounts, cetaceans, occurrence, historical ecology, marine environmental history

TRACCIA DELL'INTERAZIONE DELFINO-PESCATORE NELLE PRIME ATTIVITÀ DI PESCA GRECHE

SINTESI

È stata condotta una revisione esaustiva dei riferimenti aneddotici relativi alle informazioni sulla pesca dei delfini nei mari greci durante la prima fase dello sviluppo della pesca (1900-1975). In quel periodo i pescatori percepivano i delfini come concorrenti e li uccidevano intenzionalmente come ritorsione per le perdite che i delfini causavano ostacolando le operazioni di pesca e danneggiando gli attrezzi da pesca. Questa rassegna evidenzia come l'interazione tra delfini e pesca sia stata una delle principali cause di preoccupazione per i pescatori greci fin dall'inizio del XX secolo, intensificandosi con lo stile di vita della società moderna.

Parole chiave: testimonianze storiche, cetacei, occorrenza, ecologia storica, storia dell'ambiente marino

INTRODUCTION

Human-marine environmental interaction has occurred throughout history and the study of the dynamics of ecosystems and their biota needs to be temporarily broadened (Holm, 2022; Thurstan, 2022). The understanding gained and passed on from earlier periods, when human impact was limited (Moutopoulos & Stergiou, 2011), could serve as a useful knowledge repository in the efforts toward a re-evaluation of management thresholds (Zeller & Pauly, 2018). In this context, the body of historical and "forgotten" science combined with modern natural observations has increased significantly, particularly within the frameworks of marine historical ecology and marine environmental history (Fortibuoni *et al*., 2017a; Mazzoldi *et al*., 2019), and nowadays incorporates findings from a wide range of multidisciplinary scientific fields (e.g., Engelhard *et al*., 2016).

The Mediterranean Sea provides ample possibilities of interaction between human activities and the surrounding communities (Coll *et al*., 2010). In this context, dolphins represent important elements of historical and cultural heritage of marine ecosystems (e.g., Greek waters: Papadopoulos *et al*., 2002; Portugal: Brito & Vieira, 2010; Brito & Sousa, 2011). The importance of dolphins for the marine ecosystems is reflected in their very appellation, namely, the origin of the word dolphin is the ancient Greek word δελφίνι, meaning "womb", as the sea is the womb of all life on the planet. Although the number of historical dolphin-human interaction studies for Mediterranean waters has considerably increased over the past decades (for review see: STECF, 2019) and corresponding data are easily found for the western Mediterranean (e.g., Brito & Vieira, 2010; Brito & Sousa, 2011; Sousa & Brito, 2011), such information is generally lacking for the eastern part of the basin.

The present study aims to evaluate dolphin-human interaction in Greek waters during the early phase of fishery development (1900-1975). The data collection method has been harmonised with the European Commission for Marine Knowledge 2020 and the information incorporated into the European Marine Observation and Data Network (EMODnet).

MATERIAL AND METHODS

Greek fisheries officially started to organise in 1911, and by the mid-1970s, they had passed from an essentially pre-industrial stage to the industrialisation of fishing activities (Moutopoulos & Stergiou, 2012). An exhaustive search of traditional and digital libraries (i.e., newspapers, technical reports, and books) related to dolphins was conducted using the keyword "dolphins" for retrieving issues on dolphin-human interactions in the Greek seas during the early phase of fishery development (1900-1975). The following Athenian and regional journals were found in the National Library of Greece (http://efimeris.nlg.gr/ns/main.html?fbclid=IwAR0n__4AKJQ-ci7BFEwxCxZmu-90qQRZhlGhyMSmmcpkvB9gThXn-wQmwi8E): Eleftheria (1944-1967), Empros (1896-1969), Macedonia (1911-1981), Rizospastis (1917-1983), Scrip (1893-1963), Acropolis (1883-1884), and Tachydromos of Egypt (1958-1977). For the journals published on the island of Crete and in the Dodecanese, old archives were found in an online database (http://vikelaia-epapers.heraklion.gr/%CE%B5%CF%86%CE%B7%CE%BC%CE%B5%CF%81%CE%AF%CE%B4%CE%B5%CF%82/). Duplicate records of the same report published in different journals were excluded.

RESULTS

Overall, 28 historical records on dolphin-fishery interactions and dolphin occurrences were retrieved from the 1900—1975 period (Tab. 1). Records were more frequent for the Aegean Sea and mostly focused on conflicts between dolphins and fisheries, rather than on natural history reports. The first record (1906) of the presence of dolphins in the Greek seas refers to a shipwreck incident in Messinia, in which seamen were rescued by dolphins (Fig. 1) (Anonymous 1906). Later on, during the interwar period (1920-1940), dolphin conflicts with fisheries were increasingly reported (Tsakakis, 1950) creating the impression that "dolphins are enemies of the fishers" (Tsakakis, 1950). The first post-World War II reference describes nets destroyed by dolphins in the Chalkida area (Yakoumis, 1948). The fishers' appeals to the competent authorities continued throughout the 1950s, describing damaged nets, calling for action against dolphins in cooperation with competent bodies and ichthyologists (Anonymous, 1953a, 1954c), asking for compensation for damaged nets, requesting permission to hunt dolphins with firearms (Tsakakis, 1950), and claiming monetary rewards for killed dolphins (Anonymous, 1959a).

During the 1950s, dolphins were described as "the plague of the Greek seas" (Anonymous, 1952) (Fig. 2). The spatial extent of this conflict encompassed the Kavala and Thessaloniki Bays, Limnos, Mytilene, and Chalkida in the northern and central Aegean. In 1951, a petition for the granting of the right to use weapons against dolphins was signed by professional fishers from all around Greece and sent to the Directorate of Fisheries (Anonymous, 1952). The same trend continued in the following decades with reports of damaged nets (Anonymous, 1952), calls for culling, compensation claims for damaged fishing gear, tips for "fighting" dolphins (Anonymous, 1975a), and demands for effective dolphin tracking measures (Anonymous, 1970). In 1975, trawlers and purse seiners from the Kavala port (Thracian sea) demanded that the government allocate 500,000 Greek drachmas (an amount equivalent to € 7,000 today) for extermination of dolphins by professional shooters (Anonymous, 1975a). However, during the 1970s the first signs of a changing human attitude towards dolphins appeared in local periodic magazines, describing dolphins as "the intellectuals of the seabed" (Katiforis, 1970).

Tab. 1: References on dolphin-fishery interaction in the Greek seas during the 1900–1975 period.
Tab. 1: Reference o interakciji med delfini in ribištvom v grških morjih v obdobju 1900–1975.

Year	Area	Details	Reference
1906	South Ionian (Messinia)	Ship-wreckers were rescued by dolphins.	Anonymous (1906)
1948	Evvoikos Gulf (Chalkis)	Nets destruction by dolphins. The Chalkis Coastal Fishers' Association has made an official request to the Ministry for allowing the use of harpoons in order to hunt and kill dolphins.	Anonymous (1948)
1951	Greek Seas	Nets destruction by dolphins. in the Greek seas, according to letters provided from fishers all throughout Greece. Fishers asked the Custom Port Authorities for permission to kill dolphins using guns.	Anonymous (1951)
1952	North Aegean (Kavala)	Appeals from fishers to the Ministry authorities for effective dolphin prosecution. A memorandum was signed from the Fisher's Association in Kavala port. Dolphins were responsible for net destruction and fish catch losses. Dolphins are referred to as "beasts". Fishers applied for a gun license allowing killing dolphins.	Anonymous (1952)
1953	North and Central Aegean (Kavala, Lesvos and Chios Islands)	Request by the professional fishers for the use of guns for the repelling of dolphins.	Anonymous (1953a)
	Greek Seas	At the first professional fishers' workshop, fishers reported that the cost of losses due to dolphin attacks were equal to 10 fishing days each month..	Anonymous (1953b)
1954	Thracian Sea (Kavala)	A request has been made to the Governor of Thrace by an editor of the Kavala newspaper "Proini" to take action to prosecute dolphins in collaboration with competent ichthyologists.	Anonymous (1954c)
	North Aegean (Kavala)	Fishers' memorandum to the Governor of Thrace, citing dolphin-caused fishing gear destruction. Fisher's associations request funding for the replacement of damaged nets. A request for the repelling of dolphins has been also made.	Anonymous (1954d)
	Eastern Aegean (Limnos)	Reports on net damages and loss of the catches. Report about ineffective use of hunting weapons on dolphins.	
	Greek Seas	Claims from fishers to the Directorate of Fisheries for an official allowance of the use of fire gun for the repulsion of dolphins.	Anonymous (1954b)
	Greek Seas	The Ministry of Industry is considering the introduction of awards for professional fishers who will catch dolphins. According to the available data, the damage to the purse seiners is the most serious.	Anonymous (1954a)
1956	North Aegean (Kavala, Thessaloniki)	Nets damages caused by dolphins. A craft with guns was reported for pre-war employment in the Thermaikos Gulf for killing dolphins, whereas the use of this method was outlawed in 1956. Fishers proposed measures to kill dolphins by using explosive capsules. Proposal for the exploitation of the dead dolphins (skin, fat).	Tsakakis (1956)
1958	Pagassitikos Gulf (Volos)	Reports were made for dolphins' attack on the fishing gears.	Anonymous (1958)
1959	Thracian Sea (Kavala)	A compensatory measure was proposed by the Fisher Association of Kavala to the Ministry of Industry by a payout of 200 drachmas (current value of 55 €) per dead dolphin.	Anonymous (1959c)
	Inner Ionian Archipelagos (Astakos)	Two dolphins bycaught by a nylon fishing net.	Anonymous (1959b)
	Greek Seas	Fishers proposal to the Ministry of Marine for the persecution of dolphins by using firearms.	Anonymous (1959a)
	Eastern Aegean (Lesvos Island)	Fishers claim that purse seine catches were reduced due to dolphins.	Anonymous (1959d)
1960	Thracian Sea (Kavala)	Nets damages caused by dolphins. The vessels of the Port Authority were pursuing dolphins. Request for persecution of the dolphins.	Anonymous (1960)
1961	Amvrakikos Gulf (Ionian Sea)	According to a local newspaper 3,000 dolphins devastating the Amvrakikos Gulf.	Gonzalvo *et al.* (2015)
1962	Thracian Sea (Kavala)	From July to September 1961, the hiring of Turkish crews for hunting dolphins has resulted from a 15% to 20% increase in fish catches, as well as the avoidance of expenses of 800,000 drachmas (current value of 210,000 €) for repairing fishing gear. A grant of 250,000 drachmas (approximately 66,000 €) was requested to re-establish three hunting teams to kill dolphins during the 1962 fishing season.	Anonymous (1962)
	Saronikos Gulf (Athens)	Rescue of an injured dolphin in July 1962.	Katiforis (1970)
1963	North Aegean, Central Aegean (Kavala, Volos, Lesvos Island)	Net losses have been reported, similar to those caused by the olive fruit fly and downy mildew. Dolphins were considered as "beasts of the seas". The Fisheries Directorate has been requested to coordinate dolphin hunts and allocate fundings for this purpose.	Anonymous (1963)
1965	Saronikos Gulf (Athens)	Schooling dolphins can be seen.	Anonymous (1965)
1966	Patraikos Gulf (Ionian Sea)	A grant of 600 drachmas (current value of 1.76 €) have been petitioned to subsidize the pursuit of dolphins by fishers.	Anonymous (1966)
1970	Greek Seas	The request for effective dolphin hunting was one of the outcomes of the 8th Pan-Hellenic Conference of Fishers (March 1970).	Anonymous (1970)
1975	Thracian Sea (Kavala)	The owners of trawl and purse seine vessels have petitioned the government for 500,000 drachmas (current value of 70,000 €) to subsidize the pursuit of dolphins by shooters.	Anonymous (1975a)
1975	Thracian Sea (Kavala)	Fisher's association from Kavala issued a memorandum on dolphin killing and extinction (December 23, 1975). The Custom Port Authorities and the Navy have asked the Ministries of Agriculture and Merchant Marine to prosecute dolphins by hiring special shooters. There have been reports of extensive gear damages as well as a loss of catch. Dolphins have been compared to "sea wolves".	Anonymous (1975b)
1945-1970	Thermaikos Gulf (Thessaloniki)	Dolphins attacked on purse seine nets. Fishers change their fishing tactics in response to the dolphins' net destruction.	Fragoudi (2010)

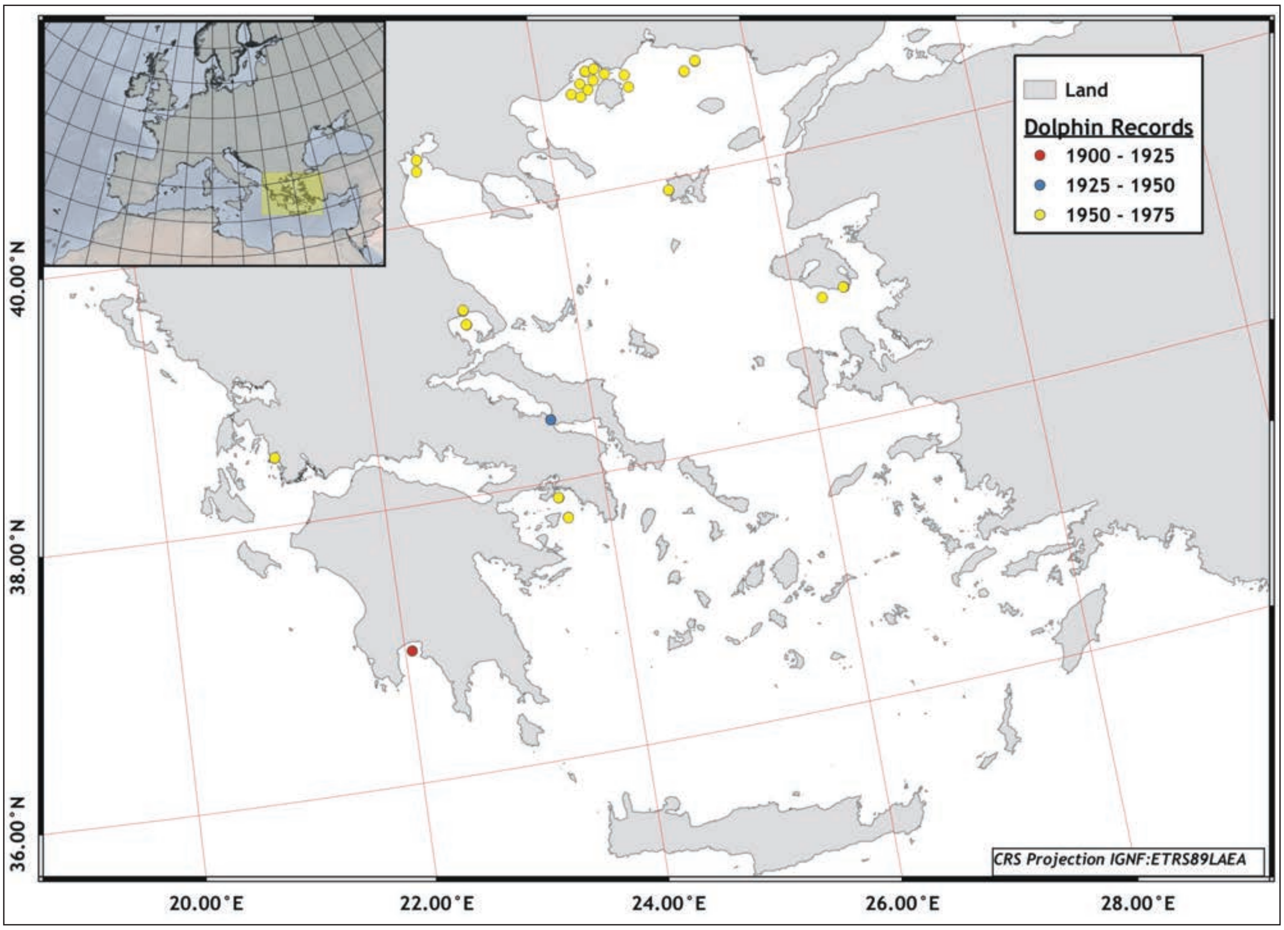

Fig. 1: References on sightings and strandings indicating the presence of dolphins during the early period of Greek fishery development (references for historic data up to 1975 presented in Tab. 1).
Sl. 1: Reference o opažanjih in primerih nasedlih delfinov, ki kažejo na njihovo prisotnost v zgodnjem obdobju razvoja grškega ribištva (reference za zgodovinske podatke do leta 1975 so predstavljene v Tabeli 1).

DISCUSSION

Greek waters have always been a key habitat for coastal dolphin populations (Frantzis, 2007; Crowley, 2010). After the official organisation of the fishery sector (1911) (Moutopoulos & Stergiou, 2011) the dolphin-human interaction in Greek Seas increased, especially in the wake of fishing gear depredation, catch and income losses, a pattern that was present throughout the Mediterranean and beyond (STECF, 2019). This negative development in the human-dolphin relations, which emerged in Greece later than in other regions of the world (Brito *et al.*, 2016), shaped new attitudes and resulted in the characterisation of dolphins as "beasts" (Anonymous, 1952) and "sea wolves" (Anonymous, 1975b). Ten years after the end of World War II, Greek fishers proposed using explosive capsules to kill dolphins (Tsakakis, 1950) and for almost two decades the extinction and deliberate killing of dolphins was one of the main activities of Greek fisheries (Anonymous, 1975b). Dolphin hunting and killing were legal (Fragoudi, 2010), and anyone killing a dolphin was entitled to compensation from the port authorities for each individual killed (Bearzi *et al.*, 2003, 2004; Fragoudi, 2010). This highly conflictive period extending into the mid-1970s coincided with the reported decline of the species that started in the late 1960s (Bearzi *et al.*, 2021). However, as it is indicated in our review, all reports of dolphin-fishery interaction were gathered in enclosed gulfs adjacent to large ports and cities on the mainland, and on large islands (Fig. 1). This is because during the first mid-1900s most Greek fisheries were characterised by poorly equipped fishing vessels, which limited the spatial and temporal extent of their operations (Moutopoulos & Stergiou, 2011). This likely had a strong impact on local populations of dolphins living in continental shelf waters, particularly on common and bottlenose dolphins, as the total biomass otherwise removed by fisheries in such areas may exceed that predated by dolphins (Bearzi *et al.*, 2009).

Fig. 2: Articles published in the fisheries magazines during the 1950s and 1960s on the topic of dolphin-fishery interaction: Main article title "Dolphins, plague of the Greek seas" (top), images of killed dolphins (bottom).
Sl. 2: Članki, objavljeni v ribiških revijah v petdesetih in šestdesetih letih prejšnjega stoletja na temo interakcije med delfini in ribištvom: Naslov glavnega članka »Delfini, kuga grških morij« (zgoraj), slike ubitih delfinov (spodaj).

At the time of ancient Greece, dolphins were considered fishers' friends, an incarnation of gods helping them herd fish schools towards their fishing gear, and indicators of fish abundance (Fragoudi, 2010). However, with the modernisation and spatiotemporal expansion of Greek fisheries, strong competition gradually developed, not only with dolphins but with marine mammals in general, (Vergitsi & Trova, 1997). In more recent times, unsustainable fishing and habitat degradation have contributed to dramatic ecological changes in the Mediterranean Sea (Fortibuoni *et al*. 2017b) and also in Greece (Tsikliras *et al*., 2021), exacerbating the perception that dolphins reduce fishery yields (Reeves *et al*., 2001), which was also present among Greek fishers during the 1950s and 1960s (Table 1).

The protection of dolphins - which is supported by a variety of legal provisions, both national and European, such as for instance the Habitats Directive, which is related to the conservation of habitat types and of habitats of species (Council Directive 92/43/EEC) - cannot solely rely on legislative measures, both because of the long time the relevant laws take to be enacted and/or ratified and because of the far too common lack of law enforcement, which often translates as non-compliance on the part of the stakeholders (e.g., fishers). Formal commitments to protect the dolphin population conflict with geopolitical complexity and socio-economic benefits, and a generally weak political will results in inaction (Bearzi *et al*., 2016). Although nowadays the dolphin-human interaction is still a critical topic, information on the presence, distribution and status of dolphin populations is spatially limited. The present study provides valuable data for implementing marine strategy policies, such as the Common Fisheries Policy of the European Union and the EU Marine Strategy Framework Directive (2008/56/EC).

CONCLUSIONS

Historical anecdotal data can improve our understanding of past system dynamics and rising concerns about long-term human impact on the ecosystem (Brito & Vieira, 2016; Thurstan, 2022). These sources of historical information can also help us curb the phenomenon of shifting environmental baselines described by Pauly (1995), who noted that each generation subconsciously views as "natural" the way the environment appeared in their youth. The present study showed that some attitudes and behaviours that were once acceptable and even presented by the media as commendable, are nowadays illegal and socially unacceptable. Historical science may play an important role in comprehending present-day effects and conditions (Brito & Vieira, 2010). Historical accounts of cetaceans may also be extremely useful in adding new data to the occurrence and distribution of marine mammals in poorly studied areas, many of which are distributed along the coasts of eastern and southern Mediterranean (Brito & Vieira, 2010).

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SLEDENJE INTERAKCIJ MED DELFINI IN RIBIČI V ZGODNJIH GRŠKIH RIBIŠKIH DEJAVNOSTIH

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POVZETEK

Avtorji so izvedli izčrpen pregled anekdotičnih sklicevanj v zvezi z informacijami o ribolovu na delfine v grških morjih v prvi fazi razvoja ribištva (1900-1975). Takrat so ribiči delfine dojemali kot tekmece in jih namenoma ubijali zaradi izgub, ki so jih delfini povzročili z oviranjem ribolova in poškodovanjem ribiškega orodja. Ta pregled poudarja, kako je bila interakcija med delfini in ribištvom glavni vzrok za zaskrbljenost grških ribičev od začetka 20. stoletja, ki se je stopnjevala z življenjskim slogom sodobne družbe.

Ključne besede: zgodovinski pregled, kiti, pojavljanje, historična ekologija, zgodovina morskega okolja

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NOVI NAJDIŠČI PLEISTOCENSKE FAVNE POD KRAŠKIM ROBOM. SMO KONČNO NAŠLI TUDI JAMO *GROTTA DELL'ORSO?*

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IZVLEČEK

V prispevku predstavljamo dve novi najdišči pleistocenske favne na Kraškem robu. V Podrti jami pred Zazidom sta bili odkriti ena fosilizirana kost planinskega orla in ena fosilizirana kost taksonomsko ožje neopredeljivega medveda. V prekopanem sedimentu pod Previsom s spodmolom v Luskanici pri Podpeči, kjer so pred več kot sto leti uredili gredice za zeljne sadike, pa so bili najdeni fosilni ostanki jamskega medveda. Z analizo objav in podatkov, ki so bili na voljo, smo ugotovili, da bi bila lahko tako imenovana Grotta dell'Orso*, iz katere fosilne kosti jamskega medveda hrani Pokrajinski muzej v Kopru, prav Previs s spodmolom v Luskanici.*

Ključne besede: Podrta jama, Previs s spodmolom v Luskanici, *Grotta dell'Orso*, Jama pri železniškem useku, Jama v Kovšci, pleistocenska favna

NUOVI SITI DI FAUNA PLEISTOCENICA NELL'AREA DEL CIGLIONE CARSICO. ABBIAMO FINALMENTE INDIVIDUATO ANCHE LA GROTTA DELL'ORSO?

SINTESI

Nel seguente contributo vengono presentati due nuovi siti con resti di fauna pleistocenica nell'area del Ciglione carsico. Nella grotta Podrta jama, in prossimità di Zazid, sono state rinvenute due ossa fossili: la prima appartenente all'aquila reale e la seconda a un orso non identificabile dal punto di vista tassonomico. Dall'area antistante il riparo "Previs s spodmolom v Luskanici" presso Podpeč, utilizzato più di un secolo fa per la coltivazione delle piantine di cavolo, sono state trovate nel terreno rimaneggiato ossa fossili di orso delle caverne. Dall'analisi delle pubblicazioni esistenti e di altri dati disponibili, gli autori deducono che il "Previs s spodmolom v Luskanici" corrisponde alla Grotta dell'Orso*, dalla quale provengono i resti fossili dell'orso delle caverne custoditi nel Museo provinciale di Capodistria.*

Parole chiave: grotta Podrta jama, Previs s spodmolom v Luskanici, *Grotta dell'Orso*, Grotta presso il raccordo ferroviario, Grotta a Kovšca, fauna pleistocenica

UVOD

Kraški rob je geološka, geomorfološka in tudi klimatska meja med Krasom ter flišno pokrajino Istre, ki jo zaznamujejo značilne navpične apnenčaste stene. Te se raztezajo v obliki posameznih lusk iz italijanske strani preko doline Glinščice, vse do Učke nad Reko na Hrvaškem. Na ozemlju Slovenije je Kraški rob sestavljen iz 47 kamnitih sten oziroma lusk, ki skupno predstavljajo približno 51 km skalnih sten (Placer, 2007). Množica večinoma vodoravnih jam in spodmolov (previsov) ob vznožjih apnenčastih sten (pogosto na spodnjem stiku s flišem) je že dolgo poznana po arheološki in/ali paleontološki vsebini. Ostanke živalstva (večinoma ledenodobnega) za zdaj poznamo iz dvanajstih lokacij: Sveta jama pri Socerbu, kat. št. 1157 (Leben, 1978; Riedel, 2002), Kamnolom v Črnotičah (Bosak *et al.*, 1999; Mihevc, 2001; Jamnik *et al.*, 2013), zasuta brezna na zgornji in srednji terasi črnokalskega kamnoloma (Pohar & Pavlovec, 1997; Pohar & Kralj, 2002; Jamnik *et al.*, 2013; Križnar & Preisinger, 2017; Križnar, 2019), s sedimenti zapolnjena Jama v kamnolomu nad Črnim Kalom, kat. št. 1578 (Brodar, 1958; Rakovec, 1958, 1973; Pohar & Pavlovec, 1997; Pohar & Kralj, 2002; Jamnik *et al.*, 2013; Križnar, 2019; Toškan, 2019), jama Č2 – Jama pod Škorjašco, kat. št. 5404 (Turk, 1982), Ladrica, kat. št. 3754 (Dirjec *et al.*, 1992; Bernardini *et al.*, 2014), Globoka jama, kat. št. 3753 (Jamnik & Blažina, 2019), Jama velikih podkovnjakov ali Bobalova jama, kat. št. 3752 (Pavšič & Turk, 1989; Turk in Saksida, 1990; Dirjec *et al.*, 1992; Toškan, 2019; Križnar *et al.*, 2021; Križnar, 2021), Ločka jama (Müller, 1914; Lepori, 1937; Brodar, 1960–1961; Rakovec, 1973; Jamnik & Blažina, 2019), jama Brežec 3, kat. št. 5415 (Dirjec, 2001), Globoška peč (Toškan, 2019; Jamnik *et al.*, 2020) in Partizanska jama, kat. št. 4771 (Jamnik *et al.*, 2015; Toškan, 2019).

Vznožja kamnitih sten oziroma lusk so le delno preiskana. Že več let, predvsem v zimskem in zgodnjem pomladanskem času, ko je zaradi manj bujne vegetacije dostop do skalnih sten nekoliko lažji, v okviru rednega evidentiranja najdišč fosilov in neformalnega projekta *Dokumentiranje najdišč jamskega medveda v Sloveniji*, ki ga v Prirodoslovnem muzeju Slovenije izvaja Kustodiat za geologijo, pregledujemo skalne stopnje. S sistematičnim pregledovanjem širšega območja Kraškega roba evidentiramo še neodkrite jame ali ostanke nekdanjih jamskih sistemov in v njih morebitne ostanke pleistocenske favne in flore.

REZULTATI IN DISKUSIJA

Podrta jama nad izravnavo »Pred Senico« ob Zazidu

V letu 2014 smo opravljali preglede skalnih lusk od vznožja Goliča nad zaselkom Rakitovec v smeri severozahodno proti zaselku Zazid in naprej proti Podpeči. Kraški rob na tem območju sestavlja več skalnih stopenj, najmanj pet daljših in nekaj vmesnih, krajših. Ena takih krajših skalnih stopenj, dolgih le približno 500 metrov, se dviguje nad ožjo izravnavo, poimenovano Pred Senico, po kateri je speljana cestna povezava med Zazidom in Podpečjo. V skalni stopnji je registrirana tudi Z3 – Jama pred Senico, kat. št. 7162, ki je poznana kot arheološko najdišče (Turk, 2004: 17–18).

Le 95 metrov severneje od vhoda v jamo Z3 je ob vznožju skalne stene mogoče prepoznati ostanek nekdanje večje jame. Od nje je ostalo le nekaj metrov rova, ki danes tvori približno 10 metrov visok previs, ob katerem je vzporedno s skalno steno ohranjen še 8 metrov dolg ozek rov, ki se iz stene odpre v obliki do 2 metrov širokega okna.

V previsu so lepo vidni ostanki kapniških tvorb, na stenah nekdanjega jamskega rova pa trije nivoji starih zapolnitev jame s sedimenti, ki so bili med speleogenezo denudirani (Sl. 1a, 1b). Menimo, da so sledi procesov zasipanja in odstranjevanja sedimentov starejši od podora jame, po katerem je od nekdanje večje jame do danes ostal previs. Med najvišjim in srednjim nivojem nekdanje zapolnitve je ob severni jamski steni del starega sedimenta ohranjen v obliki breče. Danes so sedimenti pod previsom ohranjeni le še v dolžini približno 8 metrov, kolikor je od kapa previsa do zadnje stene.

Pod previsom se takoj za kapom pobočje strmo prevesi navzdol, po strmem pobočju pa ležijo veliki skalni bloki, ki pričajo o zadnjem, najmlajšem podoru jame. Skalni bloki so še razmeroma ostrorobi, zato domnevamo, da zadnji podor, ki se je zgodil, ne more biti zelo star. Morda se je zgodil že v holocenu. Na ne povsem preraslem strmem pobočju pod previsom, ki ga erodira tudi občasen pretok meteorne vode, je lepo videti, da se že manj kot en meter pod ohranjenim sedimentom v previsu pojavi fliš, ki ga lahko sledimo vse do naravne izravnave »Pred Senico«, po kateri je speljana lokalna cesta v Zazid. Prehod med tlemi previsa in pobočjem pred jamo z ostanki podora je oster. Da bi ugotovili, ali je sediment na današnjih tleh previsa ostanek nekdanjega jamskega sedimenta ali pa gre morda že za holocenske nanose, ki so se pod previsom odložili po podoru jame, smo oster prehod med sedimentom in pobočjem očistili v širini 0,60 m (Sl. 1b). V globini 0,50 m se je pojavil skalni blok, ki je preprečil globlje čiščenje profila. Večje globine avtohtonih jamskih sedimentov niti ni mogoče pričakovati, saj se že pol metra nižje v pobočju pokaže flišni sediment. Globina ohranjenega gruščnato-ilovnato-meljastega sedimenta na današnjih tleh previsa ne presega globine 1 metra. V očiščenem profilu je mogoče prepoznati dve različni plasti. V prvih 0,10 do 0,15 m je na današnjih tleh previsa sipka, popolnoma suha ilovnato humusna plast, v kateri so le redki manjši koščki grušča. Plast označujemo z oznako »A«. Na globini 0,10 do 0,15 m je med plastmi ostra meja. Navzdol do globine 0,50 m je odložen značilen avtohtoni jamski, ilovnato gruščnat sediment z vključki kosov odpadle sige in manjših kosov od stropa odpadlih kosov kamenja. Sediment je zelo zbit in na nekaterih mestih že delno sprijet v brečo (Sl. 2). Plast označujemo kot plast »B«.

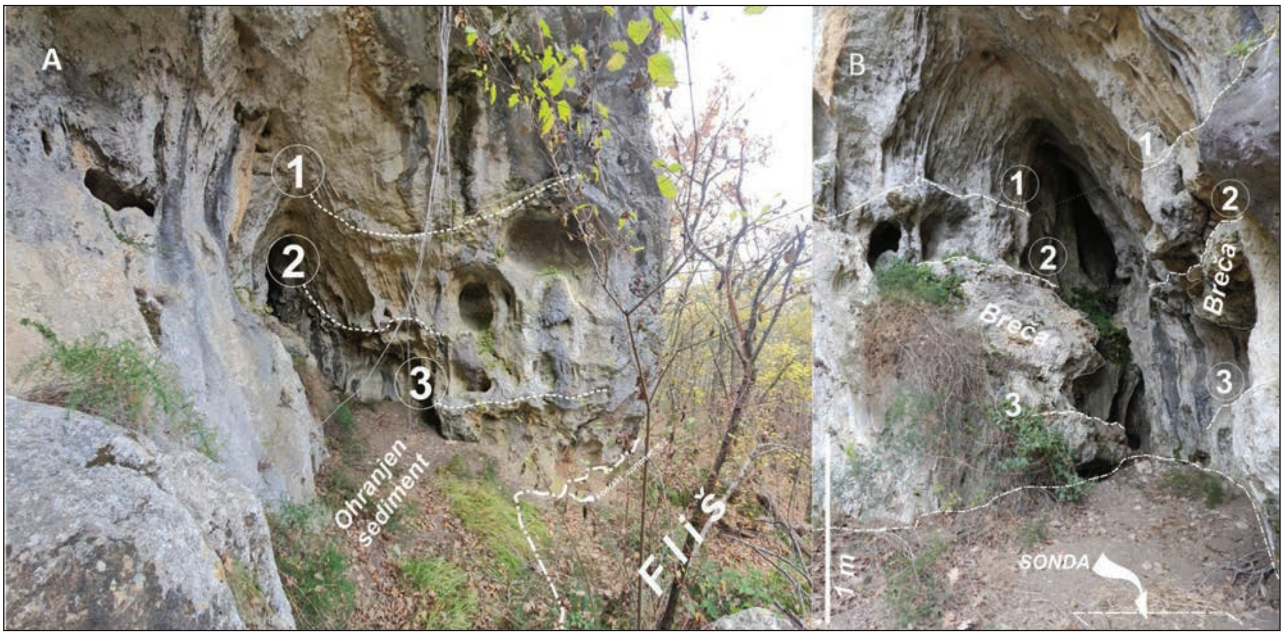
V tej plasti sta bili na globini 0,30 m najdeni dve povsem fosilizirani kosti in štirje majhni nedoločljivi kostni fragmenti. Taksonomsko je bilo mogoče določiti le dve kosti. Najbolje ohranjena je prva prstnica (Sl. 3), ki jo pripisujemo planinskemu orlu (*Aquila chrysaetos*). Ohranjena fosilizirana kost dimenzijsko ustreza manjšim osebkom planinskega orla. Ker gre za odrasel primerek, bi ga lahko pripisali samcu. Drugi fosilni kostni ostanek, ki je slabše ohranjen, je druga ali tretja dlančnica (Mc 2 ali Mc 3) neke zveri. Glede na dimenzijo in nekatere delno ohranjene sklepne površine bi lahko pripadal manjšemu jamskemu oziroma manjši vrsti jamskega medveda (*Ursus spelaeus s. l.*). Kateri vrsti medveda (*Ursus spelaeus*, *U. ingresuss*, *U. ladinicus* ali *U. eremus*) je pripadal, na podlagi najdene, slabo ohranjene dlančnice ne moremo natančno določiti. Mogoče pa je, da kost pripada celo rjavemu medvedu (*Ursus arctos*). Za štiri manjše, le nekaj milimetrov velike kostne fragmente ni mogoče določiti niti tega, ali pripadajo sesalcem ali pticam.

Trenutno zbrana fosilna favna iz Podrte jame pred Zazidom ne omogoča natančne določitve starosti. Prav dosti si ne moremo pomagati niti s stratigrafijo odloženih sedimentov. Glede na stopnjo fosilnosti in strukturo plasti »B« lahko rečemo le, da kostni ostanki nedvomno spadajo v pleistocen. Planinski orel je bil v Sloveniji odkrit le še v pleistocenskih (poznoglacialnih) plasteh Lukenjske jame pri Novem mestu (Pohar, 1983). Vrsta pa se pojavlja tudi vzdolž vzhodne Jadranske obale na nekaterih pleistocenskih najdiščih (Šandalja I in II, Kopačina) (Mauch Lenardić *et al.*, 2018).

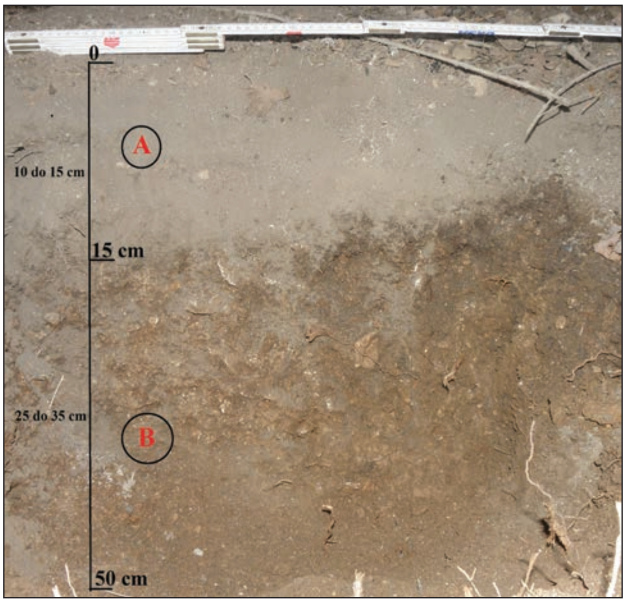
Previs s spodmolom v Luskanici

Pred leti so na pobočju Luskanice, nekaj sto metrov vzhodno od Podpeči, tik nad makadamsko cesto, ki se vzpenja proti Brežcu, posekali večje borovce, ki so pred tem zastirali pogled na skalno stopnjo Kraškega roba. Med opazovanjem sten Kraškega roba iznad Smokvice pri Gračišču smo opazili pod skalno steno večji previs (Sl. 4), pred katerim so bile vidne suhozidne terase. Ker na tem območju ni registrirane nobene jame, smo marca 2022 opravili ogled previsa.

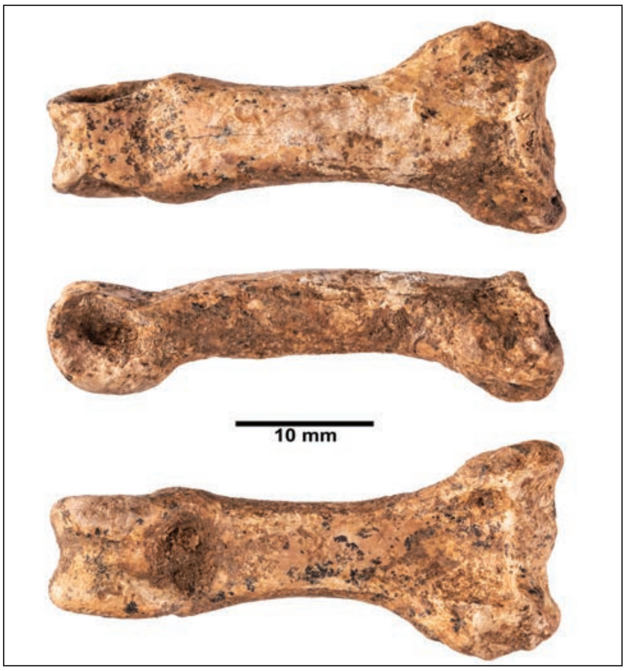
Iz pobočja pod previsom do vznožja skalne stene je narejenih pet nivojev suhozidnih teras. Najvišja in tudi najširša terasa je narejena prav pod kapom previsa, ki se na dnu skalne stene



Sl. 1: A, B: Pogled vzhodno in jugovzhodno proti previsu Podrte jame z označenimi nivoji starih sedimentnih zapolnitev, ohranjenim sedimentom in nivojem fliša pod previsom (foto: P. Jamnik).
Fig. 1: A, B: A view of the overhang toward east and southeast. Podrta jama with marked levels of old sedimentary fillings, preserved sediment and flysch level below the overhang (photo: P. Jamnik).



Sl. 2: Profil ostanka sedimenta v Podrti jami. A – sipka ilovnato humusna plast, B – ilovnato gruščnat jamski sediment (foto: P. Jamnik).
Fig. 2: A sediment residue profile in Podrta jama. A – loose loamy humus layer, B – clayey, gritty cave sediment (photo: P. Jamnik).



Sl. 3: Fosilizirani ostanek drugega členka prvega prsta planinskega orla iz Podrte jame** (Aquila chrysaetos) **(foto: M. Křižnar).
Fig. 3: Fossilised remnant of the second joint of the first finger of a mountain eagle from Podrta jama** (Aquila chrysaetos) **(photo: M. Křižnar).

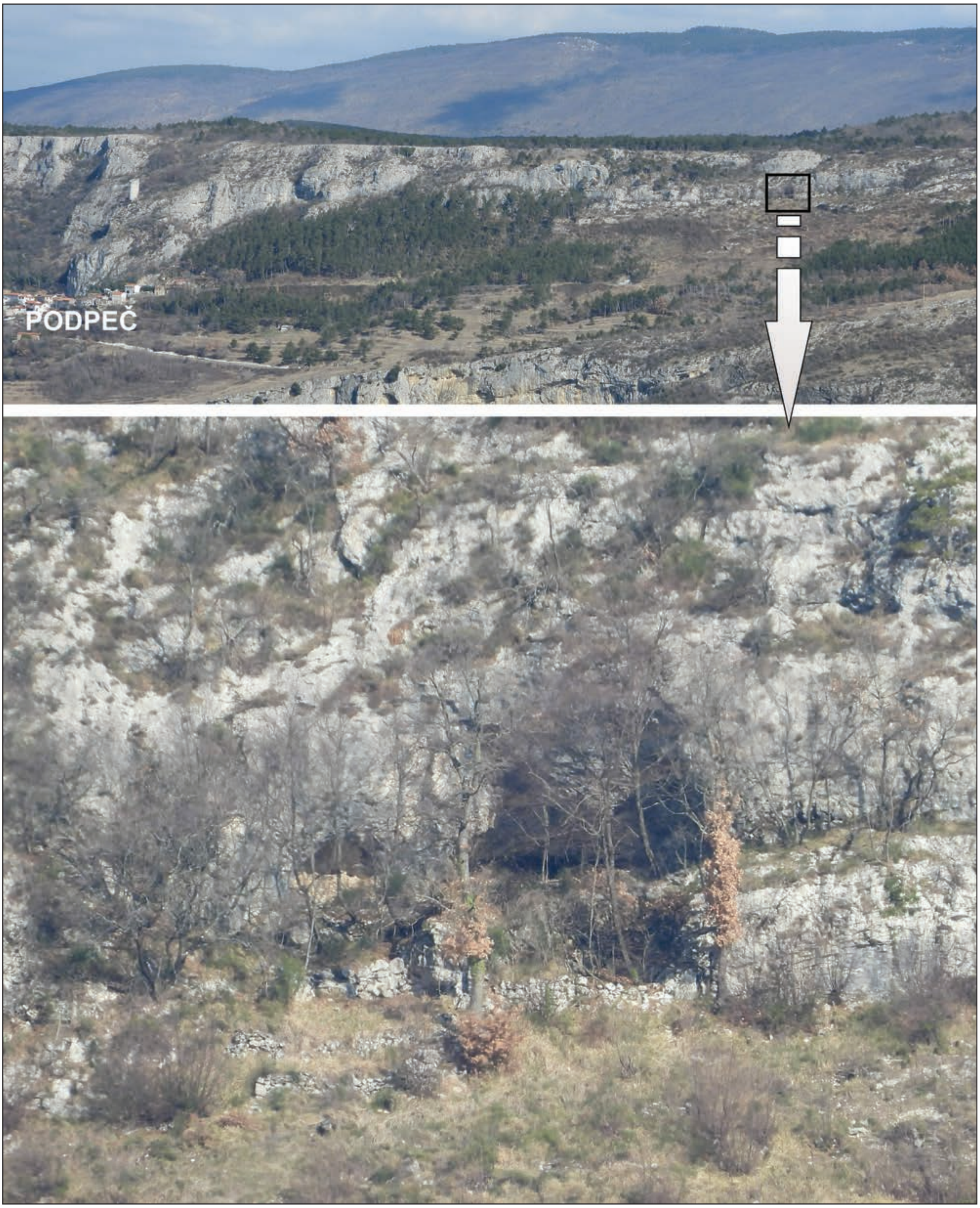
uviha v manjši spodmol. Od kapa previsa do konca manjšega spodmola je 14 m. Previs pod steno je širok približno 17 m, spodmol pa 9 m. Vhod v spodmol je visok 1 m, vendar se takoj za vhodom jamski prostor dvigne do 2,5 m, in potem spet zniža ter združi z jamskimi tlemi spodmola. Spodmol je torej le manjša kamrica za večjim previsom (Sl. 5). Tla spodmola so pokrita z od stropa odpadlimi kosi kamnov, takoj pod njimi pa je videti jamski, gruščnato ilovnat sediment.

Terase pred previsom so zaradi dobre osončenosti in zavetrne lege ljudem služile kot gredice za zeljne sadike, ki so jih pozneje presadili na njive nad skalno stopnjo, saj v okolici Podpeči zaradi strmine ni bilo možnosti za njive. Zeljne sadike so pod previsom vzgajali še nekaj let po drugi svetovni vojni, pozneje pa so bile terase opuščene. Domačin Lado Primožič se še spominja, kako je njegova mati morala vodo za zalivanje sadik pod previs nositi iz vasi Podpeč. Za previs oziroma spodmol domačini niso nikoli imeli posebnega imena. Primožič pravi, da so za poimenovanje teras z gredicami, ki so bile tudi levo in desno od previsa, vedno uporabljali le ime *»Pod luskan'co«*. Ker imena za jamski objekt ni, smo ga mi poimenovali *»Previs s spodmolom v Luskanici«*.

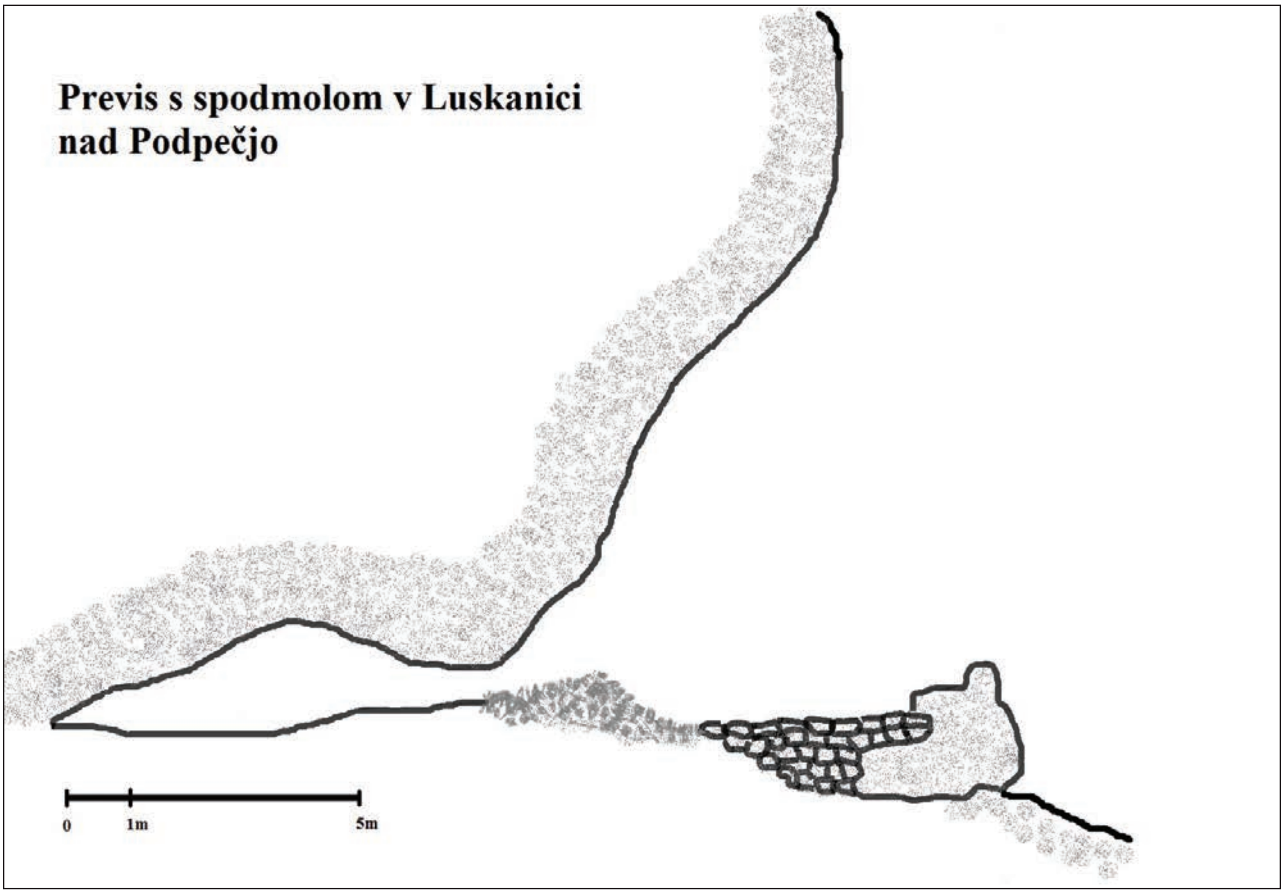
Tik pod kapom previsa je po celotni širini odložen material, ki je bil pred previsom odkopan ob izdelavi zadnje, najvišje terase dimenzij 10 m x 6 m (Sl. 6a in 6b). Ob tem je nastala približno meter visoka stopnja oziroma nasip (Sl. 6b in Sl. 7).

Dež, ki je občasno zajel tudi nastali nasip, je njegov vrhnji del že precej izpral. Zato je na prvi pogled na nasipu videti le grušč, pri natančnem pregledu pa je jasno, da gre za tipičen groboklastičen jamski sediment. Ta se je odlagal pred previsom, še v času, ko je bilo pod skalno steno več jamskega prostora. Na robovih previsa, kjer je bil sediment pred odkopavanjem za izdelavo terase izpostavljen večji vlagi, se je ob skalni steni že sprijel v brečo. Zdaj so tam ostale le manjše zaplate breče, ki je ob izdelavi terase niso odkopali. V njej smo opazili sprijete fosilne kosti (Slika 8), kar nas je spodbudilo, da smo natančneje pregledali tudi gruščnato gradivo nasipa.

Fosilne kosti smo našli tudi v nasipu. Vse pripadajo jamskemu medvedu (*Ursus* ex gr. *spelaeus*). Cele so ohranjene le nekatere dlančnice in stopalnice, vse drugo je fragmentirano. Na fragmentih kosti, ki smo jih našli, je videti, da je bila večina kosti verjetno poškodovana in razlomljena (fragmentirana) že v sedimentu, preden so ga odkopali. Po odložitvi na nasip je na kosteh, zaradi dolgotrajne izpostavljenosti vremenskim pogojem, prišlo še do podolžnega pokanja kostnih fragmentov. Tudi pri



Sl. 4: Pogled na stene Kraškega roba nad Podpečjo in na Previs s spodmolom v Luskanici ter suhozidne terase pod njim (foto: P. Jamnik).
Fig. 4: View of the rock walls of the Karst Edge above Podpeč and Previs s spodmolom v Luskanici and the dry-stone wall terraces below it (photo: P. Jamnik).



Sl. 5: Prerez Previsa s spodmolom v Luskanici (risba: P. Jamnik).
Fig. 5: Cross section of the Previs s spodmolom v Luskanici (drawing: P. Jamnik).

treh najdenih podočnikih je ohranjena le korenina, pa še v teh primerih so podolžno prepokane. Na nasipu smo skupno pobrali 41 kosti in zob. Poleg omenjenih treh podočnikov smo pobrali še 12 celih ali fragmentiranih dlančnic in stopalnic, eno vretence, večji fragment dolge kosti ter 24 manjših fragmentov anatomsko nedoločenih kosti.

Sediment pod previsom za umetno narejenim nasipom, ki se nadaljuje proti spodmolu, je še nedotaknjen. Prav tako ni videti, da bi bil kdaj prekopan sediment v spodmolu. Skoraj ni dvoma, da so fosilni ostanki tudi v tej še neprekopani plasti pred spodmolom in v njem. Menimo, da obstaja možnost, da se je na koncu spodmola z naravnim odlaganjem sedimenta celo zaprlo nadaljevanje spodmola v jamo. Na to nas napeljuje predvsem razmeroma velika količina fosilnih kosti na mestu pred previsom, saj to pomeni, da je bil spodmol mesto, kjer so jamski medvedi skozi tisočletja hibernirali. Današnji videz previsa in spodmola ne vzbuja občutka, da bi bil to najprimernejši prostor za hibernacijo (o izbiri mest za hibernacijo rjavega medveda in poskusu primerjave z načinom odzivanja na okolje glej Huber & Gužvica, 2011). Ker so bile kosti v jamskem sedimentu, ki so ga izkopali za izravnavo terase, že zunaj podkapa previsa, to pomeni, da se je bil previs s podori že zmanjšal oziroma pomaknil nazaj. Na take podore nakazuje tudi nekaj velikih skalnih blokov pod previsom, okoli katerih so zdaj narejene stopnje terasastih izravnav.

Dne 19. maja 2022 smo, arheologinji Maša Saccara in Špela Prunk iz Pokrajinskega muzeja v Kopru, arheolog Jaka Bizjak iz Zavoda za varstvo kulturne dediščine, območna enota Piran, speleolog France Malečkar in prvopodpisani avtor opravili skupni ogled Previsa s spodmolom v Luskanici. Tudi tokrat kljub natančnemu pregledu vkopa in nasipa nismo našli niti fragmenta lončenine ali ostanka, ki bi kazal, da je najdišče fosilnih kosti tudi arheološko najdišče. Kljub temu pa, glede na primernost previsa s spodmolom za zavetje, obstaja kar upoštevanja vredna možnost, da bi se morda na tem najdišču fosilnih kosti odkrili tudi ostanki človekove prisotnosti v času pleistocena. Žal te domneve brez vsaj manjšega testnega vkopa v še neprekopane sedimente ne bo mogoče preveriti.

Sl. 6: A) Pogled proti jugu na vhod v spodmol Previsa s spodmolom v Luskanici in umetno izravnano teraso pred kapom previsa. Pred vhodom v spodmol na prvoten sediment nametan na terasi odkopan material. B) Pogled na nastalo stopnjo pred vhodom v spodmol proti zahodu (foto: P. Jamnik).
Fig. 6: A) A view to the south of the entrance to the rock shelter Previs s spodmolom v Luskanici and the artificially levelled terrace in front of the overhang dripstone. In front of the entrance to the rock shelter on the original sediment imposed on the terrace excavated material. B) View of the resulting stage in front of the entrance to the rock shelter to the west (photo: P. Jamnik).

Je previs s spodmolom v Luskanici v resnici predvojna »*Grotta dell'orso*«?

V Pokrajinskem muzeju Koper je v stalni arheološki zbirki na ogled nekaj fragmentov lobanjskih kosti in sestavljena leva šapa jamskega medveda (Sl. 9). Kosti naj bi iz podatka v vitrini izvirale iz *Grotte dell'Orso* oziroma Medvedove jame pri Črnem Kalu.

Prvi, ki je to jamo omenil v literaturi, je bil leta 1977 italijanski avtor Benedetto Lonza. Že v tej prvi objavi pa se pojavijo nejasnosti glede imena in lokacije jame. *Grotto dell'Orso* je omenil na straneh 28, 71, 73 in 88 kot jamo *»di Popecchio«*, torej pri Podpeči. O njej je na strani 28 zapisal, da je to primer istrskega najdišča zunaj ožjega območja gradišč. Na strani 71 je jamo navedel v seznamu najdišč, kjer so našli trinožne krožnike, na strani 73 je omenjena v

Sl. 7: Višina stopnje med prvotnimi jamskimi tlemi pred Previsom s spodmolom v Luskanici in izravnavo za teraso pred previsom (foto: P. Jamnik).
Fig. 7: The height of the level between the original cave floor before the Previs s spodmolom v Luskanici and the levelling for the terrace before the overhang (photo: P. Jamnik).

seznamu najdišč, kjer so našli keramična rešeta za peči, na strani 88 pa je zapisal, da so v jami odkrili keramiko kaštelirskega tipa. Vse te najdbe naj bi bile shranjene v koprskem muzeju (Lonza, 1977). Vmes pa je na strani 80 uporabil drugo lokacijo jame, in sicer *Grotta dell'Orso di Cernikalle*. Zapisal je, da je risbo in podatek o nogi keramične posode in njenem verjetnem najdišču v *Grotta dell'Orso di Cernikalle* dobil iz koprskega muzeja. Lonza je takoj za navedbo lokacije v oklepaju zapisal: »*... a vemo, da je v tej jami v predvojnem obdobju raziskoval F. Stradi*«. V nadaljevanju pa je podvomil, da je posoda pripisana pravemu najdišču (Lonza, 1977).

Iz zapisanega je mogoče razumeti, kot da je Lonza imel neko informacijo o raziskovanju *Grotte dell'Orso*, ki naj bi ga v predvojnem času opravil F. Stradi. Na žalost pa ni navedel ničesar natančnejšega. Prav tako Lonza v omembah *Grotte dell'Orso* ne omenja kakršnih koli fosilnih kostnih ostankov.

Po izselitvi predvojnih upravljavcev koprskega muzeja v Italijo se podatki o lokacijah nekaterih arheoloških najdišč niso ohranili. Italijani so ob odhodu s seboj odnesli tudi dokumentacijo o arheoloških raziskavah in nekaj inventarnih knjig. Med najdišči, za katera točnejših podatkov v muzeju danes ni, je tudi jamsko najdišče *Grotta dell'Orso*. Kljub temu pa je za ugotavljanje, za katero jamo gre, zelo pomembno vsaj to, kar piše na škatlah s predmeti, ki so ohranjeni v Pokrajinskem muzeju Koper.

Fosilne kosti jamskega medveda iz škatle številka 195 in zobje jamskega medveda iz škatle številka 197 naj bi bili iz *Grotte dell'Orso di Popecchio*. V škatli številka 193 z oznako Orso pa je lončenina. V opombah je zabeleženo »*Orso, Pečina pod Steno, Grotta dell'Gallerie, Botače pri Borštu*«. Jasno je, da gre za dve različni jamski lokaciji. Kostne najdbe so iz »*Grotte dell'Orso di Popecchio*«, lončenina pa iz »*Orso, Pečina pod Steno, Grotta dell'Gallerie, Botače pri Borštu*«. Zakaj je pri imenu jame *Pečina pod Steno, Grotta dell'Gallerie* kot prvo ime navedeno »*Orso*« ni jasno. Pečina pod steno se v literaturi namreč ni omenjala kot jama Orso. Najbližja jama z

Sl. 8: Fosilne kosti v ostanku breče ob stranski steni Previsa s spodmolom v Luskanici (foto: P. Jamnik).
Fig. 8: Fossil bones in the remnant of the breccia along the sidewall of the Previs s spodmolom v Luskanici (photo: P. Jamnik).

imenom »*Grotta dell'Orso*« z italijansko katastrsko številko 7 VG je nad Gabrovico na italijanski strani in je dobro poznano paleontološko in arheološko najdišče. Domnevamo, da je prav pripis imena »Orso«, k imenu »*Grotta dell'Gallerie, Botače pri Borštu*« zavedel in povzročil razumevanje, kot da najdbe iz obeh škatel izvirajo iz ene jame. To je imelo verjetno tudi za posledico, da so bili Lonzu posredovani podatki o lončenini iz Grotta delle Gallerie / Pečina pod steno, z napačnim podatkom, da izvira iz jame Grotta dell'Orso di Cernikalle.

Grotta delle Gallerie / Pečina pod steno (VG 420, cat. reg. 290) je arheološko znana jama že vse od leta 1890. V skupno 104 metre dolgem jamskem sistemu je bilo od vseh jam na območju Glinščice opravljenih največ raziskav. Prva izkopavanja je izvedel že Marchesetti leta 1890, pozneje pa so v jami kopali še Battaglia, Cossiansich & Neumann v letih 1914 in 1923, Stradi v letu 1938/39, Cannarella & Valles v letu 1954/55, skupina Gruppo Speleologico San Giusto leta 1959 in raziskovalci iz institucije Centro Studi Carsici leta 1975 (Leben, 1967; Flego & Župančič, 1991). Gradivo je shranjeno v različnih muzejskih zbirkah. V plasteh so kot najstarejši elementi zastopane najdbe zgodnjega, mlajšega in poznega neolitika. Večina najdb pa pripada bronasti dobi, prisotne so tudi najdbe iz železne dobe. V vrhnjih plasteh je prisotna antična lončevina (Leben, 1967; Flego & Župančič, 1991; Gilli & Montagnari Kokelj, 1993; Jamnik *et al.*, 2018 in tam navedena literatura). Tu je pomemben podatek, da je v jami kopal tudi Stradi, kar pomeni, da je verjetno takrat vsaj nekaj najdb prišlo v Koprski muzej.

Podatki o različnem izvoru lončenih in kostnih najdb v koprskem muzeju so bili iz neznanega razloga spregledani. Kmalu po Lonzovi objavi je tudi arheolog Pokrajinskega muzeja v Kopru Matej Župančič začel na območju Kraškega roba iskati jamo, v kateri sta prisotna tako lončenina kot tudi kostni ostanki jamskega medveda.

Leta 1980 je Župančič izvedel arheološko sondiranje v Jami pri železniškem useku, ki jo je v katastru Jamarske zveze Slovenije leta 1979 pod številko 3735 regis-

Sl. 9: V Pokrajinskem muzeju Koper razstavljene kosti šape jamskega medveda iz tako imenovane Grotte dell'Orso (foto: P. Jamnik).
Fig. 9: Exhibited bones of the cave bear paws in the Provincial Museum of Koper from the so-called Grotta dell'Orso (photo: P. Jamnik).

triral speleolog F. Malečkar (Malečkar, 1979). V objavi rezultatov leta 1982 je za Jamo pri železniškem useku Župančič uporabil novo ime, in sicer Jernejeva jama. Kot se spominja F. Malečkar, je jamo na novo poimenoval v času izkopavanja, po svojem takrat rojenem sinu. V objavi je navedel stratigrafske podatke o odkopanih plasteh (»*1. zemlja, pomešana s kamenjem in amfornimi fragmenti antične in recentne keramike do 40 cm gl.; 2. do 40 cm db. sterilna plast rdeče oker ilovice in nato flišna rahla plast, prerita z rovi, napolnjenimi s črno rahlo zemljo.*«). Prav tako je zapisal: »*Med obema vojnama so v jami večkrat kopali; PM Koper hrani iz nje prazgodovinsko keramiko in bodalo. Po spominu arheologa amaterja Manila Peracce iz Milj je to tako imenovana 'Grotta d'Orso'*« (Župančič, 1982: 214). Izgleda, da je Župančič verjel, da so arheološke in paleontološke najdbe v koprskem muzeju, na katerih so oznake najdišča *Grotta dell'Orso di Popecchio* in *Orso*, iz iste jame, zato je ocenil, da je to pravzaprav Jama pri železniškem useku. Kot dodaten argument, da gre res za isto jamo, pa je navedel še mnenje amaterskega arheologa Peracce.

Župančič je pri svojem delu sodeloval s speleologom Francetom Malečkarjem iz jamarskega društva Dimnice. Leta 1982, torej že po Župančičevem izkopavanju v Jami pri železniškem useku, je Malečkar v kataster oddal dopolnilni zapisnik k Jegliški jami (kat. št. 2401), v katerem je zapisal, da »*arheološka izkopavanja M. Župančiča iz Pokrajinskega muzeja v Kopru kažejo, da je Jama pri (nad) Loki ali Grotta dell'Orso, arheološka jama, verjetno Jama pri Železniškem useku, kat. št. 3735 in bi kazalo njuni katastrski številki zamenjati*« (Malečkar, 1982).

Leta 1985 pa je Malečkar ob pregledovanju predvojnega italijanskega jamskega katastra ugotovil, da ta njegova domneva ne drži. Jama, ki jo Italijani v svojem katastru vodijo pod kat. št. 2218 VG kot Grotta di Loka / Jama Stajelska, jama, je v slovenskem jamskem katastru vpisana pod imenom Jegliška jama (kat. št. 2401) in ne Jama pri železniškem useku (kat. št. 3735), kot je domneval tri leta prej. Pri Jegliški ali Grotta di Loka / Stajelski jami gre torej za jamo, ki ima v italijanskem katastru številko 2218, v slovenskem pa 2401. Prvotna Malečkarjeva navedba možnosti, da naj bi bila morda Jama pri železniškem useku italijanska Grotta di Loka / Stajelska jama, je torej odpadla. Ni pa v italijanskem katastru ob načrtu Grotte di Loka / Stajelska jama nikjer omembe imena Grotta dell'Orso.

Zakaj je Malečkar torej leta 1982, ob prvi domnevi o istovetnosti Jame pri železniškem useku z Grotto di Loka / Stajelsko jamo, k njima sploh dodajal še ime Grotta dell'Orso? Župančič je Malečkarju ob začetku iskanje Grotte dell'Orso zagotovo posredoval tudi podatek, da naj bi bila

Grotta dell'Orso jama z arheološkimi ostanki. Ob Župančičevem odkritju arheoloških najdb v Jami pri železniškem useku in ker tudi Malečkar kot poznavalec terena na tem območju ni vedel za nobeno drugo vodoravno jamo, se mu je zato verjetno zdela ta povezava povsem logična. Še zlasti, ker se je Župančič že v prvi objavi izkopavanja v Jami pri železniškem useku (Župančič, 1982) skliceval na spomin ljubiteljskega arheologa iz Milj, da je Jama pri železniškem useku v resnici Grotta dell'Orso.

Leta 1990 je v članku o arheološki podobi Brega s Kraškim robom Župančič vnovič omenil Grotto dell'Orso. Tokrat je imenu Grotta dell'Orso dodal še lokacijo, in sicer Popecchio (Podpeč). Še vedno pa jo je kljub oddaljenosti med Črnim Kalom in Podpečjo povezoval z Jamo pri železniškem useku. K vsem dosedanjim imenom te jame, ki jo je v objavi navajal z glavnim imenom Jernejeva jama, je dodal še eno novo ime: »*[...] bronastodobne ostanke zasledimo v vrsti jam, morda so do sedaj najpomembnejše v Jernejevi jami ('Grotta del'Orso di Popecchio', Jama pri železniškem useku, Jama v Kavšci). Tu so pred vojno izkopali bronastodobno bodalo in keramiko*« (Župančič, 1990).

Od kod se je za Jamo pri železniškem useku pojavilo še eno novo ime *Jama v Kavšci*, je Župančič pojasnil šele leta 2008, ko je v članku obravnaval obiske Ludwiga Karla Moserja na Kraškem robu. V njem je predstavil Moserjevo prisotnost v Predloki in bližnji Bržaniji na osnovi dopisov dunajski Osrednji spomeniški komisiji, ki se hranijo v Avstrijskem državnem arhivu (ÖSA AVA) na Dunaju. Moserjevo delovanje je povzel iz rokopisnih pisem, ki jih je pošiljal na dunajsko Osrednjo komisijo. Pri tem je zapisal, da si je nekoliko pomagal tudi z Moserjevimi, v Trstu ohranjeni dnevniki, ki jih je lahko uporabil pri rekonstrukciji Moserjeve dejavnosti na obravnavanem območju. Osnovni poročili Spomeniški komisiji sta dopisa v Avstrijskem državnem arhivu (ÖSA AVA, 2 za Osp) in (ÖSA AVA, 1 za Bezovico, Predloko in Črni Kal). Župančič je takole rekonstruiral Moserjevo pot: »*Iz Predloke se je avtor 27. oktobra 1898 odpravil proti Črnemu Kalu. [...] Nad vasjo stoji na skalnati luski pred kraško steno ruševina Grad. Moserja je prevzela slikovitost pogleda, in ga je tudi upodobil v svinčniku. Skica VI naj bi kazala ruševino s Steno od strani, viden je pri tem tudi del nižje ležečega jamskega gradu. [...] Desno se v ozadju vidi jamska pečina, morda je skiciral tudi jamsko utrdbo. Ugotavljamo, da je desno od Gradu opazil vhod v jamo 'Felsenhöhle'), verjetno Jamo v Kovšci, ki jo je pozneje tudi želel obiskati*« (Župančič, 1990). Župančič se je skliceval na Moserjevo skico, ki naj bi bila v njegovem članku predstavljena kot slika 5, vendar je očitno prišlo do napake, saj Župančič te slike v članek ni dodal. V opombi 22 ob omembi Jame v Kovšci pa je zapisal: »*Jama v Kovšci: imenovana tudi Grotta dell'orso di Poppecchio, Jama v Kavšci, Jernejeva jama, Jama pri železniškem useku: kat. št. 3735. Omenja jo Lonza (1977, 200), izkopavanj B. Lonze se je spominjal tudi M. Peracca iz Milj (Župančič, 1982)*« (Župančič, 1990). Žal je tudi tu očitno pri Župančiču prišlo do napake, saj Lonza na strani 200 Grotte dell'Orso ne omenja. Prav tako Lonza nikjer ni navedel, da bi on izkopaval v tej jami, temveč je kot izkopavalca omenil F. Stradija. Iz Župančičevega članka ni povsem razvidno, kateri od podatkov, ki jih je navedel, izvira iz katerega vira.

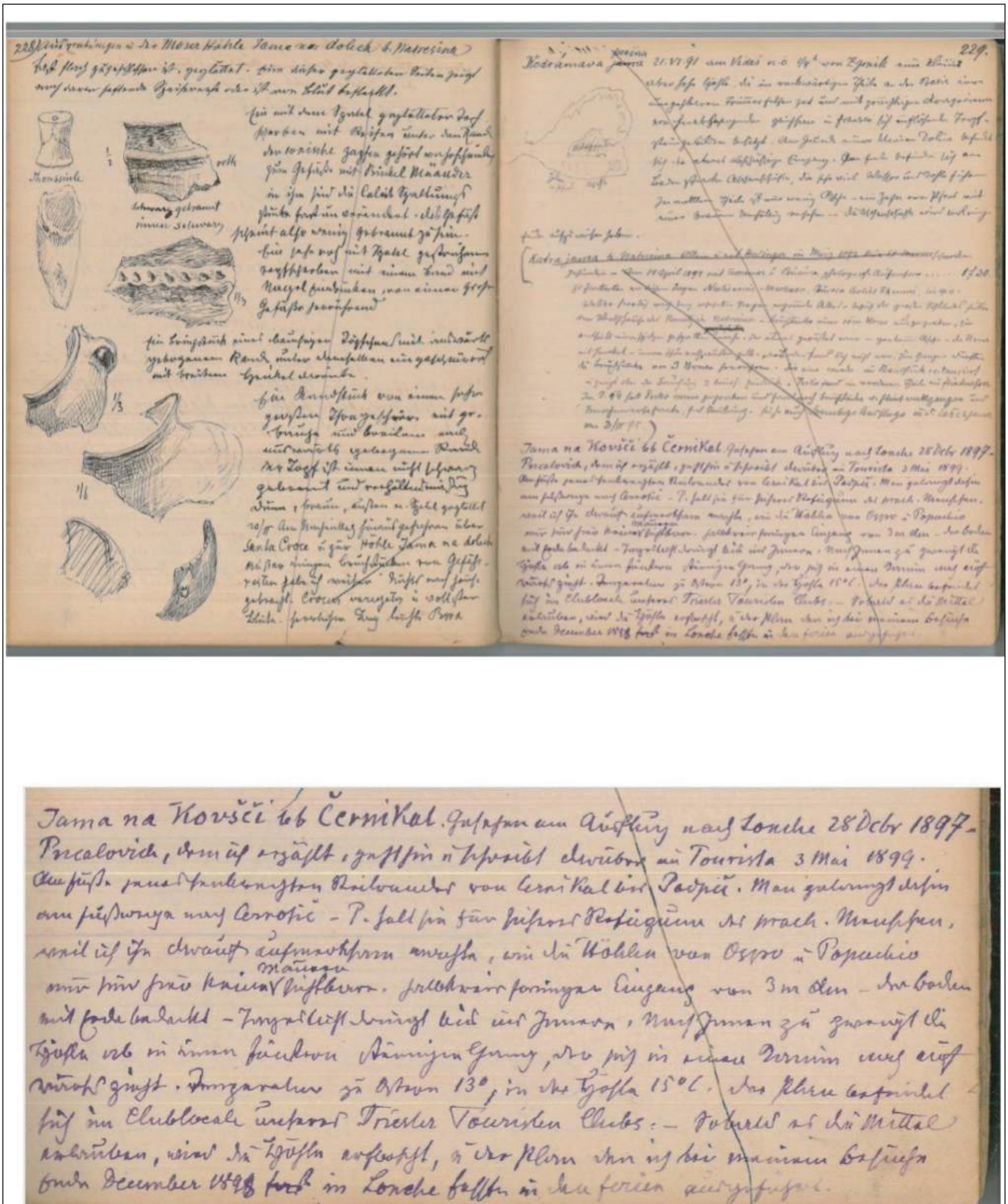
Leta 2008 sta v analizi Moserjevih dnevnikov in opisu obiskanih jam Stanko Flego in Matej Župančič naštela kot eno od jam, ki jih je Moser omenil v svojem dnevniku, nahajajo pa se na današnjem območju Slovenije, tudi Jamo v Kovšci (Flego & Župančič, 2008). V poznejši študiji Flego in Rupel zaradi nejasnih lokacijskih podatkov o Jami v Kovšci te nista vključila v pregled Moserjeve dejavnosti (Flego & Rupel, 2018).

Na naše zaprosilo nam je kustosinja dr. Deborah Arbulla iz Museo Civico di Storia Naturale v Trstu prijazno posredovala fotografijo strani iz Moserjevega dnevnika, kjer omenja to jamo (Sl. 10), za kar se ji najlepše zahvaljujemo.

Iz precej slabo čitljivega zapisa v dnevniku je mogoče prebrati sledeče: »*Jama na Kovšci pri Črnem Kalu. Najdena na nekem izletu proti Loki (Lonche) 28. 12. 1897. Pukalovič mi je povedal, da je jamo našel neki turist. 3. maja 1899 smo bili na izletu od Črnega Kala proti Podpeči [...* nečitljivo*...] in prišli do Cernotič [...* nečitljivo*...] P. nam je govoril o jamah v Ospu in v Podpeči [...* nečitljivo*...] obokani vhod, visok 3m s podpisi prejšnjih obiskovalcev (Mary Juvanova) [...*nečitljivo*...] temperatura 13° C in 15° C [...*nečitljivo*...] Podatki so spravljeni v klubskem arhivu Triester Touristen Club [...* nečitljivo*...] decembra 1899 še enkrat v Loki, tokrat na dopustu.*«.

Pomembno je upoštevati, da gre pri Moserju za dva časovno ločena podatka o skoraj zagotovo dveh različnih jamah. Na skici, ki jo v svojem članku omenja Župančič in naj bi bila priložena dopisu dunajski Osrednji komisiji (Župančič, 1990), je desno ob gradu nad Črnim Kalom jamo z oznako »*Felsenhöhle*« narisal 27. oktobra 1898, ko je opravil pot od Predloke proti Črnemu Kalu. Jama na Kovšci pa naj bi bila po v zapisu v njegovem dnevniku najdena eno leto prej, že 28. decembra 1897.

Župančič je žal ti dve Moserjevi časovno različni omembi, skoraj zagotovo različnih jam nekritično poistovetil z *Grotto dell'orso di Poppecchio*. Ob tem je dodal še poimenovanje Jama v Kavšci in Jernejeva jama, vsa imena pa pripisal Jami pri železniškem useku (Župančič, 1990, 2008).



Sl. 10: Izvirni Moserjev dnevniški zapis o Jami na Kovšci pri Črnem Kalu (foto: D. Arbulla, vir: Ludwig Karl Moser, Diario 1, pp. 228/229, Fondo Ludwig Karl Moser, Museo Civico di Storia Naturale di Trieste).
Fig. 10: The original Moser diary entry about the Cave at Kovšca near Črni Kal (photo: D. Arbulla, source: Ludwig Karl Moser, Diario 1, pp. 228/229, Fondo Ludwig Karl Moser, Museo Civico di Storia Naturale di Trieste).

Trinajst let po Moserjevem obisku Črnega Kala – leta 1910 – je Ivan Andrej Perko objavil študijo o kraških jamah na Krasu. V pregledu je podal tudi karto z vrisanimi jamami na obravnavanem območju. Na območju od Črnega Kala do Podpeči so bile po njegovem vedenju do takrat poznane le tri jame, in sicer blizu Črnega Kala (natančnejša lokacija, kje okoli Črnega Kala, ni mogoča, ker je karta premalo natančna) jama Felshöhle, jama Felshöhle hrib in Wasserhöhle v. Podpecchio (Perco, 1910). Ali je morda katera od obeh Perkovih Felshöhle, in Felshöhle hrib ista jama, kot jo je v svojo skico kot »*Felsenhöhle*« zarisal Moser, ni mogoče ugotoviti.

Z Moserjevim zapisom v dnevniku si pri ugotavljanju lokacije Jame na Kovšci prav tako ni mogoče pomagati. Kljub temu pa je mogoče domnevati, da je opisoval neko jamo z obokanim vhodom med Črnim Kalom in Loko, ki je glede na stare podpise očitno bila obiskovana. Ker je Moser zapisal, da so podatki v klubskem arhivu, bi bilo morda mogoče sklepati, da je imel v mislih Jegliško jamo, kat. št. 2401, ki je v italijanskem arhivu poimenovana Grotta di Loka / Stajelska jama, kat. št. 2218. Ni pa mogoče tega trditi z gotovostjo, saj je bila Grotta di Loka / Stajelska jama v italijanskem arhivu glede na katastrsko številko registrirana verjetno šele v začetku tridesetih let dvajsetega stoletja. Jama pod železniškim usekom ni evidentirana v italijanskem katastru. Glede na Moserjevo opravljeno pot proti Loki bi takrat lahko naletel tako na Jegliško kot tudi na Jamo pri železniškem useku. Kljub temu se zdi, da bi Moserjeva Jama na Kovšci le nekoliko bolj odgovarjala Jami pri železniškem useku.

Za razjasnitev zmešnjave, ki je nastala z neargumentiranimi združevanji imen jam, smo si poskušali pomagati tudi s pomenom imena V/Na Kovšci oziroma V/Na Kavšci. Domačini na območju Črnega Kala in Podpeči v besedi kavšca prepoznajo le nekaj, kar nakazuje na bližino kala oziroma lokve, vendar pa tega imena za kakršno koli jamo v njihovi bližini ne poznajo.

Jama z enakim imenom je tudi na italijanski strani meje v bližini Sesljana (Grotta Koušca, kat. št. VG 413). Odpira se pod skalno steno, vendar pod njo ni pobočja, temveč je jama v večji udornici »Dolini«. Jezikoslovec Pavle Merku je ime razložil z verjetnim pomenom »*plitvejša kotanja s stoječo vodo, kjer se napaja živina*« (Merku, 2006).

Na katastrski mapi Franciscejskega katastra (1818–1828) je zapisan jugovzhodno od Črnega Kala, v smeri proti Loki, toponim »Pod Kouschze« (Pod Kovšce). Skoraj ne more biti dvoma, da je Moser ob svojem obisku opazil neko jamo prav na tem območju in za njeno poimenovanje v svojem dnevniku uporabil toponim za območje, na katerem se jama nahaja. Glede na lokacijo toponima Moserjevi Jami na Kovšci najbolj ustreza Jama pri železniškem useku.

Kaj je iz vseh teh različnih poimenovanj in združevanj različnih jam sploh mogoče ugotoviti o pravi lokaciji Grotte dell'Orso?

Pokrajinski muzej v Kopru hrani arheološke predmete in fosilne kosti jamskega medveda iz dveh različnih najdišč. Keramiko iz jame, Orso, Pečina pod Steno / Grotta dell'gallerie, Botače pri Borštu in kosti jamskega medveda iz Grotte dell'Orso di Popecchio. Keramika in medvedove kosti torej niso iz istega najdišča.

Arheolog koprskega muzeja Župančič je po arheološkem sondiranju v Jami pri železniškem useku, v kateri je odkril bronastodobne ostanke, izhajal iz domneve, da lončenina, shranjena v muzeju pod imenom Orso, izhaja iz te jame. Ker je spregledal, da kosti in keramika v muzeju nista iz istega najdišča, je začel za Jamo pri železniškem useku uporabljati tudi ime Grotta dell'Orso di Popecchio.

Čeprav je v koprskem muzeju na kosteh oznaka Grotta dell'Orso di Popecchio, se v objavah lokacija te jame pripisuje enkrat bližini Črnega Kala, spet drugič Podpeči, ne da bi bilo pojasnjeno, zakaj je tako.

Ob vseh poskusih ugotavljanja, kje je *Grotta dell'Orso, Grotta dell'Orso presso Cernicale, Grotta dell'Orso di Popecchio*, se zdi za naš prispevek in iskanje jame s pleistocenskimi kostnimi ostanki pomembno še eno dejstvo.

Grotta dell'Orso di Popecchio nakazuje neko povezavo z medvedi, zato je jasno, da mora biti temeljno izhodišče pri iskanju prisotnost fosilnih medvedovih kosti. Poimenovanja jam po medvedih, če so bile v njih najdene fosilne kosti, je pač skoraj pravilo. Tako je na primer na območju Doline na Tržaškem pred nekaj desetletji ime Medvedja jama / Caverna degli Orsi dobila tudi jama, v kateri je bila odkrita večja količina fosilnih kosti jamskega medveda (glej Boschian & De Santis, 2011). Že prej pa smo omenili tudi jamo Grotta dell'Orso nad Gabrovico na italijanski strani meje.

V Jami pri železniškem useku Župančič fosilnih kosti ni našel. Iz opisa plasti (Župančič, 1982) je skoraj gotovo, da v tej jami kosti ni, saj jih pod flišno plastjo, ki jo je s sondiranjem dosegel, ni mogoče pričakovati. Če bi bile fosilne kosti prisotne že v prvi odkopani plasti, bi Župančič pri kopanju v dokaj veliki sondi naletel na vsaj nekaj fragmentov, zato smo prepričani, da Jama pri železniškem useku ne more biti Grotta dell'Orso di Popecchio.

Če kljub navedbi Podpeči na muzejski škatli pri iskanju primerne jame upoštevamo celotno območje med Črnim Kalom in Podpečjo, kjer bi lahko ali so

Sl. 11: Vse v besedilu obravnavane jame: 1. Pečina nad Črnim Kalom, 2. Jama v kamnolomu nad Črnim Kalom, 3. Jama pri železniškem useku, 4. Jegliška jama, 5. Jama v gradu nad Podpečjo, 6. Previs s spodmolom v Luskanici / Grotta dell' Orso, 7. Podrta jama nad Zazidom (foto: P. Jamnik).
Fig. 11: All the caves discussed in the text: 1. Pečina nad Črnim kalom, 2. Jama v kamnolomu nad Črnim Kalom, 3. Jama pri železniškem useku, 4. Jegliška jama, 5. Jama v gradu above Podpeč, 6. Previs s spodmolom v Luskanici / Grotta dell' Orso, 7. Podrta jama above Zazid (photo: P. Jamnik).

bile v sedimentih katere od jam celo že potrjene ohranjene fosilne kosti, pridejo v poštev tri možnosti.

Nad Črnim Kalom pod ostankom utrdbe na skali je danes vidna le še široka razpoka med skladi. Razpoka je v katastru Jamarske zveze Slovenije registrirana kot Pečina nad Črnim Kalom (kat. št. 2713). V njenem danes vrhnjem delu je bil nekoč mogočen kamniti zid, ki je bil vhod v srednjeveški tabor. Kamenje zidu so po vojni porabili v druge namene, vse od zidu navzdol pa odkopali konglomerat, ki so ga uporabili pri gradnji (Malečkar, 2015; Lajovic, 2020). Danes o taboru in sedimentih ni več sledu. Glede na predvojni načrt jame bi bilo v sedimentih povsem upravičeno pričakovati tako arheološke kot tudi paleontološke najdbe. Izkopavanje konglomerata naj bi se začelo že pred vojno in nadaljevalo vse do 50. let 20. stoletja. Ne vemo, kako je odkopavanje konglomeratnih plasti potekalo. Če pa so morda vrhnje plasti, torej te, ki so ležale takoj pod kamnitim zidom, odkopali že pred vojno, bi obstajala možnost, da so naleteli v njih tako na arheološke kot tudi paleontološke najdbe. Dvomimo, pa da bi ob tem spreminjali ime jame, saj je bila jama kot jamski tabor v italijanskem katastru registrirana že precej pred drugo svetovno vojno pod imenom Grotta di S. Sergio (kat. št. VG 270), zato menimo, da se ne zdi verjetno, da bi bila to Grotta dell'Orso.

Druga možnost iz okolice Črnega Kala je območje današnjega kamnoloma. Te možnosti žal zaradi pretečenih let na terenu ni več mogoče preveriti. Ko se je leta 1955 pri miniranju v kamnolomu pokazal s sedimenti zapolnjen rov (Jama v kamnolomu nad Črnim Kalom, kat. št. 1578), je bil kamnolom že dolgo v funkciji. Po podatkih domačinov so na tem območju odprli kamnolom že precej pred drugo svetovno vojno. Nič nenavadnega ne bi bilo, nasprotno – bilo bi celo pričakovano, da je bil zapolnjen rov, v katerem so bili najdeni paleontološki in arheološki ostanki (Brodar, 1958; Rakovec, 1958, 1973), le del večjega jamskega sistema. Morda je bil v manjšem delu v obliki spodmola ali poševne jame vsaj delno še nezapolnjen s sedimenti in pred začetkom kamnoloma tudi dostopen. Na tako možnost nakazujejo tudi najdbe rovov blizu zapolnjenega rova, v katerih so bili ob odprtju z miniranjem še na jamski površini najdeni pleistocenski kostni ostanki (Gams, 1955).

Tretja možnost je Jama v gradu, kat. št. 3773, nad Podpečjo. Jama je evidentirano arheološko najdišče, vendar ni znanih podatkov o morebitni najdbi fosilne pleistocenske favne, prav tako pa v jami ni sledi o posegih, s katerimi bi posegli globlje v jamske plasti, zato dvomimo, da bi medvedove kosti iz koprskega muzeja lahko izvirale iz te jame.

Na koncu nam ostaja možnost, da kosti jamskega medveda, ki so v koprskem muzeju shranjene v škatlah s podatkom o izvoru iz Grotta dell'Orso di

Popecchio, izvirajo izpod Previsa s spodmolom nad Luskanico, ki smo ga marca 2022 našli nad Podpečjo. V Previsu s spodmolom nad Luskanico se je med kopanjem moralo pokazati veliko fosilnih kosti in zob. Če bi ljudje kosti še nekako spregledali, pa so zobje nedvomno pritegnili njihovo pozornost. Le še vprašanje časa bi bilo, kdaj bi glas o najdbah prišel tudi do predvojnih uslužbencev koprskega muzeja, ki so morda odšli pogledat, kaj je bilo najdeno, ob tem pa shranili tam najdene medvedove kosti in jih glede na pripadnost jamskemu medvedu označili kot najdišče Grotta dell'Orso di Popecchio. Ob naših obiskih smo prekopan sediment, ki so ga zmetali pred vhod v spodmol, zelo natančno pregledali in v njem ni bilo niti najmanjšega fragmenta lončenine. Domnevamo, da tudi predvojni koprski arheologi ob ogledu razen kosti pod previsom ali v spodmolu niso našli arheoloških predmetov. So pa shranili medvedove kosti, na škatlo zapisali ime Grotta dell'Orso di Popecchio, najdišče pa je šlo v pozabo.

Menimo, da je Previs s spodmolom nad Luskanico pravzaprav najdišče kosti jamskega medveda, ki so ga pred drugo svetovno vojno poimenovali Grotta dell'Orso di Popecchio. Če bodo pod previsom in v spodmolu kdaj opravljene raziskave, je v plasteh mogoče pričakovati tudi sledi bivališča kamenodobnih ljudi. Do takrat pa Previs s spodmolom nad Luskanico oziroma Medvedova jama/Grotta dell'Orso di Popecchio ostaja najdišče kostnih ostankov jamskega medveda.

ZAKLJUČEK

Z odkritjem dveh novih, čeprav gre pravzaprav za odkritje enega novega in prepoznavo enega že pred približno sto leti odkritega najdišča pleistocenske favne, smo na območju Kraškega robu dobili nove podatke o prisotnosti živalskih vrst, ki so to območje poseljevale v času pleistocena. Še zlasti v paleogeografskem pogledu je pomembna najdba ostanka planinskega orla, saj gre tudi za redko najdbo na ozemlju Slovenije.

Z analizo zgodovinskih in terenskih podatkov o Grotti dell'Orso di Popecchio smo poskušali preveriti, ali morda obstaja možnost, da fosilne kosti jamskega medveda, ki jih hrani Pokrajinski muzej v Kopru, izvirajo prav iz Previsa s spodmolom v Luskanici. Po izključitvi vseh drugih možnosti smo prepričani, da so med izdelavo terasastih izravnav pred Previsom s spodmolom v Luskanici za najdbo kosti jamskega medveda izvedeli takratni italijanski arheologi Koprskega muzeja in najdišče poimenovali Grotta dell'Orso.

Jama pod železniškim usekom, ki so jo avtorji enačili tudi z Grotto dell'Orso, je verjetno Moserjeva Jama na Kovšci, in z Grotto dell'Orso nima nikakršne zveze.

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TWO NEW SITES OF PLEISTOCENE FAUNA UNDER KARST EDGE. HAS A *GROTTA DELL'ORSO* CAVE BEEN FINALLY FOUND?

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SUMMARY

The Karst Edge, as a geological and climatic boundary between the karst topography and the flysch landscape of Istria, is characterised by typical limestone walls stretching in the form of individual scales from the Italian side across the Glinščica valley to Učka above Rijeka in Croatia. The total length of the Karst Edge on the territory of Slovenia is about 20 kilometres, and it consists of 47 stone walls or scales with a total length of about 51 kilometres. Paleontological finds are currently known from twelve locations: Sveta Jama near Socerb, Črnotiče quarry, buried abyss on the upper and middle terrace of the Črni Kal quarry, Jama v kamnolomu above Črni Kal filled with sediments, Č2 cave under Škorjašca, Ladrica, Globoka jama, Jama velikih podkovnjakov or Bobalova jama, Ločka jama, Brežec 3, Globoška Peč and Partizanska jama. The article presents two new sites of Pleistocene fauna on the Karst Edge. Podrta jama before Zazid is the remains of a former larger cave, of which only a few meters of tunnel remain. The latter forms about 10 meters high overhang, along which parallel to the rock wall another 8 meters long narrow tunnel is preserved opening from the wall in the form of up to 2 meters wide window. On the walls of the overhang, three levels of old fillings of the cave with sediments, which were denuded during the speleogenesis, are clearly visible. Today, the sediment preserved under the overhang reaches only the overhang dripstone and does not exceed a depth of 1 meter. Two different layers can be identified in the cleaned profile. The sediment is already slightly glued to the breccia in some places. In the middle of the cleared layer, two completely fossilised mountain eagle bones were found at a depth of 0.30 m and an indeterminate bear and several indeterminate bone fragments. When about a hundred years ago, under the Previs s spodmolom v Luskanici near Podpeč, a layer of sediment almost 1-meter-thick was excavated before the overhang for the formation of terraced beds for cabbage seedlings, fossil remains of a cave bear were found. By analysing old publications and available data, we found out whether the so-called Grotta dell'Orso *is from which the fossil bones of the cave bear are kept by the Provincial Museum in Koper, but it was never known where this cave was, almost certainly Previs s spodmolom v Luskanici. If new research is ever carried out in it, possible traces of Stone Age people can also be expected in the strata.*

Key words: Podrta jama, Previs s spodmolom v Luskanici, *Grotta dell' Orso*, Jama pri železniškem useku, Jama v Kovšci, Pleistocene fauna

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OCENE IN POROČILA

RECENSIONI E RELAZIONI

REVIEWS AND REPORTS

Book review:
PLASTIC POLLUTION AND MARINE CONSERVATION. APPROACHES TO PROTECT BIODIVERSITY AND MARINE LIFE

Editors: Giuseppe Bonanno, Martina Orlando-Bonaca
Authors: Alessandro Acquavita, Carlo Giacomo Avio, Oliver Bajt, Nicola Bettoso, Giuseppe Bonanno, Francesco Cumani, Mateja Grego, Ernesta Grigalionyte-Bembič, Katja Klun, Manca Kovač Viršek, Lovrenc Lipej, Martina Orlando-Bonaca, Valentina Pitacco, Ana Rotter, Giuseppe Suaria, Rachel Tiller
Publisher: Academic Press,
346 pp.

In Europe and elsewhere the number of researchers interested in marine plastic pollution is rising. Anyone who is interested in this field, especially from the Mediterranean Sea area, is warmly invited to read this book.

Written and edited by seven Slovenian and five Italian plastic researchers and/or biologists, "Plastic Pollution and Marine Conservation: Approaches to Protect Biodiversity and Marine Life" is a comprehensive review of publications on marine litter issued during the last decade or so, with a focus on local peculiarities.

Published by the Academic Press in 2022, the volume offers us an interesting, comprehensive and the most recent overview of published data on plastic and microplastic litter in the Mediterranean Sea. The origin, sources, fate, and impacts of marine plastic and microplastic litter are presented and complemented by an investigation into how this topic has been treated by social media publications over the last decade.

When the editors of the book asked me to do a review, I was intrigued with its volume (covering 346 pages), but at the same time a little concerned about whether I would be able to squeeze such a huge task in my already full schedule. As it turned out, I need not have worried at all.

In fact, as soon as I started the book, I was completely absorbed in it. It captivated me even though I am quite familiar with the field. And now I know more and understand even better how this field developed in the Mediterranean Sea and what must be done in the future. It is definitely a much-needed survey that scientists, researchers, publicists, activists, policy- and decision-makers, and environmental staff in the industry should read. Hopefully this book will not end up forgotten on library shelves as this topic is now more current than ever.

Dr Giuseppe Suaria, a rising star of microplastic research, sets the tone of the book with his wonderful preface, pointing out the most critical spots in this field of scientific research. Through Chapter 1, the reader becomes familiar with information about what exactly plastics, or better, polymers are, how they are produced and where they are used. Through a brief historical overview, we are then shown why and who started bringing to attention that these might not only be fantastic materials, but actually a new "tragedy of the commons." Microplastics are now recognised as a major concern and Dr Giuseppe Bonanno introduces us to these materials.

Chapter 2 provides an overview of microplastic pollution in the Mediterranean Sea and subtidal sediment. The authors, three Slovenian pioneers in microplastic research in the Adriatic Sea, give us a comprehensive view of concentrations data, distribution, types by size, shape and material, methodologies, assessments, sources and challenges of microplastic research throughout the Mediterranean Sea. Publications up to the end of June 2021 are analysed, compared and the most interesting facts coming from them are presented. The fate of microplastics is discussed and suggestions on further research are offered. This chapter makes us understand just how much pollution there is, while the following four ones allow us a very interesting

insight into the impact and environmental harm of plastics and microplastics.

The editors demonstrate their commitment to the protection of biodiversity, biomonitoring and their biological background and take us through the effects of plastic pollution on planktonic and benthic organisms, food webs, sharks and rays and marine organisms as bioindicators of plastic pollution. These chapters cover entanglement and ingestion problems and the effect of microplastics on marine biota through retention and food web transfer. The authors of these chapters are Slovenian and Italian biologists, who know these organisms very well and are concerned with the negative effect of plastic pollution on the largest to the smallest organisms in the sea.

The marine environment acts as the main repository for plastic litter worldwide. This pollution does not stop at the borders of any protected area. In fact, many of these areas have turned out to be the most polluted, with different kinds and sizes of plastic litter. Chapter 7 of this book is dedicated to showing just how severe plastic pollution is in marine protected areas worldwide. The prevention of input of plastic into the marine or any other environment is of utmost importance if any progress is to be made in the effort to solve this problem.

The authors of Chapter 8 present us with the so-called 8R Model (Recognize, Reduce, Replace, Reuse, Recycle, Recover/Restore, Remove and Regulate), recently developed by the authors themselves. The key to achieving any changes is the awareness of key people in our society. This point was nicely demonstrated at the 5th International Marine Debris Conference in Hawaii, when an artist of local origin told us the story on how ancient Hawaiian people paid attention to the status of their environment. When tribes living on Hawaiian Islands were faced with the lack of certain species of the fish they relied on, they were immediately told by their tribe leader to cease all hunting activities until the stocks restored: a simple yet very effective way of ancient commingling with nature that we could learn from and replicate today.

Ceasing to produce and use such quantities of polymer material would bring us closer to what we all aspire to – a safe and healthy future. In Chapter 8, we are also shown the results of the research regarding how public media pushed this topic increasingly in the last decade and how a citizen science approach is turning into a useful tool for convincing people that there is something wrong. There is indeed something wrong.

The Mediterranean Sea has been identified as one of the areas most affected by marine litter in the world. Marine plastic litter researchers and marine biologists are aware of this problem, maybe more than anybody else. Because we/they love the sea. And having such a comprehensive overview of all plastic pollution assessment done in our home, the Mediterranean Sea, is very inspiring and shows us how much has already been achieved. And how each and every one of us counts. We are putting together this enormous marine plastic puzzle where pieces are coming from you and me, through years of work that we have put into this crisis. In order to save this world, for marine biota and for our own sake, I invite you to read this book. It is a valuable new asset that the Mediterranean marine litter community has acquired and will use in the future. Thank you!

Andreja Palatinus
independent aquatic plastic litter researcher
and entrepreneur

KAZALO K SLIKAM NA OVITKU

SLIKA NA NASLOVNICI: Avgusta 2022 se je na območju miramarskega podvodnega parka pojavil veveričjak (*Holocentrus adscensionis*). Obiskujoči potapljači so ga opazili na nočnem potopu ter ga posneli in fotografirali. Izkazalo se je, da gre za prvo najdbo v Jadranskem morju in šele drugo v vsem Sredozemskem morju (Foto: S. Ciriaco).

Sl. 1: Veveričjak (*Holocentrus adscensionis)* ima vse lastnosti dobrega kolonizatorja, saj lahko v ribiških mrežah preživi več dni, obenem pa se lahko pojavlja tudi v zelo onesnaženem okolju (Foto: S. Ciriaco).

Sl. 2: Morski pes orjak (*Cetorhinus maximus*) je relativno redka vrsta v Jadranu, toda od začetka 21. stoletja se je število opažanj te vrste v njem znatno povečalo. V dvesto letih od prvega zapisa o pojavu te vrste v Jadranskem morju leta 1822 jih je bilo objavljenih 75 (Foto: T. Rus).

Sl. 3: Navadni morski pes (*Mustelus mustelus)* je ena od najbolj pogostih vrst morskih psov v Sredozemskem morju in je zato tudi nekoliko bolje raziskana od drugih. Podatki kažejo, da so v zadnjih desetletjih tudi njene populacije doživele občutno številčno izgubo (Foto: B. Mavrič).

Sl. 4: Konec leta 2021 so mesečinko (*Pelagia noctiluca*) prvič opazili v Marmarskem morju. Ta majhna toploljubna klobučnjaška meduza se lahko pojavlja v ogromnem številu (Foto: T. Makovec).

Sl. 5: Onesnaženje s plastiko postaja čedalje hujši problem v vseh morjih in oceanih. Še posebej pereča je mikroplastika, ki jo najdemo tudi na planktonskih organizmih. Na fotografiji je harpaktikoidni rak ceponožec (Copepoda - Harpacticoida) s številnimi delci mikroplastike (modro) na hitinskem oklepu (Foto: M. Grego).

Sl. 6: Številne vrste večjih morskih organizmov se zapletejo v zavržene ali izgubljene ribiške mreže. Takim mrežam in njihovim ostankom, ki svoje delo opravljajo še naprej, pravimo fantomske mreže (Foto: B. Mavrič).

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FRONT COVER: In August 2022, a long-jawed squirrelfish (*Holocentrus adscensionis*) appeared in the area of the Miramare Marine Reserve. It was spotted by visiting divers who sighted it during a night dive and filmed and photographed it. It turned out to be the first record of this species in the Adriatic Sea and only the second in the entire Mediterranean (Photo: S. Ciriaco).

Fig. 1: The long-jawed squirrelfish (*Holocentrus adscensionis*) has all the qualities of a good colonizer, as it can survive in fishing nets for several days, and can do well even in very polluted environments (Photo: S. Ciriaco).

Fig. 2: The basking shark (*Cetorhinus maximus*) is considered a relatively rare species in the Adriatic, but since the beginning of the 21st century, the number of sightings of this species has increased significantly. Over the two centuries since its first appearance in 1822, a total of 75 records of sightings of this species have been recorded (Photo: T. Rus).

Fig. 3: The smoothhound (*Mustelus mustelus)* is one of the commonest sharks found in the Mediterranean Sea, which is why it is also somewhat better studied than other species. The data show, however, that in recent decades the populations of this species have been virtually decimated (Photo: B. Mavrič).

Fig. 4: At the end of 2021, the mauve stinger (*Pelagia noctiluca*) was observed for the first time in the Sea of Marmara. This small thermophilous scyphozoan sometimes appears in huge numbers (Photo: T. Makovec).

Fig. 5: Plastic pollution is an increasingly serious problem in all seas and oceans. Particularly worrisome are microplastics, which are also found on plankton organisms. The photo shows a harpacticoid copepod (Copepoda - Harpacticoida) with many microplastic particles (blue) on its chitinous shell (Photo: M. Grego).

Fig. 6: Many larger marine organisms become entangled in abandoned, discarded or lost fishing nets. Such fishing nets and their remains that continue to do their work are called ghost nets (Photo: B. Mavrič).

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