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50 LET MORSKE BIOLOŠKE POSTAJE NACIONALNEGA INŠTITUTA ZA BIOLOGIJO

I 50 ANNI DELLA STAZIONE DI BIOLOGIA MARINA DELL'ISTITUTO NAZIONALE DI BIOLOGIA

50 YEARS OF THE MARINE BIOLOGY STATION OF THE NATIONAL INSTITUTE OF BIOLOGY

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FIRST RECORD OF SERGEANT MAJOR, *ABUDEFDUF SAXATILIS* (LINNAEUS, 1758) IN THE ADRIATIC SEA

Lovrenc LIPEJ & Domen TRKOV
Marine Biology Station, National Institute of Biology Piran, SI-6330 Piran, Slovenia
e-mail: lovrenc.lipej@nib.si

Domen STANIČ
DOPPS, Tržaška cesta 2, SI-1000 Ljubljana, Slovenia

Sara CERNICH
Agency for Nature Conservation, SI-6310 Izola, Slovenia

Saul CIRIACO
WWF Miramare, Strada Costiera 334, Trieste, Italy

ABSTRACT

A specimen of Segeant major Abudefduf saxatilis *(Linnaeus, 1758) was observed in a shallow rocky area for several weeks in August and September 2019 at Punta Sottile, in waters off Muggia (Gulf of Trieste). The specimen probably entered the Strait of Gibraltar and arrived at northernmost limits of the Adriatic Sea. This is the first record for this species in the Gulf of Trieste and also the Adriatic Sea.*

Key words: Sergeant major, damselfish, first record, Atlantic influx, Gulf of Trieste

PRIMO RITROVAMENTO DI DAMIGELLA A STRISCE, *ABUDEFDUF SAXATILIS* (LINNAEUS, 1758) IN MARE ADRIATICO

SINTESI

Un esemplare di damigella a strisce Abudefduf saxatilis *(Linnaeus, 1758) è stato osservato in una zona rocciosa poco profonda per diverse settimane ad agosto e settembre 2019, a Punta Sottile, nelle acque al largo di Muggia (Golfo di Trieste). L'esemplare probabilmente è entrato dallo stretto di Gibilterra ed è arrivato ai limiti più settentrionali del mare Adriatico. Si tratta della prima segnalazione per questa specie nel Golfo di Trieste e anche nell'Adriatico.*

Parole chiave: damigella a strisce, castagnole, primo ritrovamento, afflusso atlantico, Golfo di Trieste

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INTRODUCTION

In recent years, many fish species of tropical origin have been reported from different areas of the Mediterranean Sea. The majority of them enter the Mediterranean Sea through the Suez Canal and are known as Lessepsian migrants. During the last decades, the arrival of newcomers has accelerated due to rapid biotic globalization and various anthropogenic factors such as mariculture, maritime transport, the aquarium trade and others (see Zenetos *et al.*, 2012, 2016; Tsiamis *et al.*, 2018). Certain Atlantic newcomers have also entered the Mediterranean basin through the strait of Gibraltar and could be considered as evidence of natural range expansion (sensu Occhipinti *et al.*, 2011), unaided by human activities (Zenetos *et al.*, 2012). Higher temperatures during last decades also enable the spreading of Atlantic fish species into the Mediterranean Sea (Bianchi, 2007). They include many tropical coral reef dwelling fish entering the Mediterranean Sea through both gates.

The Gulf of Trieste, which is the northernmost part of the Adriatic Sea, has withnessed the arrival of some alien species or species related to the phenomenon of tropicalisation. In this paper, we report on the sighting of *Abudefduf saxatilis* (Linnaeus, 1758) at Punta Sottile (Muggia) near Trieste in the summer months of 2019. To our knowledge, this is the very first evidence of the species's appearance in the Adriatic Sea.

MATERIAL AND METHODS

On August 16th 2019, a single specimen of a non-native damselfish was sighted during snorkeling along the coast off Punta Sottile in the Italian part of the Gulf of Trieste (Figs. 1a and c). The specimen was swimming in waters less than 2 m deep (45° 36' 13" N; 013° 43' 05" E), in a low vegetation habitat (turf) (Fig. 1b). The specimen was seen picking organisms on the sea floor and pinching the combjelly *Mnemiopsis leidyi*, present at the time in high density. The species was easy to approach to a distance of only few decimeters. All tentatives to collect the observed specimen with SCUBA diving equipment failed; however, photographic material obtained using a Fuji camera, Finepix XP140, was helpful for species determination. The specimen was observed regularly with the last sighting documented on 16th September 2019.

RESULTS AND DISCUSSION

The specimen was identified as a pomatocentrid species of the genus *Abudefduf* due to an oval compressed body, typical colour pattern with light and five blue-black

Fig. 1: A specimen of Sergeant Major *Abudefduf saxatilis* ***at Punta Sottile (near Trieste) (A and C) at the end of August 2019 in a reef-like habitat, made of sandstone boulders, covered mainly with turf (B) (All photos: D. Stanič). Sl. 1: Primerek velikega seržanta,*** *Abudefduf saxatilis* ***opaženega blizu Tankega rtiča (pri Trstu) (A in C) na koncu avgusta 2019 v grebenastem okolju iz peščenjakovih plošč, poraslih z nizko blazinasto vegetacijo (B) (vse fotografije: D. Stanič).***

dark vertical bands, and forked tail. *Abudefduf saxatilis* is often confused with a similar Indopacific relative *A. vaigiensis* (Quoy & Gaimard, 1825) (Fig. 2, below), which has already been reported from the Mediterranean Sea as Lessepsian migrant (Bariche *et al.,* 2015; Vella *et al*., 2016a). In fact, both species are considered as cryptic species, that do not differ in terms of meristic counts and morphometric parameters (Deidun & Castriota, 2014), although they are not sympatric in their original biogeographic provinces. Some authors such as Tsadok *et al*. (2015) have expressed doubts about the occurrence of *A. vaigiensis* in the Mediterranean Sea.

However, we checked the photographic material and tried to identify the species according to morphological characters. The specimen was identified as *A. saxatilis* (Fig, 2, above) due to the following characteristics (see Allen, 1991; Randall, 1996; Deidun & Castriota, 2014): the origin of the fourth vertical bar is located at the last dorsal spine or immediately behind it (Fig 2, arrow A); the extention of the fifth dark vertical bar from the origin of the dorsal fin to the anal fin (Fig 2; arrows B1 and B2); and the presence of two dark dots on the caudal peduncle (Fig. 2, arrow C). A complete description of the species is available in Allen (1991).

Damselfishes (family Pomacentridae) are common inhabitants of rocky sea floors and coral reefs (Allen, 1991). The Sergeant major is an abundant coral reef fish, generally dwelling in shallow waters up to 10 m of depth. It is normally present in schools. It is an herbivorous fish, feeding on different algae on the sea floor (Allen, 1991). However, young specimens were observed participating in cleaning symbiosis, picking ectoparasites and necrotic tissue from nectonic organisms such as marine turtles (Grossmann *et al*., 2006).

The authors of this contribution also prepared and published information on the occurrence of Sergeant major in the local Slovenian (Lipej, 2019) and Italian media (Anonymous, 2019). Subsequently, a reader contacted us and informed us that such a specimen was sighted almost daily from June to August in an embayment of the marine protected area of Strunjan (Mesečev zaliv, Slovenia). It was observed cruising among giant boulders, resembling a small reef, in shallow waters below 2 m of depth. We checked whether the specimen was still present in the area on 12th September, but without success. It is probable that the observed specimen is the same as the one of Punta Sottile.

This sighting represents the first record of *A. saxatilis* in the Gulf of Trieste and, as far as we know, also in the Adriatic Sea. The first occurrence of the Sergeant major in the Mediterranean Sea was reported by Azzurro *et al.* (2013) when a specimen was sighted and photographed in shallow waters along the coast of Tarragona, Spain. The presence of *A. saxatilis* has also been confirmed in Maltese (see Deidun & Castriota, 2014; Vella *et al.,* 2016a), Turkish (Bilecenoglu, 2016) and Israeli waters (Tsadok *et al.*, 2015) (Tab. 1).

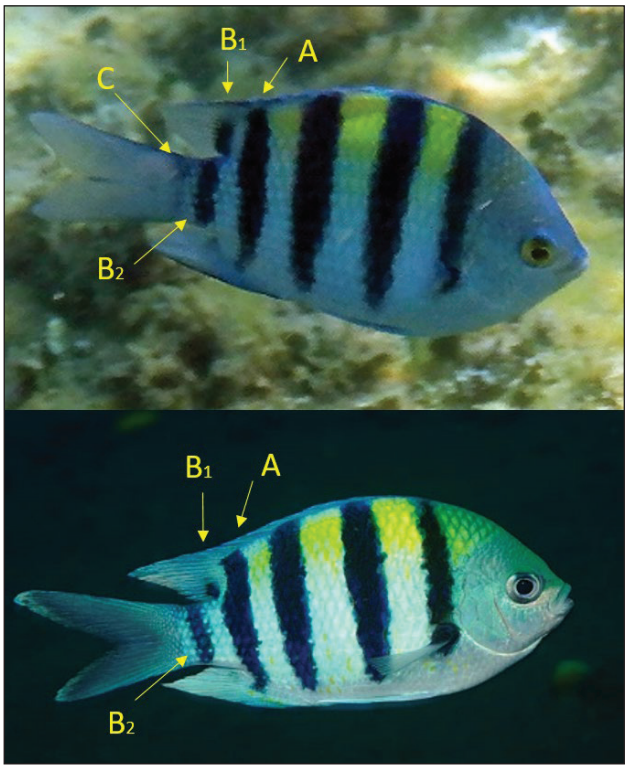

Fig. 2: Comparison of two similar species of** Abudefduf**, both already recorded in the Mediterranean Sea as alien species. Above is the studied specimen of** A. saxatilis **from Punta Sottile (Photo: D. Stanič) and below a specimen of** A. vaigiensis **from the island of Bali, Indonesia (Photo: B. Furlan). The arrow A shows that in** A. saxatilis **the origin of the 4th vertical bar is located under the last dorsal spine, while in** A. vaigiensis **it is placed behind the spine in the soft part of the dorsal fin. The arrow B_1 shows the extension of the 5th black vertical bar from the origin of the dorsal fin to the anal fin in** A. saxatilis**, which is shorter and discontinued in** A. vaigiensis **and is located on the caudal peduncle (arrow B_2). The arrow C shows the presence of two dark dots on the caudal peduncle in** A. saxatilis**.

***Sl. 2: Primerjava dveh zelo podobnih vrst seržantov iz rodu** Abudefduf**, ki sta že bili zabeleženi v Sredozemskem morju kot tujerodni vrsti. Zgoraj je obravnavani primerek vrste** A. saxatilis **iz Tankega rtiča (Foto: D. Stanič), spodaj pa primerek vrste** A. vaigiensis **iz voda blizu otoka Bali, Indonezija (Foto: B. Furlan). Puščica A označuje, da je pri vrsti** A. saxatilis **začetek četrte navpične proge pod zadnjim trnom hrbtne plavuti, medtem ko je pri vrsti** A. vaigiensis **nameščen za trnom v delu hrbtne plavuti z mehkimi plavutnicami. Puščica B_1 označuje razširitev pete navpične proge, ki se prične od osnove hrbtne plavuti do podrepne plavuti pri vrsti** A. saxatilis**, ki pa je krajša in prekinjena pri vrsti** A. vaigiensis**, obenem pa je nameščena na repnem korenu (puščica B_2). Puščica C označuje navzočnost dveh temnih pik na repnem korenu pri vrsti** A. saxatilis.*

To date, at least six alien damselfish species have been recorded in the Mediterranean Sea. A closely related species *Abudefduf vaigiensis* (Allen, 1991) has also been reported from the Mediterranean Sea as a Lessepsian migrant (Tardent 1959; Goren & Galil 1998; Vacchi & Chiantore 2000; Vella *et al*., 2016a). The African sergeant major, *A. hoefleri* (Vella *et al.,* 2016b) was caught in Maltese waters, whereas the Scissortail Segeant, *A. sexfasciatus,* was recently reported from the Aegean Sea by Giovos *et al.* (2018). Other alien damselfishes have been recorded in the Mediterranean Sea such as *Stegastes variabilis* (Vella *et al*., 2015) and *Chrysiptera hemicyanea* (Deidun *et al*., 2018), both in Maltese waters. *Chrysiptera cyanea,* on the other hand has been recorded in Portorož, in Slovenian waters (Lipej *et al.,* 2014a).

The arrival of species of tropical origin in the Mediterranean Sea could be attributed to different reasons such as Lessepsian migration, Atlantic influx, drift, ballast waters or acquarium trade. The later two reasons seem to be less probable. In fact, Ben Rais Lasram & Mouillot (2009) stated that "the introduction of fish into the Mediterranean Sea by ships and aquaculture-mediated introductions is extremely rare". However, in the case of another damselfish, the Blue Devil, *C. cyanea,* reported in the waters off Piran (Slovenia), the intentional release of the species from an acquarium seems very reasonable (Lipej *et al.,* 2014a). The native area of distribution of *A. saxatilis* is the Caribbean Sea and the tropical coastal waters of western Africa (Allen, 1991). As an Atlantic species, *A. saxatilis* most probably entered the Mediterranean through the Strait of Gibraltar. Azzurro *et al.* (2013) mentioned natural range expansion through this gate as a reasonable hypothesis; however, they do not exclude the possibilities of an acquarium escape or ship transport. Schools of damselfish planktivores of the genera *Abudefduf* and *Chromis* are known to associate with floating objects (see Dempster *et al*., 2002; Luiz *et al*. 2012). The same phenomenon of alien fish, following debris, plastic objects and other floatsam has also been observed with certain alien fish species, already reported from the Adriatic Sea, e.g. *Pampus argenteus* (Dulčić *et al*., 2004).

Despite its northermost position, the Gulf of Trieste and the adjacent northern Adriatic Sea witnessed records of other alien fish species. The first such alien species was the silver pomfrey *P. argenteus*, caught in waters off Rijeka (Fiume) in 1896 (Dulčić *et al*., 2004), which was also the first ever recorded Lessepsian migrant in the Adriatic Sea, as well. The second case was the capture of an alien grouper *Epinephelus coioides*, reported by Parenti & Bressi (1998) for the Gulf of Trieste. Later on, some other alien fish species were reported such as *Terapon theraps* in waters off Piran in 2007 (Slovenia) (Lipej *et al.,* 2008), *Siganus luridus* (Poloniato *et al*., 2010) at Miramare (Trieste), *Stephanolepis diaspros* (Bay of Piran)

Tab. 1: Non-native damselfish records in the Mediterranean Sea according to the available published data.
Tab. 1: Tujerodne vrste rib koralnic v Sredozemskem morju na podlagi razpoložljivih objav.

	Damselfish species	**locus**	**state**	**source**
1	*Abudefduf saxatilis*	Tarragona	Spain	Azzurro *et al*., 2013
	Abudefduf saxatilis	Candarli Bay	Turkey	Bilecenoglu, 2016
	Abudefduf saxatilis	Valetta	Malta	Vella *et al*., 2016a
	Abudefduf saxatilis	Valetta	Malta	Deidun & Castriota, 2014
	Abudefduf saxatilis	Sdot-Yam	Israel	Tsadok *et al*., 2015
	Abudefduf saxatilis	Trieste	Italy	*this work*
2	*Abudefduf vaigiensis*	Gulf of Naples	Italy	Tardent, 1959
	Abudefduf vaigiensis	Ligurian Sea	Italy	Vacchi *et al*., 2000
	Abudefduf vaigiensis	Valetta	Malta	Vella *et al.*, 2016a
	Abudefduf vaigiensis	Lebanese waters	Lebanon	Bariche *et al.*, 2015
	Abudefduf vaigiensis	North coast	Israel	Goren & Galil, 1998
3	*Abudefduf sexfasciatus*	Sounio	Greece	Giovos *et a*l., 2018
4	*Abudefduf hoefleri*	Southern Malta	Malta	Vella *et al.,* 2016b
5	*Stegastes variabilis*	Senglea	Malta	Vella *et al.,* 2015
6	*Chrysiptera cyanea*	Portorož	Slovenia	Lipej *et al*., 2014
7	*Chrysiptera hemicyanea*	Manoel Island	Malta	Deidun *et al.,* 2018

(Lipej *et al.,* 2014b) and *Oplegnathus fasciatus (*Muggia) (Ciriaco & Lipej, 2016). There is also mentioned reference to a Blue Devil (*C. cyanea*) in the waters off Piran, which could be most likely considered as an intentional release from an acquarium. One specimen, which was caught by SCUBA divers, was held in the acquarium tank of the Marine Biology Station for many months till it died (Lipej *et al.,* 2014a).

It is interesting to mention the fact that some alien species were recorded for the very first time in the northernmost part of the Adriatic Sea as is the case of *T. theraps*, *S. luridus*, *O. fasciatus* and now *A. saxatilis*. Neither of those species has been recorded again in the Gulf of Trieste, so we should therefore consider them as 'Casual' species (*sensu* Evans *et al.,* 2015). As with all mentioned cases, in the case of *A. saxatilis* only a single specimen was sighted in the studied area, so it is rather probable that it should be considered as an isolate record. In all cases, specimens were first sighted during the warmer part of the year (e.g. from June to September), with rather high sea temperatures. It is possible that the low winter temperatures in the Gulf of Trieste do not allow the settlement or survival of such alien fish species. The same is also true for the tropical alien algae *Caulerpa cylindracea*. The northernmost record of this species is located in area near the Istrian city of Umag (Sladonja & Banovac-Kuča, 2014); however, to date, it has not been able to reach the adjacent Gulf of Trieste.

If possible, it is always better to follow basic ichthyological procedures for publishing first records as this is the best practice approach (*sensu* Bello *et al.,* 2014); it includes meristics, morphometry or even genetic identification. However, in the case of alien tropical fish species, which are easily detected among the native fish community due to their conspicuous colour pattern, an evidenced record such as photographic material or footage could also be very helpful. They are normally sighted as single specimens and recorded during the warmer part of the year, For example, the first record of *S. luridus* in the Adriatic Sea was reported from the area of WWF Miramare near Trieste based on photographs and footage recorded in the area (Poloniato *et al.*, 2010). Subsequently, more cases of the same species were reported from the Adriatic Sea by Dulčić *et al*. (2011, 2013) and Đurović *et al*. (2014). The same happened with another alien fish species, *O. fasciatus* (Ciriaco & Lipej, 2016), which was reported for the first time from the Gulf of Trieste, according to a photographed specimen, and later recorded again in Urinj (Rijeka Bay, northern Adriatic Sea) (Dulčić *et al.*, 2016).

To date, 444 fish species have been recorded in the Adriatic Sea (Kovačić *et al*., submitted) with at least one positive record of the species in the area. Thus, with the inclusion of Sergeant major, the checklist of Adriatic fish fauna now includes 445 fish species. Due to the ongoing arrival of alien fish species through the Suez Canal and range extending species from the Atlantic, the number of fish will certainly increase in the near future.

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PRVI ZAPIS O POJAVLJANJU VELIKEGA SERŽANTA, ABUDEFDUF SAXATILIS (LINNAEUS, 1758) V JADRANSKEM MORJU

Lovrenc LIPEJ & Domen TRKOV
Marine Biology Station, National Institute of Biology Piran, SI-6330 Piran, Slovenia
e-mail: lovrenc.lipej@nib.si

Domen STANIČ
DOPPS, Tržaška cesta 2, SI-1000 Ljubljana, Slovenia

Sara CERNICH
Agency for Nature Conservation, SI-6310 Izola, Slovenia

Saul CIRIACO
WWF Miramare, Strada Costiera 334, Trieste, Italy

POVZETEK

Primerek velikega seržanta Abudefduf saxatilis *(Linnaeus, 1758) so avtorji avgusta in septembra 2019 dalj časa opazovali v plitvinah skalnatega dna pri Tankem rtiču (Punta Sottile, Milje, Tržaški zaliv). Najverjetneje je zašel na skrajni severni del Jadranskega morja skozi gibraltarsko ožino. To je prvi zapis o pojavljanju te vrste v Tržaškem zalivu in tudi Jadranskem morju.*

Ključne besede: veliki seržant, riba koralnica, prvi zapis, atlantski prihod, Tržaški zaliv

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FIRST RECORD OF *FLABELLIDERMA CINARI* KARHAN, SIMBOURA & SALAZAR-VALLEJO, 2012 (POLYCHAETA: FLABELLIGERIDAE) FROM THE ADRIATIC SEA

Valentina PITACCO
Marine Biology Station, National Institute of Biology, Fornače 41, 6330 Piran, Slovenia
e-mail: valentina.pitacco@nib.si

Selahattin Ünsal KARHAN
AMBRD Laboratories, Hanimefendi Sok, 160/6 Sisli, 34384 Istanbul, Turkey

ABSTRACT

Eleven specimens of the flabelligerid polychaete Flabelliderma cinari *Karhan, Simboura & Salazar-Vallejo, 2012 were found in colonies of the Mediterranean stony coral* Cladocora caespitosa *(Linnaeus, 1767), in the northern Adriatic Sea. This finding represents the first record of the species outside its type range and provides additional information on its area of distribution and potential ecological role.*

Key words: *Flabelliderma cinari, Cladocora caespitosa,* symbiosis, northern Adriatic

PRIMA SEGNALAZIONE DI *FLABELLIDERMA CINARI* KARHAN, SIMBOURA & SALAZAR-VALLEJO, 2012 (POLYCHAETA: FLABELLIGERIDAE) NEL MARE ADRIATICO

SINTESI

Undici esemplari del polichete flabelligeride Flabelliderma cinari *Karhan, Simboura & Salazar-Vallejo, 2012 sono stati osservati all'interno delle colonie della madrepora a cuscino* Cladocora caespitosa *(Linnaeus, 1767) nell'Adriatico settentrionale. Si tratta della prima segnalazione di questa specie al di fuori dell'area di ritrovamento del suo olotipo e ha permesso di ottenere ulteriori informazioni sulla sua distribuzione e sul suo potenziale ruolo ecologico.*

Parole chiave: *Flabelliderma cinari, Cladocora caespitosa,* simbiosi, Adriatico settentrionale

MORSKA BIOLOŠKA POSTAJA PIRAN
MARINE BIOLOGY STATION PIRAN
50 1969 2019

INTRODUCTION

Polychaetes of the family Flabelligeridae de Saint-Joseph, 1894 live within sediments, among marine plants on rocks or other hard substrates, and they occasionally bore into calcareous rocks or consolidated sediments (Salazar-Vallejo, 2007; Salazar-Vallejo *et al.*, 2008). They can often be distinguished from other polychaetes by their long cephalic chaetae, retractable head region, and papillate body surfaces. Current understanding of the flabelligerid polychaetes is quite irregular and the whole family presents many taxonomic uncertainties (Salazar-Vallejo, 2012). Within this family, the genus *Flabelliderma* Hartman, 1969, includes species sharing notopodial lobes with globular papillae, dorsal tubercles of varying length, and neuropodial hooks with articulated handle and blunt entire crest (Salazar-Vallejo, 2007). The latest revision of the genus (Salazar-Vallejo, 2007) described seven species recorded in different habitats from shallow tropical to deep Antarctic waters. The genus *Flabelliderma* was recorded in Mediterranean Sea for the first time in 2012, when the species *Flabelliderma cinari* Karhan, Simboura & Salazar-Vallejo, 2012 was described, based on a record from the Turkish coast of the Eastern Mediterranean Sea (Karhan *et al.*, 2012).

During a research carried out on the fauna associated with the Mediterranean stony coral *Cladocora caespitosa* (Linnaeus, 1767) eleven specimens of *F. cinari* were collected from the northern Adriatic Sea. This collection represents the first record of this species outside its type locality. A brief description of the species, along with additional information on its distributional range and ecological role, is presented herein.

Fig. 1: Areas where** Flabelliderma cinari **has been recorded to date, with details of sampling sites where specimens of F. cinari were found associated with colonies of** Cladocora caespitosa **(Debeli Rtič – DR, Pacug – PA, Cape Ronek – RR and Strunjanček – STR).
Sl. 1: Predeli, v katerih je bila doslej najdena vrsta** Flabelliderma cinari **s podatki o vzorčevalnih lokalitetah, kjer je bila vrsta najdena v kolonijah sredozemske kamene korale (Debeli Rtič – DR, Pacug - PA, Rt Ronek – RR in Strunjanček – STR).

Material and Methods

Eleven specimens of *F. cinari* were found in the Gulf of Trieste (northern Adriatic Sea) strictly associated to colonies of the scleractinian coral *C. caespitosa*. The collection of the colonies was carried out by SCUBA diving in 2012 at four different sites (Fig. 1) between depths of 4 m and 9 m (Tab. 1).

Colonies fix to small rocks and detritus, and they were easily detached from the substrate without hammer and chisel, collected, immediately put in plastic buckets full of seawater and brought to laboratory. The total volume of each colony (Tab. 1) was measured through water displacement, after covering them with a plastic foil (Schiller, 1993). The precise percentage of living polyps within colonies was also estimated in laboratory (Tab. 1). Colonies were broken apart and animals were sorted from coral fragments under a stereomicroscope, then fixed and preserved in 75% ethanol. Diagnostic characters of the specimens were examined, drawn and photographed under a compound microscope. Light micrographs of the specimens were taken using a digital camera (Olympus DP25) mounted on a compound (Olympus CX31) and a stereo (Olympus SZX16) microscope. All specimens are deposited at the Marine Biology Station of the National Institute of Biology in Piran, Slovenia.

RESULTS

Taxonomic account

Class POLYCHAETA Grube, 1850
Order TEREBELLIDA *sensu* Rouse & Fauchald, 1997
Family FLABELLIGERIDAE de Saint-Joseph, 1894
Genus *Flabelliderma* Hartman, 1969
Flabelliderma cinari Karhan, Simboura & Salazar-Vallejo, 2012

Material examined

Eleven specimens, two of them incomplete, one lacking the anterior and the other lacking the posterior part, northern Adriatic Sea (Gulf of Trieste, Slovenian coast), spring 2012.

Description

All specimens soft, light brown. Complete specimens from 6 mm of length and 1.6 mm of width, with 18 chaetigers, to 19 mm long and 5.5 mm of maximal width, with 28 chaetigers. Body slightly convex dorsally, flat ventrally, densely covered with irregular, lobate tubercles covered by fine sediment particles (Fig. 2A, 2B). Tubercles number 13 to 20 per segment at maximum body width. Dorsal tubercles of two different sizes. Many small, more

Tab. 1: Sampling sites with coordinates, sample code, depth, date of sampling, total colony volume, percentage of living polyps and number of specimens of** Flabelliderma cinari **found.
Tab. 1: Vzorčevalne lokalitete s koordinatami, kodo in podatki o globini, celokupni prostornini kolonije, deležu živih polipov in številu najdenih primerkov vrste** Flabelliderma cinari**.

Sampling site	Latitude (N)	Longitude (E)	Sampling date	Sample code	Depth	Total colony volume	% living polyps	Number of specimens
Cape Ronek	45°32'25''	13°36'56''	9.7.2012	RR2	8.6	195	95	2
Cape Ronek	45°32'25''	13°36'56''	9.7.2012	RR3	8.7	1590	100	1
Cape Ronek	45°32'25''	13°36'56''	9.7.2012	RR4	8.5	955	60	2
Pacug	45°31'34''	13°35'24''	10.8.2012	PA2	6.0	1265	50	2
Pacug	45°31'34''	13°35'24''	10.8.2012	PA3	6.2	1230	60	1
Debeli rtič	45°35'28''	13°42'88''	19.10.2012	DR2	6.0	340	90	1
Debeli rtič	45°35'28''	13°42'88''	19.10.2012	DR5	6.0	2445	80	1
Strunjanček	45°32'5''	13°36'10''	22.8.2012	STR2	4.6	1410	50	1

globular and some bigger ones more elongated and about twice bigger on the dorsal part, while ventral tubercles are all small and globose (Fig. 2A, 2B). Dorsal tubercles with fine sediment, larger along the lateral margins, soft, clavate with narrow bases. Notopodial and neuropodial lobes shorter and masked by adjacent dorsal tubercles, only neuropodial hooks protruding from the ventral surface. Neurochaetae multiarticulate hooks (Fig. 2C), mostly a single hook per ramus, ventral in position; hooks not completely covered by the neuropodial chaetal lobe. Notochaetae multiarticulate capillaries. Each notopodium with 7-8 at most multiarticulate capillaries. Anterior end with cephalic cage (Fig. 2D) completely covered with tubercles and sediments, cephalic chaetae not exposed. Prostomium (Fig. 2D) a high cone, with dark-reddish eyes, caruncle well-developed, palps long, two branchial groups with about 30 filaments each. Posterior end tapering, pygidium without anal cirri.

DISCUSSION

This is the first record of *F. cinari* outside its type locality in the Eastern Mediterranean coast of Turkey. Species of *Flabelliderma* are poorly known, despite the wide distribution of the genus, because they can easily be overlooked or confused with sediment granules or debris (Karhan *et al.*, 2012). In fact, the body papillae of *Flabelliderma* form large tubercles, often coated with sediment particles (Salazar-Vallejo, 2007). Current knowledge is still limited for assessing its distribution and ecology, but it is reasonable to guess a wide geographical and ecological distribution for the species. In particular, the Gulf of Trieste (northern Adriatic Sea) is characterised by the lowest winter temperatures in the Mediterranean Sea (Boicourt *et al.*, 1999), suggesting a wide thermal tolerance for the species. The genus is known for being free living in rocky or mixed bottoms and often associated with other species (Salazar-Vallejo, 2007; Karhan *et al.*, 2012). This species was found under boulders surrounded by *Cymodocea nodosa* meadow (at the type locality) and in corals surrounded by sciaphilic algal communities (present work).

These new findings prove it to be also a symbiont of the scleractinian coral *C. caespitosa*. Living tropical and temperate scleractinian corals provide microhabitats for a large number of parasitic and commensal associates, which use the tissue and skeletons of the colonies as substrata (Arvanitidis & Koukouras, 1994; Floros *et al.* 2005; Stella *et al.*, 2011; Pitacco *et al.*, 2014). Most of these coral associates stress the coral to some degree, and some of them can do considerable harm (Sammarco & Risk, 1990; Smith & Harriott, 1998), such as the boring polychaetes species (Sammarco & Risk, 1990) or the corallivorous fireworm *Hermodice carunculata* (Wolf & Nugues, 2013). The newly described autolytine polychaete *Proceraea janetae* is also known to feed on tropical scleractinian corals and its behaviour is closer to parasitism rather than to specialized predation (Martin *et al.*, 2015). Other polychaetes associated with scleractinian corals are carnivores and it has been postulated that some of them can feed directly on their host (Giangrande *et al.*, 2000; Lattig & Martin, 2011), as it happens for the syllid *Haplosyllis spongicola*, feeding on the sponge host (Martin *et al.*, 1998). However, coral associates could also have a mutualistic relation with their host. This is the case of the serpulid *Spirobrachus giganteus*, settling on different scleractinian hosts (Hunte *et al.*, 1990; Marsden *et al.*, 1990). The coral provides the worm with support, nutrition and protection from predation and the worm enhances water circulation for coral feeding, and provides a refuge for polyps adjacent to the tube from predation and algal growth (DeVantier, 1986; Ben-Tzvi *et al.*, 2006). Commensalisms are the most abundant relationships among symbiotic polychaetes. However,

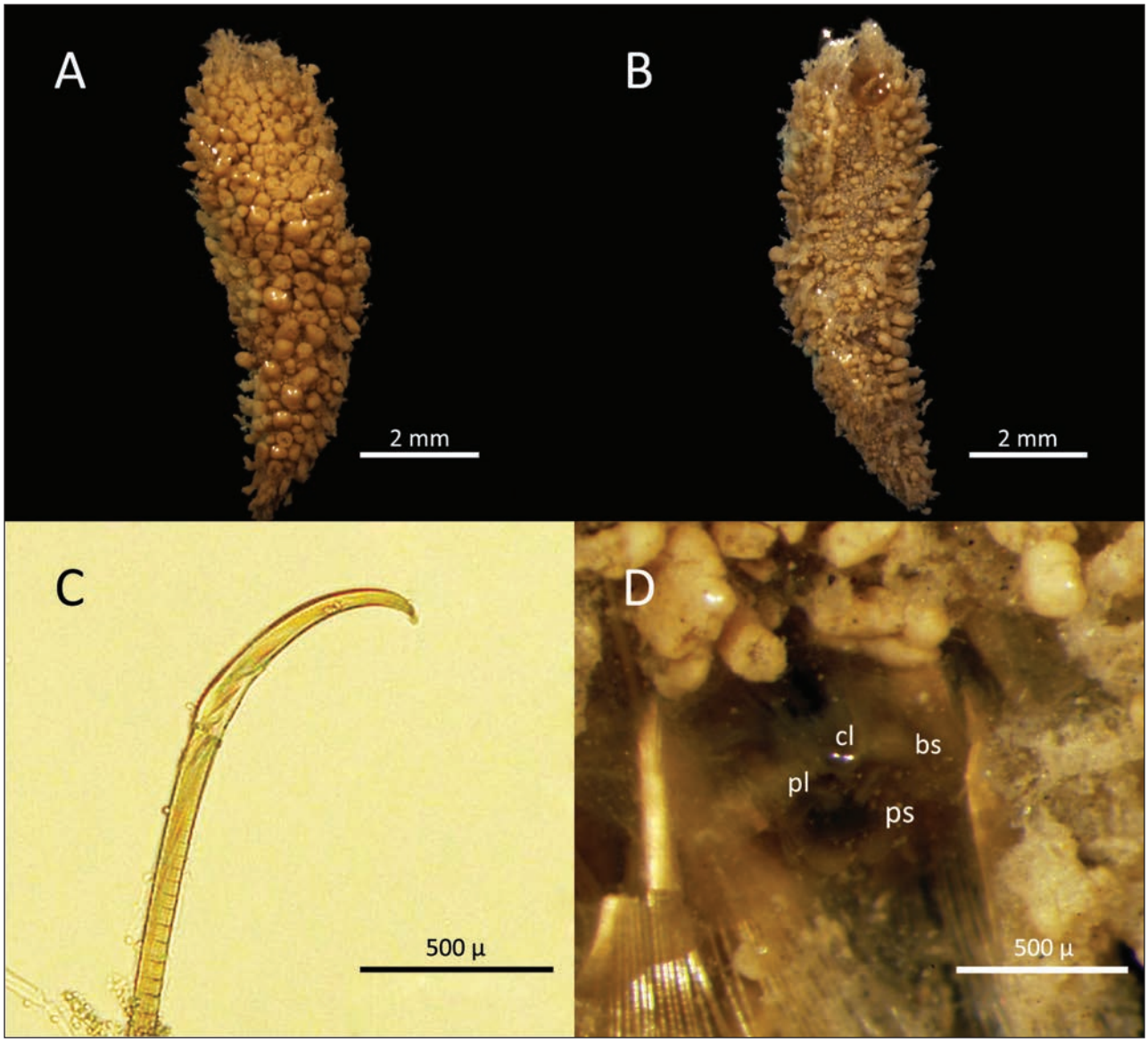

Fig. 2: Dorsal (A) and ventral (B) view of *Flabelliderma cinari* ***after fixation, tip of a neuropodial hook from a median chaetiger (C) and anterior end showing the cephalic cage chaetae in dorsal view, sediment cover, palps and tentacles removed (D). Legend: cl = caruncula, bs = branchial scars, ps = palp scars, pl = palp lobes.***
Sl. 2: Dorzalni (A) in ventralni (B) pogled na primerek vrste *Flabelliderma cinari* ***po konzerviranju, konica nevropodialnega kavlja iz sredinskega hetigerja (C) in sprednja konica naglavnih ščetin (dorzalno), potem ko je bil odstranjen sediment, palpi in lovke (D). Legenda: cl = caruncula, bs = škržne brazgotine, ps = palpne brazgotine, pl = režnji na palpih.***

their status may be further modified with the appraisal of new information on host-symbiont relationships (Martin *et al.*, 1998). Commensal polychaetes prefer organisms providing them with good shelter or animals possessing protective physiological or morphological characteristics (Martin *et al.*, 1998). Scleractinian corals provide them holes and grooves within their skeletons, as well as good chemical defences, with the nematocysts of their polyps.

All flabelligerids are surface deposit-feeders, and they can be free living or commensal. For instance, *Flabesymbios commensalis* is a commensal of a sublittoral population of the diademid seaurchin *Centrostephanus coronatus* (Verrill, 1867), often observed feeding on the faecal material of its sea urchin host (Spies, 1975). *Flabelliderma pruvoti* has been recorded in Southwestern Pacific Ocean among corals and breaking corals, and *Flabelliderma lighti* was found associated

with a species of yellow sponge (Salazar-Vallejo, 2007). Commensal forms feed in the same manner as the free-living members of the family (Fauchald & Jumars, 1979). All members of the family Flabelligeridae (Fauchald & Jumars, 1979) feed while sitting in crevices using their grooved palps to gather food particles, consisting of unicellular algae and fragments of larger algae and detritus. The nature of the relation between *F. cinari* and *C. caespitosa* requires further evidence for its clarification: it is reasonable to think of *F. cinari* as a commensal or perhaps a mutualistic symbiont. In fact, coral associates can benefit the hosts by removing detritus and coral mucus (Nogueira, 2003). Coral mucus in particular is an important carrier of energy and nutrients (Marshall & Wright, 1998; Clode & Marshall, 2002), but can also be a vector for coral pathogen bacteria adhesion (Banin *et al.*, 2001), therefore the worm may also have a potential role of pathogen removal.

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PRVI ZAPIS O POJAVLJANJU VRSTE *FLABELLIDERMA CINARI* KARHAN, SIMBOURA & SALAZAR-VALLEJO, 2012 (POLYCHAETA: FLABELLIGERIDAE) V JADRANSKEM MORJU

Valentina PITACCO
Marine Biology Station, National Institute of Biology, Fornače 41, 6330 Piran, Slovenia
e-mail: valentina.pitacco@nib.si

Selahattin Ünsal KARHAN
AMBRD Laboratories, Hanimefendi Sok, 160/6 Sisli, 34384 Istanbul, Turkey

POVZETEK

Avtorji poročajo o najdbi enajstih primerkov mnogoščetinca iz družine Flabelligeridae Flabelliderma cinari *Karhan, Simboura & Salazar-Vallejo, 2012 v koloniji sredozemske kamene korale* Cladocora caespitosa *(Linnaeus, 1767) v severnem Jadranu. Najdba predstavlja prvi zapis o pojavljanju te vrste izven njenega območja pojavljanja in podaja dodatne podatke o razširjenosti te vrste in njeni potencialni ekološki vlogi.*

Ključne besede: *Flabelliderma cinari, Cladocora caespitosa,* simbioza, severni Jadran

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ASSESSMENT OF BRYOZOAN XENODIVERSITY IN THE SLOVENIAN COASTAL SEA

Ana FORTIČ, Domen TRKOV, Borut MAVRIČ & Lovrenc LIPEJ
Marine Biology Station, National Institute of Biology, SI-6330 Piran, Fornace 41, Slovenia
e-mail: ana.fortic@nib.si

ABSTRACT

The phylum Bryozoa is one of the less studied macroinvertebrate groups in the Slovenian coastal sea. However, these animals play an important role in marine coastal ecosystems, especially as bioconstructors and filter feeders. Non-indigenous species represent five to ten percent of all Mediterranean bryozoan species. In this paper, we present an updated list of non-indigenous or cryptogenic bryozoan species recorded in Slovenia. The list includes six species: Amathia verticillata, Bugula neritina s.l.*,* Celleporaria brunnea, Tricellaria inopinata*,* Watersipora arcuata *and* Watersipora subtorquata *with comments on their morphology, ecology and distribution in the Slovenian coastal sea. Introduction vectors and possible dispersal mechanisms are discussed, as well as methodological approaches and problematic areas as regards the study of non-indigenous bryozoans. Three species reported here, A.* verticillata, C. brunnea *and* W. subtorquata*, represent the first confirmed record from the Slovenian Sea.*

Key words: non-indigenous species, Bryozoa, northern Adriatic Sea, harbour habitats, mussel farms, experimental plates

VALUTAZIONE DELLA XENODIVERSITÀ DI BRIOZOI NEL MARE COSTIERO SLOVENO

SINTESI

Il phylum Bryozoa è uno dei gruppi di macroinvertebrati meno studiati nel mare costiero sloveno. Tuttavia, questi animali svolgono un ruolo importante negli ecosistemi marini costieri, in particolare come biocostruttori e filtratori. Le specie non-indigene rappresentano dal 5 al 10 percento di tutte le specie di briozoi del Mediterraneo. L'articolo presenta un elenco aggiornato delle specie di briozoi non-indigeni o criptogenici ritrovate nel mare sloveno. L'elenco comprende sei specie: Amathia verticillata, Bugula neritina s.l.*,* Celleporaria brunnea, Tricellaria inopinata, Watersipora arcuata *e* Watersipora subtorquata*, con commenti sulla loro morfologia, ecologia e distribuzione nel mare costiero sloveno. Vengono discussi i vettori di introduzione e i possibili meccanismi di dispersione, nonché gli approcci metodologici e le aree di studio problematiche per i briozoi non-indigeni. Tre specie qui segnalate,* A. verticillata, C. brunnea *e* W. subtorquata*, rappresentano il primo ritrovamento nel mare sloveno.*

Parole chiave: specie non-indigene, Bryozoa, Adriatico settentrionale, habitat portuali, allevamenti di mitili, piastre sperimentali

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INTRODUCTION

Bryozoans are a phylum of predominantly marine colonial organisms. The phylum contains over 6000 known extant species (Bock & Gordon, 2013), which are found in the seas worldwide, whereas 556 of them are currently known to be present in the Mediterranean Sea (Rosso & Di Martino, 2016). Non-indigenous species (NIS) of bryozoans represent five to ten percent of all Mediterranean species (Rosso & Di Martino, 2016; Ferrario *et al*., 2017).

Although they are common in coastal seas, bryozoans are often overlooked, the primary reasons for that being economic insignificance, their inconspicuous nature and the lack of taxonomic expertise in the scientific community. Nevertheless, bryozoans play an important role in the ecosystems. One of the most important one is acting as bioconstructors, forming habitat and providing shelter and food for other organisms in the community (Cocito *et al*., 2000; Morgado & Tanaka, 2001; Gavira-O'Neill, 2016). Their calcareous, chitinous, membranaceus or gelatinous skeletons create diverse colony forms; from sheets to erect, highly branched morphotypes. In the fouling community, where the feeding mode of animals is predominately suspension feeding, they contribute greatly to the total filtration efficiency of the community (Bullivant, 1968a; Riisgård & Manríquez, 1997; Lisbjerg & Peterson, 2000).

Most bryozoan larvae are short-lived and in most cases cannot swim very far from their maternal colony (Keough, 1989). However, the sessile lifestyle of adult bryozoans enables them to colonise a variety of different man-made substrata and, therefore, allows them to spread easily. Furthermore, long-lived larvae or fragments of the colonies can potentially enter and exit ballast waters (Carlton & Geller, 1993). Thus, at global scale, non-indigenous bryozoans are introduced to new areas mainly through shipping (Ferrario *et al*., 2018). Specifically, the main pathways of introduction for non-indigenous bryozoans in the Mediterranean Sea include maritime transport and corridors (Zenetos *et al*., 2012). Not only are they able to travel great distances on ship hulls, but by harbouring a diverse epifauna, bryozoans can also facilitate the transport and spread of other NIS such as crustaceans (Marchini *et al*., 2015; Gavira-O'Neill *et al*., 2016).

The bryozoan fauna of Slovenia has been poorly investigated. It is one of the taxonomic groups, which was not included in early research of the Slovenian coastal sea (Matjašič & Štirn, 1975). Until 2018, 17 species had been recorded along the Slovenian coast, mostly during marine biodiversity surveys, published as lists of species in scientific reports and other publications (Vrišer, 1978; Frumen *et al*., 2003; Lipej *et al*., 2004, 2012a, 2013). Bryozoan xenodiversity is especially poorly studied. No bryozoan species are listed in the latest study of marine NIS in Slovenia (Lipej *et al*., 2012b). Recently, the status has improved, yielding a list of over 40 bryozoan species (unpublished data), including NIS, such as the record of *Tricellaria inopinata* (Fortič & Mavrič, 2018). In this paper, we present six species of non-indigenous or cryptogenic bryozoans found in Slovenian territorial waters.

MATERIAL AND METHODS

Study area

The Slovenian coastal sea is a southern part of the shallow Gulf of Trieste, the northernmost portion of both the Adriatic and Mediterranean Seas. Salinity in the gulf is typically marine (33-38.5 ‰), but is affected by heavy freshwater inflows. Water temperature normally ranges between 7°C and 26°C (Mozetič & Lipej, 2003). Rivers, mostly Isonzo (Soča), are an important source of detrital material, which originates from the hinterland. This area is influenced by bottom sediment resuspension and increasing pollution (Ogorelec *et al*., 1991). The maximum recorded depth is 33 m. The sea-bed is predominantly soft sedimentary of fluvial origin, while the coastal bottom is mostly rocky, consisting mainly of Eocene Flysch sandstone rock layers, while soft sedimentary bottom prevails in internal bays (Ogorelec *et al*., 1997). In the past decades, the Slovenian coastal area has been subjected to many anthropogenic impacts such as new infrastructure and mariculture, resulting in habitat degradation, as well as intensive fishing and farming and poorly regulated sewage outfalls (Turk, 1999).

Slovenia receives a lot of maritime traffic due to one of the biggest ports in this area, the Port of Koper. Furthermore, there are many additional mooring sites for all sizes of recreational and other vessels, *e.g.* marinas, harbours, piers. In order to obtain the number and size of these mooring sites we performed a simple analysis in QGIS 3.8 Zanzibar, with information obtained from publicly available satellite imagery (Google Earth). We included all municipal mooring sites and other sites where vessels are berthed on a regular basis.

Field and laboratory work

We employed different methods for detecting non-indigenous bryozoans in the marine waters of Slovenia. The first part of the fieldwork consisted in occasional sampling of the fouling community at NIS fouling hotspots, namely, marinas, harbours and mussel farms (Fig. 1). We sampled all three active mussel farms (Sečovlje, Strunjan and Debeli rtič) located in the Slovenian coastal sea. The largest part of the study was carried out in harbours and marinas, as all mooring sites in Slovenia were included. Sampling was performed in the period between November 2016 and September 2019. The fouling community was scraped off various substrata, including vessel hulls, using a scraping net or a paint scraper. The samples were then transported

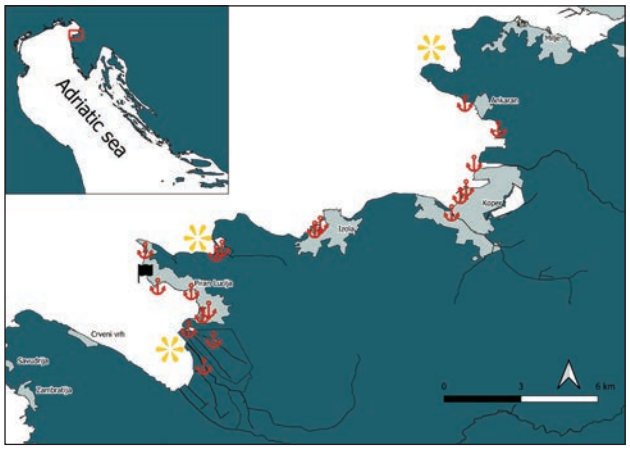

Fig. 1: Map of the Slovenian part of the Gulf of Trieste. Anchors denote the mooring sites; the flag shows the Morgan site of experimental structures and the asterisks the mussel farms.
Sl. 1: Zemljevid slovenskega dela Tržaškega zaliva. Sidra označujejo mesta privezov, zastava lokacijo eksperimentalnih struktur Morgan in zvezdice školjčišča.

to the laboratory and carefully examined for NIS. Some visual inspections were performed at different times of the year for conspicuous and easily identifiable species (e.g. *Amathia verticillata* and *Bugula neritina s.l.*). On few occasions, snorkelling and scuba diving sampling were performed in order to supplement the other work methods. Only presence data was recorded.

The second part of the study included an ongoing experiment on the succession of the fouling community on clay plates, submersed at 8-10 meters of depth. Metal structures carrying 30 vertically positioned tiles each, were gradually deployed every month over a year, starting in March 2018. The structures were set up in the Bay of Piran near the Marine Biology Station, at the locality named Morgan (see Fig. 1) in the Gulf of Trieste. The sea bottom there is muddy, with detritus elements of anthropogenic origin. Each month, a plate was taken from each structure. The plates were then carried to the laboratory, where they were photographed and carefully examined using a stereomicroscope (SZX 16, Olympus) with a camera (DP74, Olympus). This dataset contains presence and absence data on species.

If necessary, sampled species were measured and identified to the lowest possible taxon. They were preserved in an alcohol-based fixative (FineFix) and stored in the bryozoan collection of the Marine Biology Station (National Institute of Biology) in Piran.

RESULTS AND DISCUSSION

In this study, we present an updated list of non-indigenous or cryptogenic bryozoans recorded in Slovenia, with comments on their morphology, ecology and distribution in the Slovenian coastal sea. The introduction vectors and possible dispersal mechanisms are discussed. Three species reported here, *Amathia verticillata, Celleporaria brunnea* and *Watersipora subtorquata*, represent the first record from the Slovenian Sea.

Amathia verticillata (delle Chiaje, 1822)

Amathia verticillata is an erect ctenostomatid bryozoan. It forms large colonies on account of its fast growing stolons, on which clusters of spindle-shaped autozooids are arranged (Fig. 2E). The colonies are semi-transparent but, due to the epiphytes and detritus that are often attached to this bryozoan, they may appear brownish-grey or even green (Marić *et al*., 2017). Because of its large dimensions and structure, this species provides habitat for other macroinvertebrates *(e.g.* Marchini *et al*., 2015) and as such, can be considered as a bioconstructor species.

A. verticillata is regarded as a pseudoindigenous species. It was described in the Mediterranean Sea and was firstly believed to be native to the region, but recent data suggest that it was in fact introduced (Ferrario *et al*., 2014). *A. verticillata* was present in the Gulf of Trieste and other localities in the Mediterranean before 1870 (Reichert, 1870). It has a wide distribution range and it is found in tropical, subtropical and temperate waters, in the Atlantic and the Indo-Pacific region (Winston, 1995; Amat & Tempera, 2009; Bouzon *et al*., 2012; McCann *et al*., 2015; Prince *et al*., 2017; Aslam *et al*., 2019). The Caribbean is probably its native distribution range, mostly because it inhabits natural habitats there, as opposed to the Mediterranean basin and other locations, where it is found entirely in anthropogenically modified habitats. Its occurrence in marinas and harbours suggests an introduction by vessel fouling (Marchini *et al*., 2015). *A. verticillata* is considered as the most common non-indigenous bryozoan in the Mediterranean Sea (Ferrario *et al*., 2018). Nudibranch *Okenia zoobotryon* (Smallwood, 1910), another species native to the Caribbean, is known to live, feed and reproduce on this bryozoan. The close relationship between two species is another indication that *A. verticillata* is not native to the Mediterranean Sea (Winston, 1995; Galil & Gevili, 2014). However, a recent revision of the genus has revealed that several Mediterranean specimens previously believed to belong to *O. zoobotryon* are in fact another species, namely *Okenia longiductis* Pola, Paz-Sedano, Macali, Minchin, Marchini, Vitale, Licchelli & Crocetta, 2019, and *O. zoobotryon* is restricted to the Western Atlantic Ocean. Further examination of more recent specimens is required to determine their identity (Pola *et al*., 2019).

It is a thermophilic (Bullivant, 1968b) and euryhaline species (Nair *et al*., 1992). Laboratory experiments have shown that it grows and sexually reproduces best at higher temperatures (25-26°C) (Bullivant, 1968b) and survives in a salinity range of 15-35 PSU (Nair *et al*., 1992).

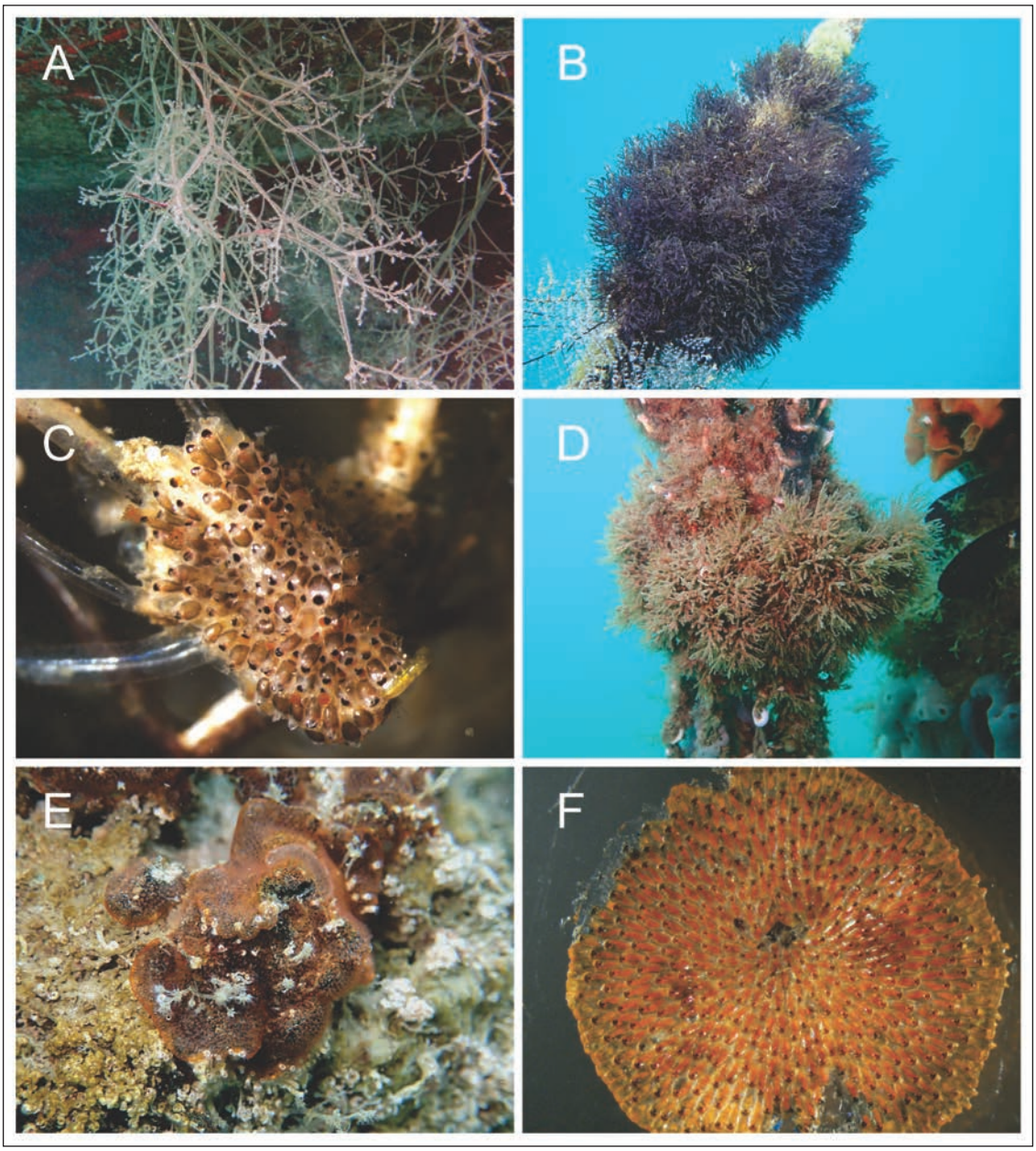

Fig. 2: Non-indigenous bryozoan species in the Slovenian sea: A) *Amathia verticillata*, ***B)*** *Bugula neritina*, ***C)*** *Celleporaria brunnea*, ***D)*** *Tricellaria inopinata*, ***E)*** *Watersipora arcuata*, ***F)*** *Watersipora subtorquata*. ***Photos: A. Fortič and B. Mavrič.***
Sl. 2: Tujerodne vrste mahovnjakov v slovenskem morju: A) *Amathia verticillata*, ***B)*** *Bugula neritina*, ***C)*** *Celleporaria brunnea*, ***D)*** *Tricellaria inopinata*, ***E)*** *Watersipora arcuata*, ***F)*** *Watersipora subtorquata*. ***Slike: A. Fortič in B. Mavrič.***

A. verticillata is one of the bryozoans that are almost exclusively found in the harbours and marinas of Slovenia, where it is well-established. In total, we recorded this species on 43 sampling occasions, which makes it the most common non-indigenous bryozoan in Slovenia (Fig. 3). The large colonies often appear together with *Bugula neritina s.l.* and *Cradoscrupocellaria bertholletii* (Audouin, 1826). The substrata where it was found primarily were vessel hulls and lines. The colonies were observed growing on concrete piers, metal stairs, floating docks and buoys. As expected, we observed that this species was the most abundant in number and size (colonies bigger than 50 cm) in the warmer part of the year (summer and early autumn). In winter, the colonies

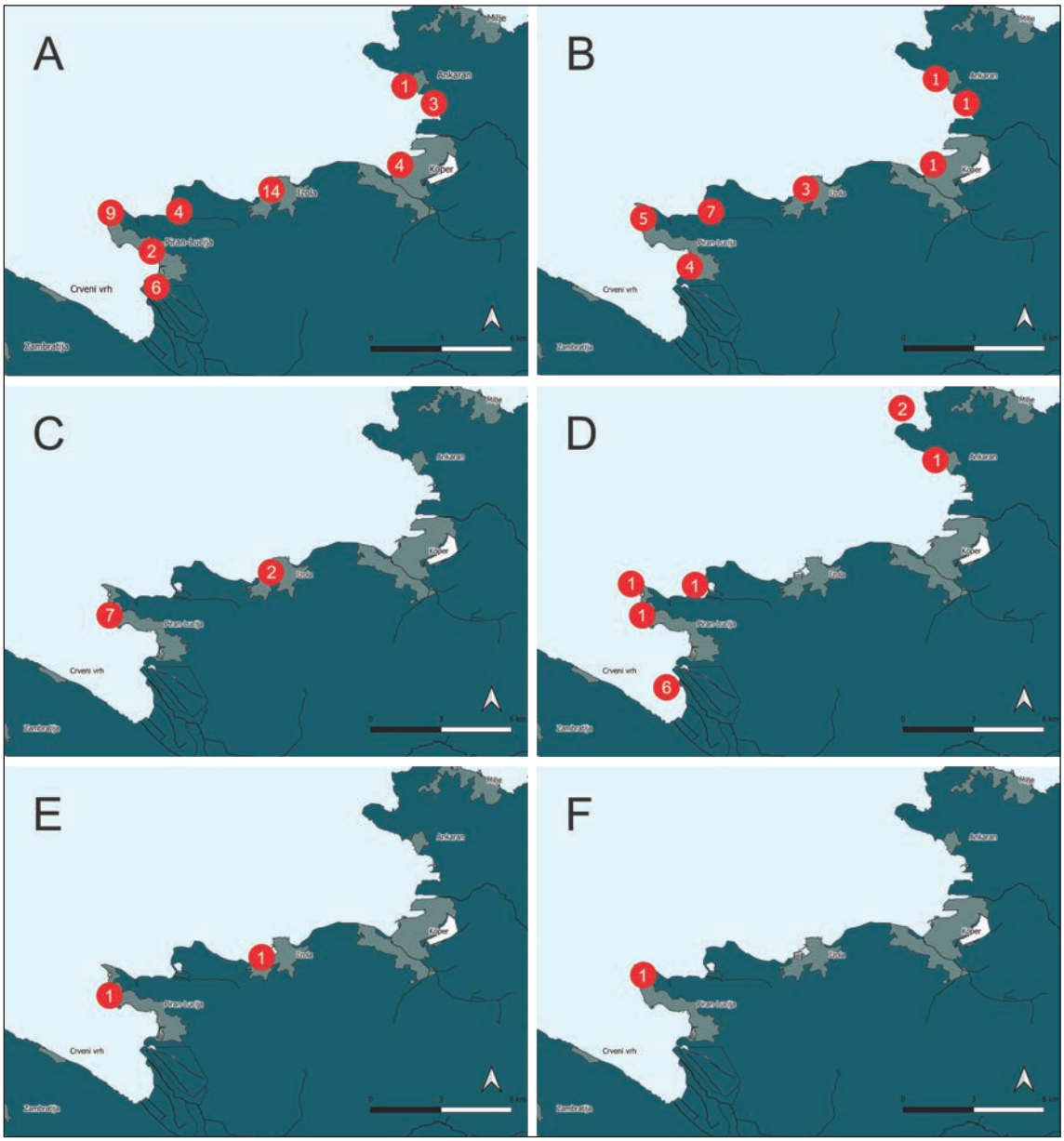

Fig. 3: Map of occurrence of non-indigenous bryozoan species. A circle denotes a macro location and the number inside the circle denotes the number of occurrences inside the macro location where the species was found: A) *Amathia verticillata*, ***B)*** *Bugula neritina*, ***C)*** *Celleporaria brunnea*, ***D)*** *Tricellaria inopinata*, ***E)*** *Watersipora arcuata*, ***F)*** *Watersipora subtorquata*.
Fig. 3: Zemljevid pojavljanja tujerodnih vrst mahovnjakov. Krog označuje število pojavljanj znotraj makrolokacije, kjer je bila vrsta najdena: A) *Amathia verticillata*, ***B)*** *Bugula neritina*, ***C)*** *Celleporaria brunnea*, ***D)*** *Tricellaria inopinata*, ***E)*** *Watersipora arcuata*, ***F)*** *Watersipora subtorquata*.

are probably reduced to fragments, which overwinter (*sensu* Geiger & Zimmer, 2002), as bigger colonies are no longer observed at that time.

***Bugula neritina s.l.* (Linnaeus, 1758)**

Bugula neritina s.l. is an erect cheilostomatid bryozoan. It is purple to brown in colour, and it is characterized by the lack of spines and bird-head avicularia, typical of the family Bugulidae. Round bright ovicells are oriented obliquely to the branch axis (Zabala & Maluquer, 1988) (Fig. 2B).

B. neritina s.l. was described in the Mediterranean Sea and America (Linnaeus, 1758). It is widely distributed in warm-temperate and subtropical coastal waters. Genetic

studies have revealed that it is a complex of three cryptic species; one of them (Type S) is widespread in tropical, subtropical and temperate regions, most probably due to anthropogenic transport. Based on genetic diversity, the probable native range of this species is the north-eastern Pacific or the south-western Atlantic (Brazil) (Fehlauer-Ale *et al*., 2013). Only one Mediterranean sample has been included in genetic analysis (from Genoa, Italy) and has been confirmed to be the invasive haplotype (Ryland *et al*., 2011). Some authors consider *B. neritina s.l.* to be a NIS in the eastern Atlantic and the Mediterranean Sea (Ryland *et al*., 2011; Harmelin *et al*., 2016), introduced via shipping (Ryland *et al*., 2011), while others claim that it is cryptogenic (Ferrario *et al*., 2018). However, more tests should be performed in order to determine the origin of the Mediterranean *B. neritina*.

In Mediterranean waters, it is usually present throughout the year, but with a peak in abundance in the warmer part of the year, and it is not very common during the winter (Igić, 2007). In Florida, where this species is found in natural habitats, namely seagrass meadows, its populations increase in the autumn or even dominate during the winter, when the temperatures are lower (Keough & Chernoff, 1987; Winston, 1995). Haplotype-specific differences in temperature-related fitness for *B. neritina* have been observed (Fehlauer-Ale *et al*., 2013). Thus, different haplotypes might be observed in the future even within the Mediterranean populations.

To our knowledge, the first record of its presence in the Slovenian part of the Gulf of Trieste was from the Bay of Piran, in 2003 (Frumen *et al*., 2003). We consider *B. neritina s.l.* an established species and it is almost exclusively found in marinas and harbours. It attaches to vessel hulls, lines, piers, floating piers and to other fouling species, *e.g. A. verticillata*. In total, we recorded this species on 22 sampling occasions. It seems to be more common during the colder part of the year, in autumn and winter, when larvae were also present. Furthermore, it was observed at the Morgan site of experimental structures, in the Bay of Piran.

***Celleporaria brunnea* (Hincks, 1884)**

Celleporaria brunnea is an encrusting white to brown cheilostomatid bryozoan. It is characterized by the dark brown colour of the opercula, sclerites of avicularia mandibles, base of spines and lophophore tentacles. The orifice distal margin is rounded with a moderately raised peristome usually bearing spines, whereas the proximal margin has a rounded border with condyles partially closing the opening (Ferrario *et al*., 2017).

Its native distribution range is the Northern Pacific and tropical Eastern Pacific (Lodola *et al*., 2015). The present distribution of this species extends from British Columbia to Ecuador and the Atlantic Sea (Soule & Soule, 1964; Canning-Clode *et al*., 2013). It was recorded in the Mediterranean in 2004 for the first time in Izmir Bay (Koçak, 2007). The first occurrence in the Adriatic Sea was reported in 2014, from Biograd na Moru, in the eastern Adriatic (Marić *et al*., 2017). The introduction pathway for this species is unknown. As it is commonly found in ports and harbours, as a fouling species on ships and artificial structures, shipping is probably the main pathway of introduction (Canning-Clode *et al*., 2013; Lodola *et al*., 2015).

This species has been known to inhabit tropical as well as warm and cool temperate waters (Soule & Soule, 1964). In the central Mediterranean, this species was mostly recorded during the warmer period of the year, from July to October (Lezzi *et al*., 2015). In Slovenia, however, the species was present sporadically all year round on the experimental plates at Morgan. The colonies were found on structures erected in late summer and autumn, after 5-12 months of exposure. Only a few colonies were observed on each experimental plate.

The colonies found in Slovenia were mostly green-coloured, which might be due to the presence of some microalgae as already observed in some other bryozoans (*e.g. A. verticillata* Marić *et al*., 2017). Besides the experimental plates, the species was found in a marina and was observed exclusively growing on the stolons of *A. verticillata* (Figures 2B and 3B). In total, we recorded this species on 9 sampling occasions.

***Tricellaria inopinata* d'Hondt & Occhipinti Ambrogi, 1985**

Tricellaria inopinata is a light brown to creamy coloured arborescent cheilostomatid bryozoan. It is dichotomously branched, with autozooids arranged in two rows. It has large lateral avicularia and globular, multi-pored ovicells. The scuta partially cover the opesia and are highly diverse in shape, even in a single colony, but they are usually antler-shaped (Dyrynda *et al*., 2000).

Although the native distribution of this species is unknown, it is assumed that the bryozoan originates from the Northern Pacific (Dyrynda *et al*., 2000). *T. inopinata* was first described in the Lagoon of Venice (d'Hondt & Occhipinti Ambrogi, 1985), where it spread rapidly throughout the lagoon. There it has been reported as an invasive NIS as it has replaced most of the native arborescent bryozoans in the area (Occhipinti Ambrogi & d'Hondt, 1994). Since then, it has been found at several locations, from the Eastern and Western Atlantic coasts to the Arctic Sea (De Blauwe & Faasse, 2001; Breton & d'Hondt, 2005; Arenas *et al*., 2006; Marchini *et al*., 2007; Buschbaum *et al*., 2012; Johnson *et al*., 2012; Cook *et al*., 2013; Porter *et al*., 2015). The introduction to Italy has been linked to the import and culture of the Pacific oyster (*Magallana gigas* (Thunberg, 1793)), whereas maritime traffic, specifically hull fouling, is a probable vector for the secondary diffusion of this species (Occhipinti Ambrogi, 2000; De Blauwe & Faasse, 2001; Cook *et al*., 2013).

T. inopinata was first spotted in the Slovenian costal sea at the site of a mussel farm, in Sečovlje in 2018.

Later, it was found at two other Slovenian mussel farming sites, Strunjan and Debeli rtič (Fortič & Mavrič, 2019). In 2019, large colonies, which covered mussel nets, mussels and ascidians, were found down to 8 m depth (Fig. 2D). A few colonies were found on boat hulls in Valdoltra harbour. In total, we recorded this species on 12 sampling occasions, 11 of them were at mussel farms (Fig 3D). Therefore, the exchange of fouled mussels between mariculture sites might be another plausible secondary diffusion vector for this species.

Even though *T. inopinata* has predominately been found on artificial structures, it was also observed attached to macroalgae and other sessile invertebrates (*e.g.* De Blauwe & Faasse, 2001; Cook *et al*., 2013). Recently, we discovered two interesting microhabitats of *T. inopinata*. Small colonies were found attached to a dead seagrass leaf floating near Cape Madona. On another occasion, a single colony of *T. inopinata* was found attached to a leg of a live *Dromia personata* (Linnaeus, 1758) crab at the Morgan experimental structures site in the Bay of Piran. These findings suggest that fouling on natural substrata can be a potential vector for small-scale diffusion of this species. Rafting, in particular, on natural and anthropogenic substrata, is widely used as a dispersal mechanism for both native and NIS species (Watts *et al*., 1998; Thiel & Gutow, 2005; Kuhlenkamp & Kind, 2013; McCuller & Carlton, 2018).

***Watersipora arcuata* Banta, 1969**

Watersipora arcuata is an encrusting cheilostomatid bryozoan belonging to the family Watersiporiidae. The autozooids are orange-red with dark mahogany-coloured opercula and autozooidal borders. The bryozoans of this family are hard to identify due to their lack of typical taxonomical features, namely, spines, avicularia and ovicells. *W. arcuata* was described in San Diego Bay, North-Eastern Pacific (Banta, 1969). There are several key diagnostic features distinguishing this species from other congeneric species. Most importantly, it has an arcuate proximal border of the orifice. Also essential for the identification, are the shape of the orifice and its height and length, the presence and shape of the sinus and condyles and the number of pseudopores (Vieira *et al.,* 2014).

The species is probably native in the tropical Eastern Pacific (Ulman *et al*., 2017). Nowadays, it is also present in San Diego Bay, the Gulf of California, the Galapagos, Australia, New Zealand and Hawaii (Skerman, 1960, Banta, 1969; Gordon & Mawatari, 1992; Coles *et al*., 1999; Mackie *et al*., 2012). This species was first recorded in the Mediterranean Sea from the marina of the Ligurian Sea in 2013 (Ferrario *et al*., 2015). Later, it was reported from the Sardinian Sea (Ferrario *et al*., 2017) and the waters of Sicily, Spain, Malta and Turkey (Ulman *et al*., 2017). Vessel fouling is, as discussed by Ferrario *et al.* (2015), the most probable vector of introduction for this and other watersiporid species.

The specimens found in Slovenia form scale-like encrusting colonies, which are dark red in colour (Fig. 2E). In this study, we report on the findings of this species at two localities (Fig. 3E). Many colonies, forming a belt at 0.5 m depth, were found in a shaded area of a marina, attached to a concrete wall during the summer of 2019. Moreover, this bryozoan was found on the experimental plates placed in the Bay of Piran near the Marine Biology Station (Morgan) (Fig. 3E). The plate, on which we found a single colony, was placed underwater in October 2018 and retrieved in January 2019. The plate was submersed for 89 days during the cold part of the year. Thus, the settlement and growth of organisms on the experimental plate was limited and the community consisted mainly of common pioneer fouling species. The most abundant organisms were the serpulid worm *Spirobranchus triqueter* (Linnaeus, 1758), covering 40% of the surface, and hydrozoans that were found on the edge of the experimental plate. Other native bryozoan species, which were not abundant, recorded on the plate were *Schizoporella dunkeri* (Reuss, 1848), *Terwasipora complanata* (Norman, 1864) and *Chorizopora brogniartii* (Audouin, 1826).

***Watersipora subtorquata* (d'Orbigny, 1852)**

Watersipora subtorquata, similary to *W. arcuata*, forms unilamellar colonies on flat substrata, becoming multilamellar and sometimes erect on irregular substrata. It is orange to brownish-purple or black. It is distinguished from other congeneric species by its distinct U-shaped sinus, an operculum with a parallel-sided dark central band with two proximal lucidae and tooth-like condyles (Vieira *et al*., 2014).

The bryozoans of the genus *Watersipora* have recently received a lot of attention from the scientific community, due to their invasive potential and the confusion regarding their identity (Ryland *et al*., 2009; Vieira *et al*., 2014). Two species were interchangeably misidentified, namely *W. subtorquata* and *W. subovidea* (d'Orbigny, 1852). The species *W. subtorquata* is now confirmed to be present in the Mediterranean Sea, as well as the Atlantic, Red Sea, Arabian Sea and the Pacific (Vieira *et al*., 2014). The first record for the Mediterranean is not reported accurately, due to the aforementioned confusion.

So far, *W. subtorquata* has been recorded at a single sampling location in the Slovenian coastal sea (Fig. 3F). Bright red unilamellar colonies were found attached sailing boat hulls in Piran harbour (Fig 2F), together with barnacle *Amphibalanus amphitrite* (Darwin, 1854) and *Bugula neritina s.l.*. The members of the genus *Watersipora* are known for their resistance to copper and copper-based antifouling paints, the latter can in some cases even facilitate the settlement of larvae (Wisley, 1958; McKenzie *et al*., 2012). Furthermore, studies have shown that watersiporid species can facilitate the settling of other, moderately copper-tolerant species (Dafforn, 2008; Piola & Johnston, 2009). Colonies were known to withstand high-speed cruises, where they are exposed

Tab. 1: Bryozoan species recorded in existing studies with habitat (1- marinas and harbours, a- vessel hulls, b- other substrates, 2- mussel farms, 3- experimental structures Morgan) and depth range for the species found in the Slovenian costal sea.
Tab. 1: Vrste mahovnjakov, ki smo jih zabeležili v raziskavi ter njihov habitat (1- marine in mandrači, a- trupi čolnov, b- druge podlage, 2- školjčišča, 3- eksperimentalne strukture Morgan) in razpon globin, kjer so bili najdeni v slovenskem obalnem morju.

SPECIES	HABITAT	DEPTH (m)
Amathia verticillata	1ab	0 - 3.5
Bugula neritina s.l.	1ab, 3	0 - 10
Celleporaria brunnea	1, 3	0 - 10
Tricellaria inopinata	1a, 2	0 - 9
Watersipora arcuata	1b, 3	0.5 - 9.5
Watersipora subtorquata	1a	0 - 2

to changing temperatures and other abiotic and biotic conditions (Allen, 1953). Therefore, it is not surprising that *W. subtorquata* was discovered for the first time in Slovenia, attached to a vessel hull.

Spatial and temporal distribution of non-indigenous bryozoans

All six species were present in port habitats (*e.g.* marinas and harbours) (Tab. 1). This is not unexpected, as harbours and marinas are one of the hotspots for bryozoan NIS (Ferrario *et al.*, 2017) and the proposed secondary diffusion vector for all of the reported species (Occhipinti Ambrogi, 2000; De Blauwe & Faasse, 2001; Canning-Clode *et al.*, 2013; Cook *et al.*, 2013; Ferrario *et al.*, 2015; Lodola *et al.*, 2015; Marchini *et al.*, 2015). In total, there are 17 mooring sites in Slovenia and, considering that the Slovenian coastline is approximately 46.7 km long, this means a high density of mooring sites, 0.36 per km. The majority of these sites are small local harbours, given that two thirds (10) of the mooring sites are less than 1 km long (Fig. 4). Regardless of their size, they are an important habitat for bryozoan NIS in Slovenia.

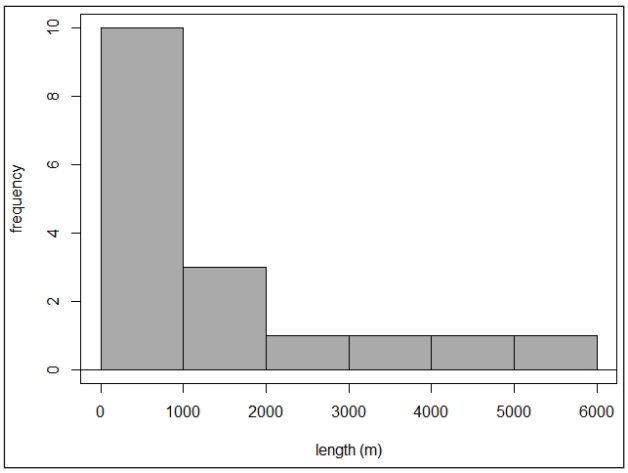

Fig. 4: Frequency distribution of the length of coastal stretch occupied by mooring sites (e.g. marinas, harbours, piers) along the Slovenian coast.
Sl. 4: Frekvenčna porazdelitev dolžine obale, ki jo zasedajo lokacije privezov (npr. marine, mandrači, pomoli) vzdolž slovenske obale.

However, *W. subtorquata* was only found on the hulls of sailing boats. Nevertheless, spreading to other immobile substrata is to be expected. Three species were present on the experimental plates in the Bay of Piran, namely *B. neritina s.l.*, *Celleporaria brunnea* and *W. arcuata*, although none of them was abundant. Moreover, *B. neritina s.l.* and *W. arcuata* were represented only by one colony. Therefore, even though the experimental plates were not a preferential habitat for most species, they proved to be a good indicator of the presence of bryozoan larvae in the water column.

Based on their occurrence on the experimental plates in Piran, more NIS were recorded during the colder part of the year (Tab. 2). *C. brunnea* was present on the experimental plates during all seasons, albeit in low abundances. Occasional *B. neritina s.l.* and *W. arcuata* colonies were present only during the winter. This may seem surprising for these species with assumed subtropical and tropical native range, especially when taking into account that the study area is characterised by the lowest winter temperatures in the Mediterranean Sea (Ogorelec *et al.*, 1991). There are several possible explanations for this observation. One of them might be the lack of competition at the time of settlement, which enabled the sporadic settlement of these opportunistic species. *B. neritina s.l.* was frequently found in harbours and marinas during the colder part of the year when larvae were also observed. Igić (2007) reports this it is

Tab. 2: Seasonal occurrence of non-indigenous bryozoan species on the experimental plates located at Morgan, Bay of Piran (+ = presence, - = absence).
Tab. 2: Sezonsko pojavljanje tujerodnih vrst na eksperimentalnih ploščah na lokaciji Morgan v Piranskem zalivu (+ = prisotna, - = odsotna).

Species	spring	summer	autumn	winter
Bugula neritina s.l.	-	-	-	+
Celleporaria brunnea	+	+	+	+
Watersipora arcuata	-	-	-	+

not a common feature of *B. neritina s.l.* in other parts of the Mediterranean Sea. Haplotype-specific differences in temperature-related fitness have been reported for *B. neritina s.l.* (Fehlauer-Ale *et al.*, 2013). In the future, it would be interesting to know which cryptic species of *B. neritina* is present in the Gulf of Trieste and if indeed it is the invasive one with the wider temperature tolerance.

The distribution data on bryozoan species presented in this study is not yet comprehensive. In order to understand the ecology and temporal as well as spatial distribution of each species better, more work should be done in the future.

Methodological approaches to the study of non-indigenous bryozoans and problematic areas

An important reason for the insufficient study of bryozoan xenodiversity is the lack of expert taxonomists (Ferrario *et al.*, 2018). The taxonomy of these animals is sometimes difficult and often requires expensive equipment such as a scanning electron microscope. Furthermore, bryozoans exhibit high polymorphism and intraspecific plasticity, which has led to many mistaken determinations in the past, followed by extensive revisions of entire genera (*e.g.* Fehlauer-Ale *et al.*, 2013; Vieira *et al.*, 2014). The lack of taxonomic expertise, combined with the small number of studies dealing with bryozoan ecology, compared to other taxonomic groups, can lead to imperfect data on the spatial distribution of bryozoan NIS.

As regards the best methodological approaches for assessing NIS, in our experience, combining several sampling techniques is the best practice. For example, encrusting species are harder to detect, especially if using a scraping net to scrape off the fouling community in marinas, harbours or mussel farms. That is because unilamellar colonies, which are attached directly to the substratum (*e.g.* vessel hulls), cannot be obtained in that way or are broken into small pieces. This is the main reason why underwater sampling techniques, snorkelling or scuba diving, is suggested as a method to supplement above water scraping techniques. Experimental plates or other structures are a good method for sampling non-target, fouling NIS (Tait & Inglis, 2016) and can provide an overview of temporal patterns of species occurrence. Thus, integration of the aforementioned methods is recommended for a more comprehensive overview of bryozoan NIS and other sessile invertebrates.

Finally, we would like to address the problem of determining the status of NIS. There is no consensus regarding the current number and identity of bryozoan NIS. The scientific community lacks a unified model for confirming the status of a NIS. Many criteria have to be met in order to grant this status, namely, ecological, geographical and evolutionary. Currently, the extent of knowledge on some species is unsatisfactory and there is no consensus among researchers regarding the status of those species (Gatto *et al.*, 2013; Katsanevakis *et al.*, 2015; Ferrario *et al.*, 2018). Early detection of new species, together with comprehensive ecological and genetic studies, focusing on clarifying introduction events and determining their natural distribution range, are important for the study of NIS. There is still a lot to be discovered, especially regarding the impact of NIS on the ecosystem (Bonnano & Orlando-Bonaca, 2019).

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OCENA KSENODIVERZITETE MAHOVNJAKOV V SLOVENSKEM OBALNEM MORJU

Ana FORTIČ, Domen TRKOV, Borut MAVRIČ & Lovrenc LIPEJ
Morska biološka postaja, Nacionalni inštitut za biologijo, SI-6330 Piran, Fornace 41, Slovenia
e-mail: ana.fortic@nib.si

POVZETEK

Mahovnjaki imajo pomembno vlogo v morskih obalnih ekosistemih, predvsem kot biokonstruktorji in filtratorji. Kljub temu je deblo Bryozoa ena najslabše preučenih skupin bentoških nevretenčarjev v slovenskem obalnem morju. Tujerodne vrste predstavljajo pet do deset odstotkov vseh vrst mahovnjakov v Sredozemskem morju. V prispevku predstavljamo posodobljen seznam morskih tujerodnih in kriptogenih vrst mahovnjakov Slovenije. Seznam vključuje šest vrst: Amathia verticillata, Bugula neritina s.l.*,* Celleporaria brunnea, Tricellaria inopinata, Watersipora arcuata *in* Watersipora subtorquata *z opisi morfologije, ekologije in razširjenostjo teh vrst v slovenskem morju. Obravnavamo vektorje vnosa in možne mehanizme razširjanja ter metodološke pristope in problematična področja preučevanja tujerodnih mahovnjakov. Za tri obravnavane vrste poročamo tudi o prvem pojavu v Slovenskem morju, in sicer za* A. verticillata, C. brunnea *in* W. subtorquata.

Ključne besede: tujerodne vrste, Bryozoa, severno Jadransko morje, pristaniški habitati, školjčišča, eksperimentalne plošče

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IMPACT OF THE PORT OF KOPER ON *CYMODOCEA NODOSA* MEADOW

Martina ORLANDO-BONACA, Janja Francé, Borut MAVRIČ & Lovrenc Lipej
Marine Biology Station, National Institute of Biology, SI-6330 Piran, Fornace 41, Slovenia
E-mail: martina.orlando@nib.si

ABSTRACT

In the Mediterranean Sea Cymodocea nodosa *is considered a valid indicator of environmental changes, due to its extensive distribution, sensitivity to different pressures, and measurability of species responses to those stressors. Navigation routes are recognized among the main pressures on the status of* C. nodosa *meadows in the Gulf of Trieste, related to a high resuspension of sediments and, in consequence, high water turbidity and reduced light levels. The MediSkew index was applied to samples collected in the* C. nodosa *meadow growing near the Port of Koper, and the ecological status was evaluated. The results were compared to those obtained for the* C. nodosa *samples from the reference site in the Gulf of Trieste, the Strunjan Nature Reserve.*

Key words: *Cymodocea nodosa,* MediSkew index, leaf lengths, Port of Koper, northern Adriatic Sea

IMPATTO DEL PORTO DI CAPODISTRIA SULLA PRATERIA DI *CYMODOCEA NODOSA*

SINTESI

Nel mare Mediterraneo Cymodocea nodosa *è considerata un valido indicatore di cambiamenti ambientali, vista la sua ampia distribuzione, sensibilità alle diverse pressioni e misurabilità delle risposte della specie a tali fattori di stress. Le rotte di navigazione vengono considerate tra le principali pressioni sullo stato delle praterie di* C. nodosa *nel Golfo di Trieste, legate a un'elevata risospensione dei sedimenti e, di conseguenza, a un'elevata torbidità dell'acqua e a livelli di luce ridotti. L'indice MediSkew è stato applicato ai campioni raccolti nella prateria di* C. nodosa *che cresce in prossimità del Porto di Capodistria per valutarne lo stato ecologico. I risultati sono stati confrontati con quelli ottenuti per i campioni di* C. nodosa *provenienti dal sito di riferimento nel Golfo di Trieste, la Riserva Naturale di Strugnano.*

Parole chiave: *Cymodocea nodosa*, indice MediSkew, lunghezza delle foglie, Porto di Capodistria, Adriatico settentrionale

INTRODUCTION

Marine angiosperms are worldwide considered as ecological engineers on shallow subtidal soft bottoms, since they create seagrass meadows, which are listed among the most valued ecosystems, providing food, shelters and nursery areas for a variety of invertebrate and fish assemblages (Heck *et al*., 2003; Wright & Jones, 2006; Como *et al*., 2008; Tuya *et al*., 2014; Espino *et al*., 2015). Additionally, seagrass meadows stabilize coastal sediments by trapping fine residues and particles that are suspended in the water column (Cabaço *et al*., 2008, 2010, 2014), provide protection against coastal erosion (Terrados & Borum, 2004), produce oxygen (Peduzzi & Vukovič, 1990) and are recognized as global carbon sinks (Duarte *et al*., 2010). For that reason, seagrass meadows are recognized as one of the priority habitats in the EU Habitat Directive (HD, 92/43/EEC).

Rapid and widespread decline of seagrass meadows were reported from many coastal areas (Orth *et al*., 2006; Tuya *et al*., 2013; Fabbri *et al*., 2015) in the last fifteen years. Coastal ecosystems are subjected to increasing anthropogenic disturbances, affecting light and nutrient resources (Hemminga & Duarte, 2000), and causing physical damage to different sea bottom types (Montefalcone *et al*., 2008; Marbà *et al*., 2014). Seagrasses have been disappearing at a rate of 110 km^2 yr^{-1} since 1980, a value equivalent to the loss rates described for mangroves, coral reefs, and tropical rainforests (Waycott *et al*., 2009). Changes observed in the global seagrass distribution point out that meadow regression phenomena should be principally attributed to the cumulative effects of local stressors, rather than to processes at basin scale, such us climate change (Telesca *et al*., 2015). The Regional Activity Centre for Specially Protected Areas (RAC/SPA) is responsible for drafting guidelines for carrying out impact studies on seagrass meadows within the Mediterranean basin. Pergent-Martini & Le Ravallec (2007) prepared such guidelines, but their real application at national levels is quite uncertain.

Four native seagrass species are present in the Adriatic Sea: *Posidonia oceanica* (Linnaeus) Delile, *Cymodocea nodosa* (Ucria) Ascherson, *Zostera marina* Linnaeus and *Zostera noltei* Hornemann (Lipej *et al*., 2006). The lesser Neptune grass, *C. nodosa*, is the most common marine angiosperm at shallow sheltered to semi-exposed sites in the Adriatic Sea, as well as along all Mediterranean soft bottom areas and at some locations in the north Atlantic (Mascaró *et al*., 2009; OSPAR, 2010). This species is known to form meadows that are mono-specific or mixed with *Z. noltei*, from the surface to 40 m of depth (Mazzella *et al*., 1993; Borum & Greve, 2004). In the Mediterranean Sea, *C. nodosa* is considered as an effective indicator of environmental changes, due to its universal distribution, sensitivity to different natural and anthropogenic pressures, and measurability of species responses to those effects (Orfanidis *et al*., 2007, 2010; Oliva *et al*., 2012; Orlando-Bonaca *et al*., 2015; Papathanasiou *et al*., 2016). Although *C. nodosa*, is characterized by a large phenotypic plasticity and is adapted to various natural and anthropogenic stressors by different physiological and morphological adaptations (Tsioli *et al*., 2018), in recent decades the species faced a severe decline in several Mediterranean and Atlantic areas (Jensen & Bell, 2001; Papathanasiou, 2013; Rosell-Fieschi & Polifrone, 2014; Fabbri *et al*., 2015).

There is still a lack of long time data series in the northern Adriatic Sea in order to support the conservation status of meadows of *C. nodosa,* while the species is currently protected only within spatially restricted Marine Protected Areas (MPAs). The ecological status of seven *C. nodosa* meadows was recently evaluated in the northern Adriatic area with the MediSkew index (Orlando-Bonaca *et al*., 2015; 2016), developed in accordance with the EU Water Framework Directive (WFD, 2000/60/EC) and the Marine Strategy Framework Directive (MSFD, 2008/56/EC) requirements.

Navigation routes are recognized among the main pressures on the status of *C. nodosa* meadows (Orlando-Bonaca *et al*., 2015) in the Gulf of Trieste, related to a high resuspension of sediments and, in consequence, high water turbidity and reduced light levels. Therefore, the aim of this study was to assess the ecological status of the *C. nodosa* meadow growing near the Port of Koper, and discuss the results in comparison to those obtained for the *C. nodosa* meadow from the reference site for this species, the MPA Strunjan Nature Reserve.

MATERIAL AND METHODS

Study area, fieldwork and laboratory work

The Port of Koper is a Slovenian multi-purpose seaport, situated in the northern Adriatic Sea, connecting mainly markets of Central and Southeast Europe with the Mediterranean Sea and Far East. The marine part of the cargo port is composed of three basins (Fig. 1), associated mooring piers and 12 specialized loading terminals (Geodetski Inštitut Slovenije, 2016). The resuspension of sediments is mainly due to the vessel propulsion along navigation routes and by the assistance of tugboats within the port's basin and in front of them. The highest turbidity values were measured during the manoeuvres of large vessels (Žagar *et al*., 2014). In the last decade the Port of Koper also ordered dredging works on the sedimentary bottom along the access channels to Basin I (Luka Koper, 2015), leading to a high sedimentation/resuspension rate.

Cymodocea nodosa samples were collected in July 2018, according to the sampling protocol presented by Orfanidis *et al*. (2007). Within the seagrass meadow found near the Port of Koper, two sites (LuKp1 and LuKp2) were chosen (Fig. 1) along the same isobath

(3 m) and, within each site, two areas (LuKp1_1, LuKp1_2, and LuKp2_1, LuKp2_2) were selected that were ca. 100 m apart. Within each area, five metallic quadrats (25 cm x 25 cm) were randomly placed on the bottom by SCUBA divers. Those five quadrats were considered as replicates of one sample. All shoots of *C. nodosa* enclosed by each quadrat were carefully uprooted. Samples were labelled and individually placed in plastic bags.

To adequately assess time-based trends in the status of *C. nodosa* meadows, including evaluations of the effects of natural disturbances within MPAs, new samples were collected in July 2018 also within the Strunjan Nature Reserve (Fig. 1). The sampling site Cy2 (areas Str_3 and Str_4) was previously sampled in June 2009 and July 2013 and, according to the low score of the Pressure Index for Seagrass Meadows (PISM), the area Str_3 was chosen as the reference area for *C. nodosa* in the Gulf of Trieste (Orlando-Bonaca *et al.*, 2015).

The samples of *C. nodosa* were stored in a freezer at –20°C at the laboratory of the Marine Biology Station Piran. They were slowly defrosted in a refrigerator on the day prior to analysis. Seagrass shoots were then retained in plastic washbasins with seawater. Twenty shoots from each quadrat were randomly chosen (Orfanidis *et al.*, 2007). For each leaf (usually 5-6 leaves per shoot), the following parameters were measured to the nearest mm: length of the sheath, length of the photosynthetic part, and its width. The age of the leaf was designated as adult (if the sheath was well-developed), intermediate (if the sheath was faintly shaped at the leaf basis), and juvenile (if the sheath was absent). The above measurements were made on at least 60 undamaged photosynthetically active leaves (adults and/or intermediates) from each quadrat. One sample was composed of five replicates of 60 leaves (300 leaves in total).

Fig. 1: Map of sampling sites for** Cymodocea nodosa **in Slovenian marine waters in 2018: near the Port of Koper (LuKp1 and LuKp2) and in the Moon Bay (Cy2), within the Strunjan Nature Reserve.
Sl. 1: Zemljevid vzorčevalnih lokalitet kolenčaste cimodoceje v slovenskem morju v 2018: blizu Luke Koper (LuKp1 in LuKp2) in v Mesečevem zalivu (Cy2) znotraj naravnega rezervata Strunjan.

Data analysis

To explore the nature of leaf lengths of *C. nodosa* in the two sampling locations, frequency histograms of ln-transformed data of lengths of the photosynthetic part of leaves (adult and intermediate) were prepared. In parallel, summary statistics for each area were examined. The normal distribution of ln-transfomed leaf lengths in every area was tested with the Kolmogorov-Smirnov test for normality (Dytham, 2003).

To quantify changes in the photosynthetic part of leaf length distribution, the MediSkew index was calculated (for details see Orlando-Bonaca *et al.*, 2015). Boundaries among status classes for the MediSkew index were set equidistantly (Table 1). Five status classes are adequate for the assessment of the Ecological Status (ES) according to the WFD. Furthermore, High and Good classes indicate a Good Environmental Status (EnS) according to the MSFD, while classes Moderate, Poor and Bad are considered as Not Good EnS.

Tab. 1: Boundaries among status classes for the MediSkew index. For the assessment of ES according to WFD, five classes should be used. For the assessment of EnS according to the MSFD, classes High and Good indicate a Good EnS, while classes Moderate, Poor and Bad are considered as Not good EnS (see Orlando-Bonaca et al., 2015).
Tab. 1: Meje med posameznimi razredi stanja za MediSkew indeks. Za opredelitev ekološkega stanja po Evropski vodni direktivi (OVS) smo uporabili 5 razredov. Za opredelitev okoljskega stanja po Okvirni direktivi o morski strategiji (ODMS), razreda Zelo dobro in Dobro označujeta Dobro okoljsko stanje, medtem ko razredi Zmerno, Slabo in Zelo slabo opredeljujejo Slabo okoljsko stanje (po Orlando-Bonaca in sod., 2015).

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

RESULTS

Cymodocea nodosa leaf length parameters in 2018

C. nodosa parameters per sampling area are reported in Table 2, while frequency distributions of leaf lengths in different areas are presented in Fig. 2. *C. nodosa* leaves were much shorter in the areas within the Moon Bay (Cy2) than in those near the Port of Koper, and consequently also the median values (Tab. 2, Fig. 2).

The differences in the median values of leaf lengths between sampling areas LuKp1_1 and LuKp1_2 were statistically significant (Mann-Whitney U = 52219.5, $P = 0.0003$), as well as those between sampling areas LuKp2_1 and LuKp2_2 (U = 53753.5, $P < 0.0001$), and between sampling areas Str_3 and Str_4 (U = 48975, $P = 0.0306$). Moreover, also between sampling sites LuKp1 and LuKp2 (U = 247070.5, $P < 0.0001$), between LuKp1 and Cy2 (U = 336657.5, $P < 0.0001$), and between LuKp2 and Cy2 (U = 331878, $P < 0.0001$), all the differences in the median values of leaf lengths were statistically significant.

Taking into account the frequency distributions of ln-transfomed leaf lengths of every single sample (Fig. 2), the Kolmogorov-Smirnov test for normality revealed that only the samples from areas Str_3 and Str_4 are normally distributed (D = 0.047, $P > 0.05$, and D = 0.026, $P > 0.05$, respectively), while all the other samples are not normally distributed. Accordingly, the skewness |G| was the lowest for the sample from area Str_4, while was the highest at the area LuKp2_1 (Tab. 2).

Assessment of the status of *Cymodocea nodosa*

MediSkew index values for each sampled area are presented in Table 3. The lowest value of MediSkew was found for the area Str_4, which was the closest to virtual reference conditions (MediSkew = 0). The highest values of MediSkew were calculated from samples collected at the area LuKp1_1 (Tab. 3), the nearest to the Port of Koper.

The Ecological Status (according to the WFD) and the Environmental Status (according to the MSFD) of sampling sites were assessed according to the boundaries in Table 1. Site Cy2 (and also both areas) was classified as High ES, site LuKp1 as Bad ES and LuKp2 as Poor ES (Table 3). According to MSFD requirements, only the samples collected in Cy2 (both areas) achieved a Good EnS.

DISCUSSION

The MediSkew value at site Cy2 in July 2018 was even lower than the value in July 2013 (MediSkew = 0.05) and in June 2009 (MediSkew = 0.08; for details see Orlando-Bonaca *et al.*, 2016). This result confirms that this site can still be considered as the reference site for the Gulf of Trieste. However, in 2018 the area Str_4 had a lower MediSkew value than the reference area Str_3, even if the difference between the MediSkew values for the two areas is insignificant (Tab. 3). According to PISM, site Cy2 is still without any anthropogenic pressures, apart from the impact of bathing in the summer period. However, since the site is difficult to reach from the hinterland and anchoring in the bay is not allowed, to our opinion this pressure could be considered as negligible. Light conditions for the *C. nodosa* meadow in the Moon Bay are mostly influenced by natural sedimentation rates and resuspension of sediments due to the erosion of an 80 m high flysch cliff along the coastline.

The leaves of *C. nodosa* sampled in the meadow near the Port of Koper are the longest measured in Slovenian coastal waters so far (see previous results in

Tab. 2: Statistic parameters (minimum, maximum, mean, median) and absolute value of skewness (|G|) of ln-transformed lengths of photosynthetically active parts of** Cymodocea nodosa **leaves from the sampling areas in sites near the Port of Koper (LuKp1 and LuKp2) and in Moon Bay (Cy2, Strunjan Nature Reserve) in 2018. The reference median value in 2018 was 13.95 cm.
Tab. 2: Statistični parametri (minimum, maksimum, povprečje, mediana) in absolutna vrednost koeficienta asimetrije (|G|) ln-transformiranih dolžin fotosintetsko aktivnega dela listov kolenčaste cimodoceje iz lokalitet blizu Luke Koper (LuKp1 in LuKp2) in v Mesečevem zalivu (Cy2, Naravni rezervat Strunjan) v 2018. Referenčna mediana v 2018 je bila 13,95 cm.

Site	Area	Date	min length (cm)	max length (cm)	mean (cm)	median (cm)	|G|
Cy2	Str_3	12.7.2018	5.4	30.5	14.5	13.95	0.261
	Str_4	12.7.2018	8.1	22.7	13.5	13.20	0.022
LuKp1	LuKp1_1	17.7.2018	5.9	66.2	37.8	41.25	1.423
	LuKp1_2	17.7.2018	6.0	57.1	34.7	37.05	1.162
LuKp2	LuKp2_1	17.7.2018	3.7	58.8	30.7	30.45	1.533
	LuKp2_2	17.7.2018	6.9	52.2	27.3	28.25	1.130

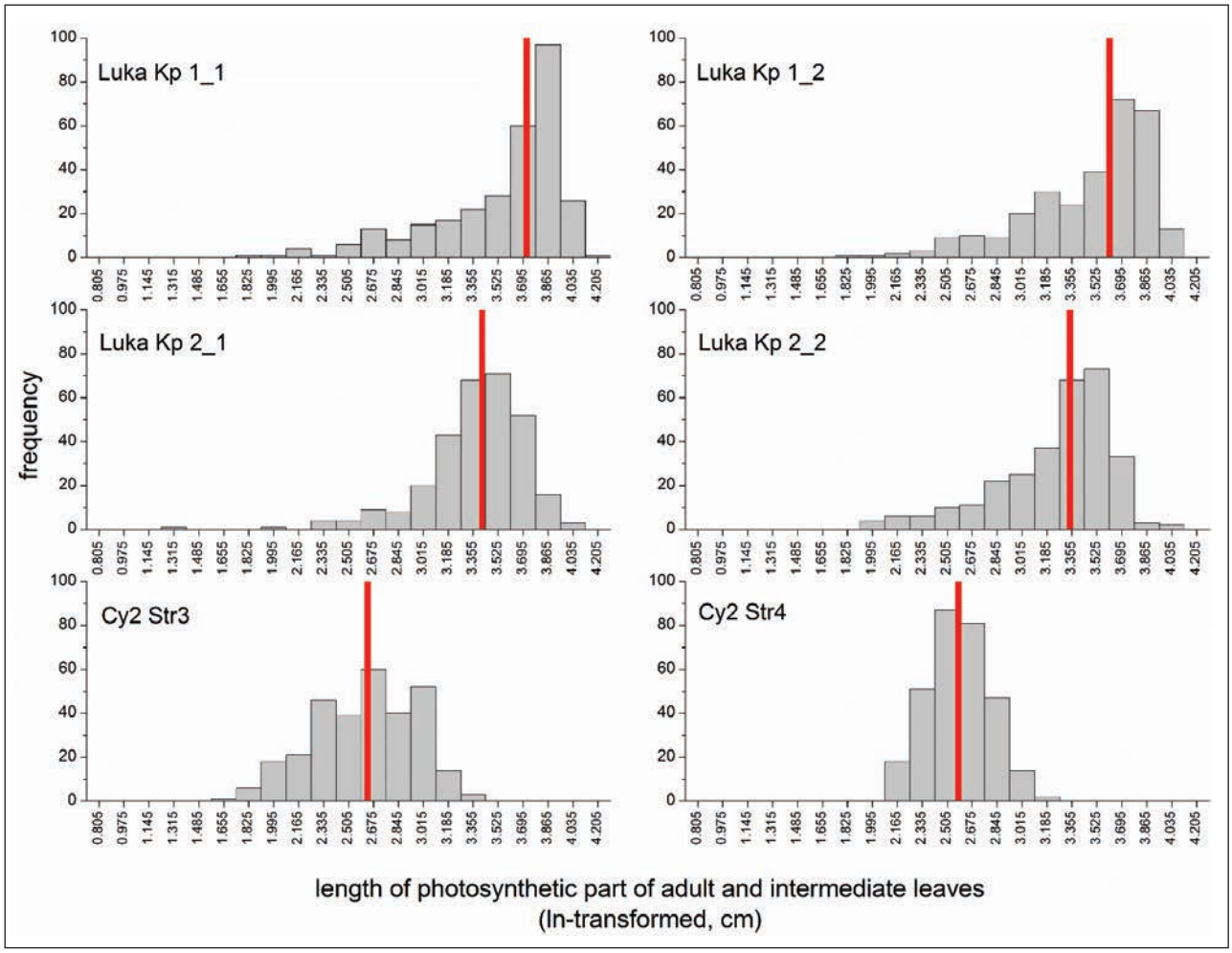

Fig. 2: Frequency histograms of ln-transformed lengths of the photosynthetic part of adult and intermediate leaves (n = 300) for *Cymodocea nodosa* ***in the four areas near the Port of Koper (LuKp1_1, LuKp1_2, LuKp2_1, LuKp2_2) and two areas in the Moon Bay (Str_3 and Str_4) in 2018. Median lengths are denoted by red vertical lines.***
Fig. 2: Frekvenčni histogrami ln-transformiranih dolžin fotosintetskega dela odraslih in srednjih listov (n = 300) za kolenčasto cimodocejo na štirih območjih v bližini koprskega pristanišča (LuKp1_1, LuKp1_2, LuKp2_1, LuKp2_2) in dveh območjih v Mesečevem zalivu (Str_3 in Str_4) v letu 2018. Mediane so označene z rdečimi navpičnimi črtami.

Orlando-Bonaca *et al.*, 2015). Seagrasses are mostly light-limited (Touchette & Burkholder, 2000) therefore, when exposed to low light levels due to high water turbidity, they respond by an increasing allocation of biomass to leaves. By prolonging leaves, marine plants can capture more light and convert it into photosynthetic production (Greve & Binzer, 2004). According to the present results, we hypothesize that the sampling area LuKp1_1, the closest to the Port of Koper, is the most impacted by sediment resuspension due to maritime traffic. Since the average maximum leaf length at site LuKp2 (55.5 cm) is lower than at site LuKp1 (61.65 cm) we can assume that with the increasing distance from the Port of Koper the sediment resuspension rate is decreasing.

In order to identify and monitor the main pressures on seagrass meadows and other benthic communities, and to correctly set threshold values, the Port of Koper should prepare and implement a long-term monitoring program inside the harbor area and in its surrounding, especially for water turbidity related to sediment resuspension/deposition. Recently, Airoldi *et al.* (2016) summarized the status and trends of the harbour of Ravenna in order to provide scientific support for the regeneration project of this area and to increase the resilience of local fragile ecosystems. The preparation of such an overview would be very useful also for the Port of Koper. Moreover, a long-term monitoring of the status of the *C. nodosa* meadow growing in the immediate vicinity of the port area is strongly recommended.

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Tab. 3: MediSkew index values for studied sampling areas of** Cymodocea nodosa **in 2018 and assessment of the Ecological Status (according to the WFD) and Environmental Status (according to the MSFD) in the Moon Bay and near the Port of Koper.
Tab. 3: Vrednosti indeksa MediSkew za raziskane lokalitete s kolenčasto cimodocejo v 2018 in opredelitev ekološkega stanja (glede na OVS) in okoljskega stanja (glede na ODMS) v Mesečevem zalivu in blizu Luke Koper.

Site	Area	Area's MediSkew	Site's MediSkew	Ecological Status	Environmental Status
Cy2	Str_3	0.065	0.04	High	Good / Achieved
	Str_4	0.024			
LuKp1	LuKp1_1	1.00	0.94	Bad	Not good / Not achieved
	LuKp1_2	0.87			
LuKp2	LuKp2_1	0.79	0.715	Poor	Not good / Not achieved
	LuKp2_2	0.64			

VPLIV KOPRSKEGA PRISTANIŠČA NA TRAVNIK KOLENČASTE CIMODOCEJE (*CYMODOCEA NODOSA*)

Martina ORLANDO-BONACA, Janja Francé, Borut MAVRIČ & Lovrenc Lipej
Marine Biology Station, National Institute of Biology, SI-6330 Piran, Fornace 41, Slovenia
E-mail: martina.orlando@nib.si

POVZETEK

*Kolenčasta cimodoceja (*Cymodocea nodosa*) je zaradi široke razprostranjenosti v Sredozemskem morju, občutljivosti na razne pritiske in merljivosti odziva na te pritiske uporabna kot dober indikator okoljskih sprememb. Med glavnimi pritiski je v Tržaškem zalivu še posebej pomembna plovba na plovnih poteh, ki povzroča znatno resuspenzijo sedimentov in posledično veliko turbidnost ter slabo osvetljenost. Avtorji so vzorce, nabrane na morskem travniku kolenčaste cimodoceje blizu Luke Koper uporabili za ovrednotenje ekološkega stanja z uporabo MediSkew indeksa. Dobljene rezultate so primerjali z rezultati iz referenčnega območja v strunjanskem naravnem rezervatu.*

Ključne besede: *Cymodocea nodosa,* MediSkew indeks, dolžine listov, Luka Koper, severni Jadran

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FOOD AND FEEDING HABITS OF *MUSTELUS MUSTELUS* (LINNAEUS, 1758) (CHONDRICHTHYES: TRIAKIDAE) ALONG THE WESTERN COAST OF LIBYA

Akraam Faraj KARA, Mohamed AL HAJAJI & Hisham GHMATI
Biodiversity department - Marine biology research center, Tajura, Libya

Esmail A. SHAKMAN
Zoology department, Tripoli University, Libya
e-mail: shugmanism@yahoo.com

ABSTRACT

A total of 269 individuals of Mustelus mustelus *(Linnaeus, 1758) were provided through monthly collection by fishermen from the western coast of Libya (South Mediterranean) between November 2015 and November 2016. Each specimen was measured, weighed and dissected to investigate the food and feeding habits. Teleosts were the most important prey of* M. mustelus*, especially in individuals bigger than 90 cm TL. Crustaceans were the second most important and abundant prey for small individuals, whereas other prey groups were of minor importance and probably constituted just incidentally ingested food. Diet composition showed little seasonal variation: teleosts were the most important prey taxon in all seasons, except in autumn. The results indicate that* M. mustelus *can be considered as an opportunistic predator feeding on a wide range of prey items.*

Keywords: Smooth-hound, Diet, South Mediterranean, Libya

ABITUDINI ALIMENTARI DI *MUSTELUS MUSTELUS* (LINNAEUS, 1758) (CHONDRICHTHYES: TRIAKIDAE) LUNGO LA COSTA OCCIDENTALE DELLA LIBIA

SINTESI

Un totale di 269 individui di Mustelus mustelus *(Linnaeus, 1758) sono stati forniti attraverso la raccolta mensile dei pescatori della costa occidentale della Libia (Mediterraneo meridionale) tra novembre 2015 e novembre 2016. Ogni esemplare è stato misurato, pesato e dissezionato per indagare sul tipo di nutrimento e sulle abitudini alimentari. La preda più importante di* M. mustelus *sono risultati i teleostei, specialmente negli individui di dimensioni superiori a 90 cm di lunghezza totale. I crostacei sono risultati la seconda preda più importante e abbondante per i piccoli individui, mentre gli altri gruppi di prede sono di minore importanza e probabilmente costituiscono solo cibo ingerito casualmente. L'analisi della composizione della dieta ha evidenziato piccole variazioni stagionali, e i taxon di teleostei sono risultati le prede più importanti in tutte le stagioni, tranne in autunno. Secondo i risultati dello studio* M. mustelus *può essere considerato un predatore opportunista che si nutre di una vasta gamma di prede.*

Parole chiave: palombo, dieta, Mediterraneo meridionale, Libia

INTRODUCTION

In the Mediterranean, Chondrichthyes species presently have lower commercial value than Osteoichthyes and shellfishes; they only represent about 0.78 % of total landings (Cavanagh & Gibson, 2007; Di Francesco, 2010). But because of general fishing pressure, they have become vulnerable since they are often captured as bycatch by bottom trawl fleets (Ragnese *et al*., 2013). According to the statistics of the Fisheries and Agriculture Organization of the United Nations (FAO), the Chondrichthyes stock declined in the Mediterranean between 1970 and 1985, with landings increasing from 10,000 to 25,000 tonnes and then slowly decreasing back to 10,000 tonnes in 2000. Recently, Bradai *et al*., (2012) reported that landings declined to 7000 tonnes. The impact of fishing on Chondrichthyes stocks has become an issue of global concern. Thus, working groups and experts, such as the IUCN Sharks Specialist Group, have developed an international action plan for the conservation and management of shark exploitation, as well as lists of species in the Annexes of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) (Stevens *et al.,* 2000). Moreover, there are many efforts at regional level, such as the Elasmobranchs studying group as one of the specific scientific groups in GFCM, and at sub-regional level, such as the Elasmobranchs working group within the MedSudMed project, with Libya as one of the main parties.

M. mustelus, commonly called the smooth-hound, is often characterized as a slender shark with a long parabolic subangular snout, dorsolateral eyes, an angular mouth, pavement teeth with cusps usually obsolete or absent, and the second dorsal fin nearly as large as the first. The species has a grey-brown back and is white underneath (Compagno, 1984). It is widespread in the Eastern Atlantic Ocean from the British Isles to South Africa and common in the Mediterranean Sea (Compagno, 1984; Goosen & Smale, 1997). *M. mustelus* is more common than the other two species of the same genus (Serena *et al*., 2009). This demersal species inhabits water depths ranging from shallow to 350 m, but is most commonly found in shallow waters, in the depth range of 5 to 50 m, on sandy and clay bottoms (De Maddalena *et al*., 2001; Serena*,* 2005). The catches of this species registered a decline of 85% between 1994 and 2006, however, there have been no actions undertaken to protect or regulate the exploitation of the shark in its range areas (Serena *et al.,* 2009).

Diet composition, which can identify the type of food preferred by each species of fish, is considered as an indicator of the availability of food in the region. In the present study, it showed that in the Gulf of Gabes (southern Tunisia, central Mediterranean Sea) *M. mustelus* feeds mainly on crustaceans, fish and cephalopods. Polychaetes, sipunculids and echinoderms are occasional preys, and there is no difference between the diets of males and females (Saidi *et al*., 2009). In a similar study conducted in Turkey in 2005, the diet of this species was heterogeneous and generalized, and it was found that crustaceans were consumed by most of the individuals (Filiz *et al*., 2009). Dietary studies for *M. mustelus* from the Adriatic Sea report that their diet mainly consists of crustaceans, teleosts and cephalopods (Jardas *et al.,* 2007a). The diet composition analysis from South Africa (Smale & Compagno, 1997) and Mauritania (Khallahi, 2004) showed similar conclusions. In addition, a study comparing the history of life and biology of two species of sympatric coastal shark, *M. mustelus* and *M. palumbes*, off southern Africa was described (Smale & Compagno, 1997). Morte *et al.* (1997) studied the feeding habits of juveniles (total length below 75 cm) in the Gulf of Valencia. Another study was conducted to describe the diet composition of the common smooth-hound in the northern Adriatic, linking its feeding habits to the structure of the gastrointestinal parasite community and providing new insight into the life cycles of the identified parasites (Gračan *et al.,* 2014).

Studies of population dynamics, such as age and growth, along with basic information on distribution, abundance, feeding and reproduction are essential for biologists to understand and predict the trend of population growth and the species' response to fishing pressure. There are no comprehensive studies that examine the biological aspects of Chondrichthyes in the Libyan coast. Therefore, the present study aims to provide new findings on the diet of *M. mustelus* along the western Libyan coast of the southern Mediterranean Sea.

MATERIAL AND METHODS

Samples of *M. mustelus* were collected monthly from fishermen on the western coast of Libya (Tripoli), between November 2015 and November 2016. The fish were transferred to the biodiversity laboratory of the Marine Biology Research Centre, where the samples were sorted and sexed, as well as measured for total length (TL) to the nearest centimetre and weighed for total weight (TW) to the nearest 10 g (Compagno, 1984). Each specimen was dissected with a ventral incision from the cloaca to the pectoral girdle in order to expose the body cavity. The stomach was removed, weighed and preserved in a 10% formaldehyde-seawater solution.

Stomach contents were examined as soon as possible after capture. Preys were identified to the lowest possible taxon. The excess liquid was drained off and the remaining mass of wet prey was determined to the nearest 0.1 g. The importance of prey was evaluated using the frequency of occurrence percentage (F %), percentage by number (% N) and percentage by wet mass (M %) (Pinkas *et al.,* 1971; Cortes, 1997; Morato *et al.,* 2003). The index of relative importance (IRI) fol-

lowing Pinkas *et al.* (1971) and modified by Hacunda (1981) was used: IRI = % F x (% N + % W). This index, which integrates the three previous percentages, allows a much more accurate interpretation of the diet by minimizing the skews caused by each of these percentages. The contribution of each prey in the diet was also estimated with the Index of Relative Importance (IRI) and its standardized value (% IRI) (Pinkas *et al.*, 1971; Cortés 1997). For assessing the diet in relation to shark size, the specimens were grouped in four size classes according to ontogenetic development: I = newborns, II = juveniles, III = subadults and IV = adults.

RESULTS

A total of 269 stomachs of *M. mustelus* were examined, 91 of them were empty (25.27 %). The diet of the specimens consisted of five major systematic groups: teleosts, crustaceans, cephalopods, nemerteans and polychaetes. Teleosts were the most important prey, constituting 50.29 % of the total IRI, followed by crustaceans (% IRI = 33.76) (Tab. 1). The relative importance of cephalopods, nemerteans and polychaetes was comparatively low.

Diet changes according to ontogenetic development

The diets were calculated and expressed as (% IRI in Fig. 1 according to the ontogenetic development of *M. mustelus* specimens from the southern Mediterranean.

Newborns

In the size class of newborns, crustaceans were the most important prey group (% IRI = 68.82), followed by teleosts (% IRI = 31.17).

Tab. 1: Major prey groups in the diet of** M. mustelus **from the western coast of Libya, by percentage number (% N), percentage weight (% W), frequency of occurrence (% F) and index of relative importance (% IRI).
Tab. 1: Najpomembnejše skupine plena v prehrani navadnega morskega psa ob zahodni libijski obali. Legenda: delež števila plena (% N), delež mase plena (% W), frekvenca pojavljanja plena (% F) in indeks relativne pomembnosti plena (% IRI).

Prey group	F %	N %	W %	% IRI
Crustacea	57.62	42.74	14.83	33.76
Teleostei	59.47	30.82	52.26	50.29
Cephalopoda	13.50	5.44	16.46	3.00
Nemertea	34.94	19.94	16.29	12.88
Polychaeta	4.00	1.03	0.14	0.04

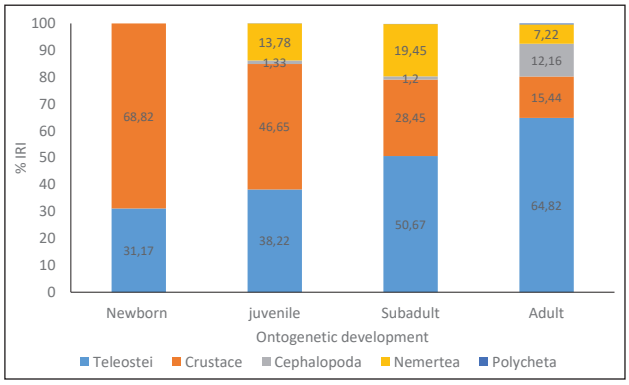

Fig. 1: Ontogenetic differences in the diet of** M. mustelus **from the western Libyan coast, expressed as % IRI.
Sl. 1: Ontogenetske razlike v prehrani navadnega morskega psa ob zahodni libijski obali, izražene kot delež indeksa relativne pomembnosti plena.

Juveniles

Crustaceans were the most frequent prey (% IRI = 46.65), followed by teleosts (% IRI = 38.22). Nemerteans (% IRI = 13.78) were the third most important group, while cephalopods and polychaetes represented minor components of the diet.

Subadults

Teleosts were the dominant prey consumed (% IRI = 50.67), followed by crustaceans (% IRI = 28.45) and nemerteans (% IRI =19.45). Cephalopods (% IRI = 1.2) and polychaetes (% IRI = 0.04) were minor components in the diet.

Adults

Teleosts were the most important prey category (% IRI = 64.82), followed by crustaceans (% IRI =15.44) and cephalopods (% IRI = 12.16), while nemerteans represented a minor component (% IRI = 7.22).

Seasonal changes in diet

The diets of *M. mustelus* in the south Mediterranean were also calculated and expressed as % IRI according to seasonal changes (Fig. 2): in spring, teleosts were the dominant group (% IRI = 64.72), followed by crustaceans (% IRI = 15.66) and cephalopods (% IRI =15.17). In summer, teleosts were the most frequently captured prey category (% IRI = 53.75), followed by crustaceans (% IRI = 35.51), while nemerteans and cephalopods were only minor components in the diet. In autumn, crustaceans constituted the bulk of the diet (% IRI = 45.16), followed by teleosts (% IRI = 33.49) and nemerteans (% IRI = 17.88). In winter, the relative importance of teleosts was

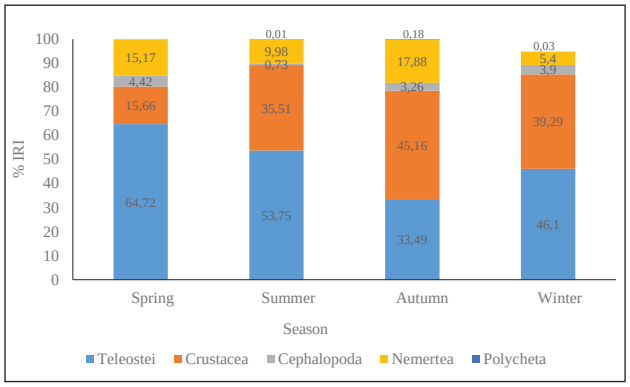

Fig. 2: Seasonal changes in the diet of* M. mustelus *from the western Libyan coast expressed as % IRI.
Sl. 2: Sezonske razlike v prehrani navadnega morskega psa ob zahodni libijski obali, izražene kot delež indeksa relativne pomembnosti plena.

high (% IRI = 46.1), followed by crustaceans (% IRI = 39.29), while nemerteans, cephalopods and polychaetes were minor components of the diet.

DISCUSSION

To understand the biological interactions of organisms in their ecosystem it is necessary to know the relationships and differences related to their diets and food consumption (Lopez *et al.,* 2009, 2012). Therefore, qualitative and quantitative analyses of feeding habits are very helpful in determining the level and abundance of prey eaten by each species in their habitats (Movillo & Bahamonde, 1971; Lopez *et al.,* 2012). Moreover, quantitative studies using the same approach can estimate the predation and, consequently, reflect the important factors and dependencies in predator diets (Wootton, 1990; Abrams, 2000; Lopez *et al.,* 2012). In this study, the results indicated that *M. mustelus* feeds on benthic and demersal preys, thus determining the feeding behaviour of this species as demersal. There were no gender-specific differences or requirements in the diet of *M. mustelus*, which suggests that the foraging habits are similar in both sexes or that they encounter the same prey items in their environments. In addition, the study provided broad support that this species could be an opportunistic predator, feeding on a variety of prey items (Cappe, 1975; Morte *et al.,* 1997; Smale & Compagno, 1997; Costantini *et al.,* 2000; Khallahi, 2004; Jardas *et al.,* 2007a; Saidi *et al.,* 2009). Its predatory habits indicate that *M. mustelus* feeds mainly on crabs, mantis shrimp, shrimp living on sandy and soft sedimentary bottom, pelagic and benthopelagic teleosts, cephalopods, nemerteans, and polychaetes (Jardas, 1996; Tortonese, 1956; Bini, 1967; Branstetter, 1986; King & Clark, 1984; Kamura & Hashimoto, 2004; Jardas *et al.,* 2007b; Saidi *et al.,* 2009; Filiz, 2009). There were, however, regional differences among prey species. The study showed that the diet consisted of five major systematic groups: crustaceans, teleosts, cephalopods, polychaetes and nemerteans. The identified preys belonged to 5 families of crustaceans, 5 families of teleosts and 2 families of cephalopods, in addition to a few unidentified species. Teleosts were the most important prey group of *M. mustelus* on the western coast of Libya, constituting (% IRI = 50.29) of the total IRI, Additionally, they were the dominant prey by mass (W % = 52.26) and had the highest frequency (F % = 59.47). This is probably due to the abundance and diversity of fishes along this coastline (Tab. 1). Crustaceans were the second most frequent prey (% IRI = 33.76), all of them belonging to the order of decapods (shrimp, crabs, and Mantis shrimps, as well as members of the Penaeidae, Majidae, Portunida, Carapidae and Squillidae, and some unidentified species).

The most consumed teleost species were mainly demersal, but there were also many pelagic species present (e.g., scombrids, clupeids). Thus, it can be determined that the smooth-hound is the major predator of benthic teleosts as well as of some species of the same genus, particularly *M. palumbes, M. henlei, M. canis,* and *M. antarcticus* (Capapé, 1975; Compagno, 1984; Simpfendorfer *et al.,* 2001). Most of the cephalopods were quantitatively important, for instance, members of the Sepiidae and Octopodidae (octopods were dominant by mass, and crustaceans were numerically important). This finding is in accordance with a study carried out by Saidi *et al.* (2009). While nemerteans represented 12.88 % of total IRI, cephalopods (octopods and sepia) stood at 3 % and polychaetes at 0.04 % of total IRI as minor components of the diet. In contrast, Smale and Compagno (1997), Costantini *et al.* (2000), Khallahi (2004), Jardas *et al.* (2007a), Saidi *et al.* (2009), Filiz (2009) recorded that this species feeds primarily on decapod crustaceans and to a lesser extent on teleosts.

Size-related changes in the diet were considered; the data obtained showed that the diet composition of *M. mustelus* changes considerably with its growth (Morte *et al.,* 1997; Smale & Compagno, 1997; Jardas *et al.,* 2007a; Saidi *et al.,* 2009), and there is a slight increase in prey diversity with the increase of shark size. These changes may be related to altered environmental conditions or to the changing energy requirements of the animal.

The new-born and juvenile sharks under study fed mainly on crustaceans (% IRI = 68.82 and % IRI = 46.65, respectively), which are considered the most important prey group in these size classes. When the sharks increase in length (70 ≤ TL <90 cm), they switch to teleosts and cephalopods. The share of crustaceans diminishes in importance, while the rates of teleosts, cephalopods (*Octopus vulgaris* and *Sepia officinalis*), nemerteans and polychaetes increase. The studied adult sharks mainly fed on teleosts (% IRI = 64.82), followed by cephalopods (% IRI = 12.16), while the relative importance of crustaceans

decreased with the increase of shark size, to a minimal level of % IRI = 15.44 in large specimens. However, the wide dietary diversity in larger specimens may reflect the ability of large individuals to use a wider range of habitat resources, also on the trophic level, due to their increased morphological adaptation. The high presence of teleosts in the stomachs of *M. mustelus* can be explained by the fact that the species is a relatively active and fast predator, agile in swimming and manoeuvring, moving from the bottom to the centre of the water column. The second factor to be perhaps considered is the mechanical damage incurred by bony fish during fishing operations involving trawling and use of other fishing tools. However, these species become vulnerable to larger predatory fishes in the surrounding medium, including *M. mustelus*. Cartilaginous fishes play an important role in protecting and cleaning the marine environment.

Little seasonal variation in the diet of smooth-hound was noticed within the study area. Values of the index of relative importance suggested that teleosts dominate the diet composition in all seasons, except autumn. The highest percentage was measured in spring, (64.72 of the total % IRI), followed by summer (% IRI = 53.75). Increased teleost consumption during these months coincides with the spawning period in many fishes, which may be present in high densities. In autumn, crustaceans constituted the bulk of the diet (% IRI = 45.16) as the most frequent prey (F % = 85.9), followed by teleost (% IRI = 33.49) and nemerteans (% IRI = 17.88). Cephalopods and polychaetes were present in stomach contents during all seasons but in smaller quantities.

CONCLUSIONS

As this study has shown, the diet composition of *M. mustelus* inhabiting the western Libyan coast displays little seasonal variation: teleosts are the most important prey taxon in all seasons, except in autumn. The results indicate that *M. mustelus* can be considered as an opportunistic predator feeding on a wide range of prey items.

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PREHRANJEVALNE NAVADE NAVADNEGA MORSKEGA PSA, *MUSTELUS MUSTELUS* (LINNAEUS, 1758) (CHONDRICHTHYES: TRIAKIDAE), VZDOLŽ ZAHODNE OBALE LIBIJE

Akraam Faraj KARA, Mohamed AL HAJAJI & Hisham GHMATI
Biodiversity department - Marine biology research center, Tajura, Libya

Esmail A. SHAKMAN
Zoology department, Tripoli University, Libya
e-mail: shugmanism@yahoo.com

POVZETEK

Med novembrom 2015 in 2016 so ribiči tekom mesečnega izlova ujeli 269 primerkov vrste Mustelus mustelus *(Linnaeus, 1758) ob zahodni obali Libije (južno Sredozemsko morje). Vsak primerek so avtorji izmerili, stehtali in secirali, da bi ugotovili prehranjevalne navade. Najbolj pomembna skupina plena so bile ribe kostnice, še posebej pri primerkih navadnih morskih psov, ki so merili več kot 90 cm v dolžino telesa. Raki so bili druga najpomembnejša skupina plena, še posebej pri manjših primerkih morskih psov, medtem ko so bile druge skupine plena manj pomembne in jih avtorji smatrajo kot slučajno ulovljen plen. Sestava prehrane kaže majhno sezonsko variabilnost: kostnice so bile najpomembnejši plen v vseh letnih časih, razen jeseni. Rezultati kažejo, da je* M. mustelus *oportunističen plenilec, ki se prehranjuje s širokim izborom plena.*

Ključne besede: navadni morski pes, prehrana, južno Sredozemsko morje, Libija

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CAPTURE OF A RARE ENDANGERED SPECIES LEAFSCALE GULPER SHARK *CENTROPHORUS SQUAMOSUS* (CHONDRICHTHYES: SQUALIDAE) FROM THE COAST OF SENEGAL (EASTERN TROPICAL ATLANTIC)

Youssouph DIATTA & Almamy DIABY
Laboratoire de Biologie marine, Institut fondamental d'Afrique noire, (IFAN Ch. A. Diop), Université Cheikh Anta Diop de Dakar, BP 206, Dakar, Senegal

Sihem RAFRAFI-NOUIRA
Unité de Recherches Exploitation des Milieux aquatiques, Institut Supérieur de Pêche et d'Aquaculture de Bizerte, Université de Carthage, BP 15, 7080 Menzel Jemil, Tunisia

Christian CAPAPÉ
Laboratoire d'Ichtyologie, case 104, Université de Montpellier, 34 095 Montpellier cedex 5, France
e-mail: capape@univ-montp2.fr

ABSTRACT

This note presents a recent record of a specimen of rare shark leafscale gulper shark Centrophorus squamosus. *A description of the specimen is given, including morphometric measurements, total body weight and dental formulae. Comments on this unusual and rare capture off the Senegalese coast are also provided.*

Keywords: Squalidae, distribution, conditions of capture, dental formula, coast of Senegal

CATTURA DI UNA SPECIE RARA E MINACCIATA, IL CENTROFORO SQUAME A FOGLIA *CENTROPHORUS SQUAMOSUS* (CHONDRICHTHYES: SQUALIDAE), AL LARGO DELLA COSTA DEL SENEGAL (ATLANTICO TROPICALE ORIENTALE)

SINTESI

Questa nota tratta una cattura recente di un esemplare di una rara specie di squali, il centroforo squame a foglia, Centrophorus squamosus. *Viene fornita una descrizione dell'esemplare, comprese le misurazioni morfometriche, il peso corporeo totale e le formule dentali. Gli autori inoltre discutono questa insolita e rara cattura al largo della costa senegalese.*

Parole chiave: Squalidae, distribuzione, condizioni di cattura, formula dentale, costa senegalese

INTRODUCTION

The leafscale gulper shark *Centrophorus squamosus* (Bonnaterre, 1788) is widely distributed on both sides of the Indian Ocean and off the western Pacific coast (White, 2003). The species is known along the eastern Atlantic shore from Iceland and the Atlantic Slope to the Canary Islands, Senegal, the Faeroes, Madeira and the Azores (White, 2003). Southward, *C. squamosus* occurs from Senegal, Gulf of Guinea to the west coast of South Africa (McEachran & Branstetter, 1984).

Previously, a total of 37 specimens *Centrophorus squamosus* had been examined, among them two large pregnant females carrying near term embryos (Cadenat & Blache, 1981). Since then, no specimen had been recorded although investigations were continuously and regularly conducted in the area (Capapé *et al*., 1994, 2001; Diatta *et al*., 2009; Diatta, 2014). Such lack of captures suggested that the species probably no longer occurred or, at least, had disappeared from the coast of Senegal. Conversely, in the wake of collaboration with experienced local fishermen, we were informed that a specimen of *Centrophorus squamosus* had been captured and delivered to our laboratory for a thorough examination. This new record forms the subject of the present paper, which includes a description of the specimen and some comments about the rare occurrence of this species in Senegalese waters.

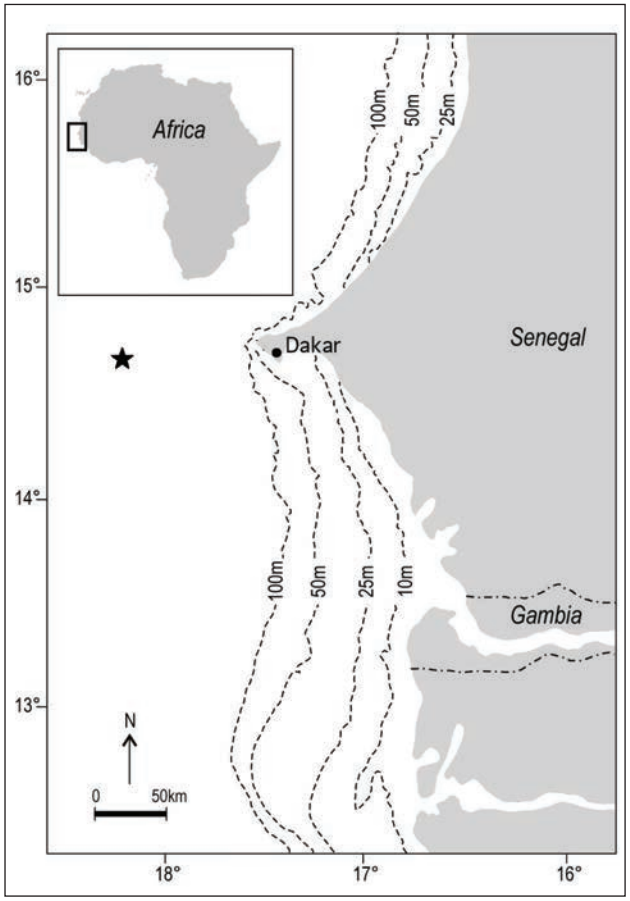

Fig. 1: Map of the coast of Senegal indicating (black star) the capture site of the specimen of *Centrophorus squamosus* ***(ref. IFAN Centr-squa 01), redrawn from Diatta et al. (2013).***
Sl. 1: Zemljevid senegalske obale z označbo lokalitete, kjer je bil primerek (ref. IFAN Centr-squa 01) vrste *Centrophorus squamosus* ***ujet. Prirejeno po Diatta s sod. (2013).***

MATERIAL AND METHODS

On 19 February 2015, a specimen of *Centrophorus squamosus* was caught by means of gill nets on rocky bottoms at a depth of 150-250 m, off the fishing site of Ouakam, located 5 km north of Dakar, in the Cape Verde Peninsula (17°36'04.20'' W and 14°40'39.31'' N) (Fig. 1).

The specimen was measured to the nearest millimetre and weighed to the nearest gram. Morphological measurements and teeth counts on upper and lower jaws were carried out following Compagno (1984) and are summarized in Table 1. The specimen was fixed in buffered formaldehyde and deposited in the Ichthyological Collection of the Institute Cheikh Anta Diop of Dakar (Senegal), under catalogue number IFAN Centr-squa 01.

RESULTS AND DISCUSSION

The studied specimen was a female, measuring 1300 mm in total length and weighing 11,200 g in total body weight (TWB). It was identified as a *Centrophorus squamosus* based on a combination of main morphological characters, such as: snout slightly long, broadly parabolic; no anal fin; both dorsal fins with large spines; first dorsal lower than the second dorsal, the latter moderately large, as high as or higher than first dorsal fin; free rear tips of pectoral fins, margins slightly extended (Fig. 2A); upper teeth erect at the centre third, but not symmetrical; lower teeth with serrated edges (Fig. 2B); denticles on the sides of the body closely-set and overlapping, leaf-like, with a high median ridge and a small lateral ridge on each side (Fig. 2C); colour uniformly dark grey.

The general morphology, the shapes of teeth and denticles, the morphometric measurements and the dental formula are in total agreement with Bass *et al.* (1976), Cadenat & Blache (1981), Compagno (1984) and McEachran & Branstetter (1984), confirming the identification of this shark, which constitutes the latest known record of *C. squamosus* from the coast of Senegal.

Species of the genus *Centrophorus* Müller & Henle, 1817 are generally targeted by fishermen, especially for the extraction of liver oil, which is highly appreciated in cosmetology and pharmacology (Diatta, 2014). Nowadays, only specimens of gulper shark *C. granulosus* (Bloch & Schneider, 1801) are commonly captured

Tab 1: Morphometric measurements (in mm and as % TL), total body weight (in gram) and dental formulae recorded in the specimen of *Centrophorus squamosus* ***(ref. IFAN Centr-squa 01).***
Tab. 1: Morfometrične meritve (v mm in kot % dolžine telesa), celotna telesna teža (v gramih) in zobna formula primerka vrste *Centrophorus squamosus* ***(ref. IFAN Centr-squa 01).***

Reference	**IFAN Centr-squa 01**	
Sex	**Female**	
Total body weight (g)	**11200**	
Measurements	**mm**	**% TL**
Total length	1300	100.0
Fork length	1140	87.7
Precaudal length	1030	79.2
Pre-first dorsal length	43	3.3
Pre-second dorsal length	830	63.8
Head length	290	22.3
Prebranchial length	220	16.9
Prespiracular length	150	11.5
Preorbital length	60	4.6
Prepectoral length	253	19.5
Prepelvic length	780	60.0
Snout-vent lenght	880	67.7
Interdorsal space	310	23.8
Dorsal caudal space	81	6.2
Pectoral-pelvic space	500	38.5
Pelvic-caudal space	700	53.8
Vent-caudal length	460	35.4
Eye length	50	3.8
Eye height	30	2.3
Prenarinal length	45	3.5
Intergill length	60	4.6
First gill slit height	35	2.7
Fifth gill slit height	42	3.2
Pectoral anterior margin	141	10.8
Pectoral inner margin	88	6.8
Pectoral posterior margin	103	7.9
Pectoral height	152	11.7
Dorsal caudal margin	210	16.2
Terminal caudal lobe	122	9.4
Subterminal caudal margin	27	2.1
Preventral caudal margin	168	12.9
First dorsal anterior margin	190	14.6
First dorsal height	80	6.2
First dorsal posterior margin	135	10.4
First dorsal base	205	15.8
First dorsal length	280	21.5
First dorsal inner margin	90	6.9
Second dorsal anterior margin	130	10.0
Second dorsal height	42	3.2
Second dorsal posterior margin	103	7.9
Second dorsal inner margin	35	2.7
Second dorsal base	125	9.6
Head height	180	13.8
Trunk height	210	16.2
Abdomen height	190	14.6
Tail height	110	8.5
Caudal peduncle height	55	4.2
Pelvic midpoint-second dorsal insertion	230	17.7
First dorsal midpoint- pelvic origin	270	20.8
Second dorsal insertion-pelvic insertion	140	10.8
Pelvic posterior margin length	80	6.2
Pelvic inner margin length	65	5.0
Pelvic base	87	6.7
Pelvic length	145	11.2
Pelvic anterior margin	130	10.0
Pelvic height	103	7.9
Interorbital space	102	7.8
Head width	240	18.5
Trunk width	300	23.1
Abdomen width	350	26.9
Caudal peduncle width	30	2.3
Mouth length	50	3.8
Mouth width	190	14.6
Internarial space	40	3.1
Dental formulae	16-1-16/13-1-13	

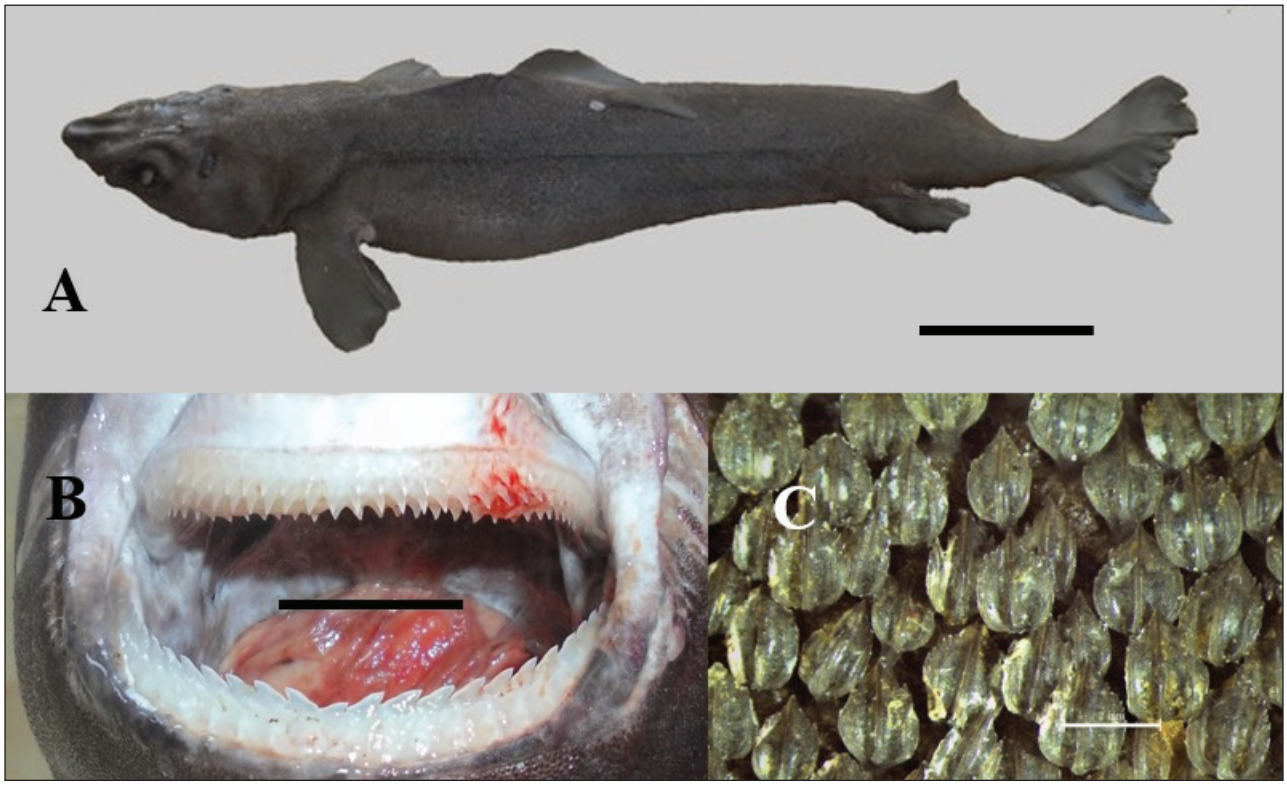

Fig. 2: A. General morphology of the specimen of *Centrophorus squamosus* ***(ref. IFAN Centr-squa 01) caught off the coast of Senegal, scale bar = 200 mm. B. Jaw of the same specimen showing upper and lower teeth, scale bar =100 mm. C. Denticles removed from the dorsal surface of the same specimen, scale bar = 2 mm.***
Sl. 2: A. Morfologija primerka vrste *Centrophorus squamosus* ***(ref. IFAN Centr-squa 01), ujetega ob obali Senegala, merilo = 200 mm. B. Čeljust z zgornjimi in spodnjimi zobmi, merilo =100 mm. C. Dentikli s hrbtne površine raziskanega primerka, merilo = 2 mm.***

throughout the Senegalese coast (Diatta *et al*., 2009). Some morphological differences allow distinguishing *C. squamosus* from *C. granulosus*. *C. squamosus* displays free rear tips of the pectoral fins, broadly angular and not reaching past the first dorsal spine, denticles in adults exhibit multiple lateral cusps. In *C. granulosus*, the free rear tips of the pectoral fins extend into narrow angular lobes, which reach past the first dorsal fin origin, and denticles in adults are without cusps, broadly rounded posteriorly. Since local fishermen are familiar with captures of *C. granulosus* in the area, they were able to distinguish this species from *C. squamosus*, and therefore they could immediately bring it to the laboratory for a thorough examination. The rarity of the species in the area could also explain why these fishermen could express a positive, or at least neutral, attitude to this shark species. The specimen was captured over continental shelf grounds at a depth of 150 to 200 m, which is normally shallower than the depth ranges reported by McEachran & Branstetter (1984). According to McEachran & Branstetter (1984), *C. squamosus* is a benthic species inhabiting deeper areas, from 400 to 1875 m, rarely below 1000 m. Although these areas are poorly exploited by fishermen, this does not fully explain the scarcity of the species in commercial catches. However, this isolated capture of a single specimen suggests that the species is not completely extinct in the area, but other records are needed to state if a viable population still occurs in the area or if the species is dangerously threatened.

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The authors wish to thank the fishermen from the fishing site of Ouakam, Senegal, who provided the specimen, and Dr Mafalda Freitas, Head of the Marine Biology Station of Funchal, Madeira Island who enabled us to identify the specimen as *Centrophorus squamosus*.

ULOV REDKEGA IN OGROŽENEGA MORSKEGA PSA *CENTROPHORUS SQUAMOSUS* (CHONDRICHTHYES: SQUALIDAE) IZ OBALNIH VODA SENEGALA (VZHODNI TROPSKI ATLANTIK)

Youssouph DIATTA & Almamy DIABY
Laboratoire de Biologie marine, Institut fondamental d'Afrique noire, (IFAN Ch. A. Diop), Université Cheikh Anta Diop de Dakar, BP 206, Dakar, Senegal

Sihem RAFRAFI-NOUIRA
Unité de Recherches Exploitation des Milieux aquatiques, Institut Supérieur de Pêche et d'Aquaculture de Bizerte, Université de Carthage, BP 15, 7080 Menzel Jemil, Tunisia

Christian CAPAPÉ
Laboratoire d'Ichtyologie, case 104, Université de Montpellier, 34 095 Montpellier cedex 5, France
e-mail: capape@univ-montp2.fr

POVZETEK

Avtorji poročajo o ulovu primerka redkega morskega psa vrste Centrophorus squamosus. *Navajajo opis vrste, morfometrične meritve, telesno težo in zobno formulo. Poleg tega razpravljajo o tem redkem in nenavadnem ulov ob obali Senegala.*

Ključne besede: Squalidae, razširjenost, podatki o ulovu, zobna formula, senegalska obala

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MORPHOLOGICAL DEFORMITIES IN A STRIPED SEA BREAM *LITHOGNATHUS MORMYRUS* (OSTEICHTHYES: SPARIDAE) FROM NORTHERN TUNISIAN WATERS (CENTRAL MEDITERRANEAN SEA)

Sihem RAFRAFI-NOUIRA
Université de Carthage, Unité de Recherches Exploitation des Milieux aquatiques, Institut Supérieur de Pêche et d'Aquaculture de Bizerte, BP 15, 7080 Menzel Jemil, Tunisia

Christian REYNAUD & Christian CAPAPÉ
Laboratoire d'Ichtyologie, case 104, Université de Montpellier, 34 095 Montpellier cedex 5, France
e-mail: capape@univ-montp2.fr

ABSTRACT

Abnormalities of the lateral line and the vertebral column are described in a specimen of striped sea bream Lithognathus mormyrus *(Linnaeus, 1758) collected from the northern coast of Tunisia. Despite these deformities, the specimen was able to live in the wild together with normal specimens. The origin of these abnormalities are commented and discussed.*

Key words: *Lithognathus mormyrus*, hyperkyphosis, lordosis, environmental pollution, length-weight relationship

DEFORMAZIONI MORFOLOGICHE IN UNA MORMORA, *LITHOGNATHUS MORMYRUS* (OSTEICHTHYES: SPARIDAE), IN ACQUE DELLA TUNISIA SETTENTRIONALE (MEDITERRANEO CENTRALE)

SINTESI

L'articolo riporta anomalie della linea laterale e della colonna vertebrale in un esemplare di mormora, Lithognathus mormyrus *(Linnaeus, 1758), proveniente dalle acque al largo della costa settentrionale della Tunisia. Nonostante queste deformità, l'esemplare è stato in grado di vivere allo stato libero insieme ad individui normali. Gli autori commentano e discutono l'origine di queste anomalie.*

Parole chiave: *Lithognathus mormyrus,* ipercifosi, lordosi, inquinamento ambientale, relazione lunghezza-peso

INTRODUCTION

The striped sea bream *Lithognathus mormyrus* (Linnaeus, 1758) is a sparid species inhabiting shallow coastal waters of the eastern Atlantic from the Bay of Biscay to South Africa, and from the south-western areas of the Indian Ocean to the Red Sea (Bauchot & Hureau, 1986). *L. mormyrus* occurs throughout the Mediterranean Sea, where it is abundantly captured by anglers for local consumption especially in the Strait of Sicily (Vitale *et al*., 2011). Additionally, the species has been recently found in the Black Sea (Aydin, 2018). It lives on sandy and rocky bottoms partially covered by seagrass and algae, to a maximum depth of 80 m (Bauchot & Hureau, 1986), and feeds on crustaceans, small teleosts and molluscs (Chessa *et al*., 2005).

L. mormyrus is one of the 21 sparid species, all having economic importance, that are commonly caught throughout the Tunisian coast. Populations of this species can also be found in brackish areas, such as Bahiret el Bibane, in the southern region, and the Lagoon of Bizerte, in the northern region, where they live and reproduce (Hammami *et al*., 2013). Additionally, the species is rather abundant in southern Tunisia, where it is targeted by fishermen, as its flesh is appreciated by the local population (Bradaï, 2000). During investigations conducted in the northern Tunisian area since 2006, focusing primarily on elasmobranch species (El Kamel *et al.,* 2009a, b) and then on all fish species (Rafrafi-Nouira, 2016), several *L. mormyrus* have been collected, among them a specimen displaying morphological deformities. Comprehensive published scientific references of recorded abnormalities in teleost species do not report any case in *L. mormyrus* (see Dawson, 1964, 1966, 1971; Dawson & Heal 1971; Jawad & Hosie, 2007; Jawad *et al.*, 2010; Jawad & Ibrahim, 2018). The aim of this note is to describe this abnormal specimen and comment on similar abnormalities previously observed in teleost species.

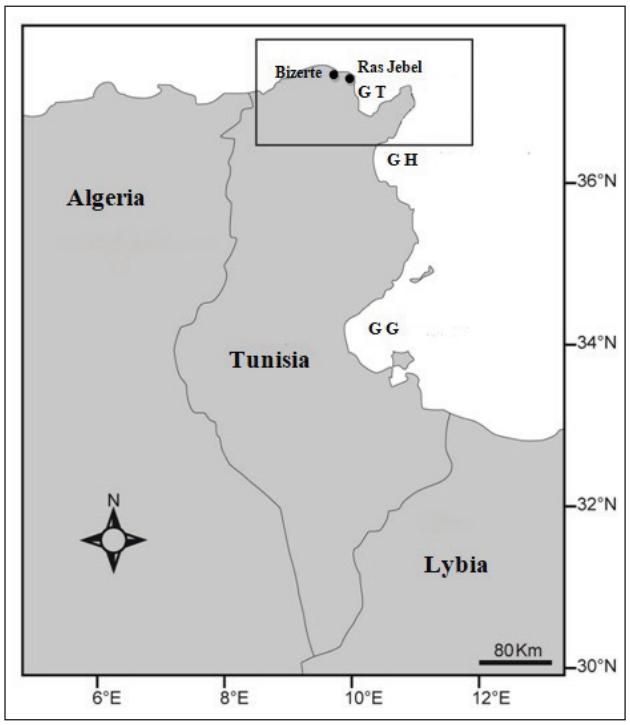

Fig. 1: Map of Tunisia indicating the capture area (rectangle) of** Lithognathus mormyrus **from the northern Tunisian coast. GT, Gulf of Tunis; GH, Gulf of Hammamet; GG, Gulf of Gabès.
Sl. 1: Zemljevid Tunizije z označenim predelom (pravokotnik), kjer je bil ujet primerek ovčice na severni obali. Legenda: GT, Tuniški zaliv; GH, Hamameški zaliv; GG, Gabeški zaliv.

MATERIAL AND METHODS

A total of 32 specimens of *L. mormyrus* were collected during years 2013 and 2014, off Ras Jebel, located on the northern Tunisian coast, among them a specimen found on 23 June 2014 presenting abnormalities on the body. All specimens were caught by commercial gillnet with a stretched mesh size of 26 mm, at 37° 14′ 57.53″ N and 10°11′ 52. 85″ E, on sandy bottom, together with other sparid and labrid species (Fig. 1).

The fresh specimens were measured for total length (TL) recorded to the nearest centimetre and weighed for total body weight (TBW) to the nearest gram. Morphometric measurements and meristic counts followed Bauchot & Hureau (1986) and Aydin (2018); they were recorded in the abnormal specimen and compared with those recorded in 2 of the normal specimens (see Tab. 1). The 3 specimens were fixed in 10% buffered formalin, preserved in 75 % formaldehyde and deposited in the Ichthyological Collection of the Institut Superieur de Pêche et d'Aquaculture de Bizerte (Tunisia), under catalogue numbers ISPAB-Lith mor 01 for the abnormal specimen, and ISPAB-Lith mor 02 ISPAB-Lith mor 03, for the 2 normal specimens, respectively. The abnormalities of the vertebral column, such as scoliosis (lateral curvature), lordosis (ventral curvature), kyphosis (dorsal curvature) and ankylosis (fusion of vertebrae), reported in many species, cultured and from the wild, were described following the Elie & Girard (2014) and Jawad & Ibrahim (2018) definitions. Additionally, three regions were taken into consideration, partially following Louiz *et al.* (2007): the anterior or cephalic region, the intermediate or abdominal region and the terminal or caudal region.

A *t*-test was performed to point out the differences in the number of line scales and vertebrae between the abnormal *L. mormyrus* and the normal specimens. The relation between the total length (TL) and the total body weight (TBW) was used as a complement following Froese *et al.* (2011), including all specimens, normal and

Tab. 1: Morphometric measurements in millimeters (mm), with percentages of standard length (% SL), meristic counts and total body weight in grams (g), recorded in an abnormal and 2 normal specimens of *Lithognathus mormyrus* ***from northern Tunisian waters.***
Tab. 1: Morfometrične meritve v milimetrih (mm), z odstotki standardne dolžine (% SL), merističnim štetjem in skupno telesno maso v gramih (g), zabeležene v neobičajnem in dveh normalnih primerkih vrste *Lithognathus mormyrus* ***iz severno tunizijskih voda.***

References	**ISPAB-Lit-mor01**		**ISPAB-Lit-mor02**		**ISPAB-Lit-mor03**	
Condition	Abnormal		Normal		Normal	
Morphometric measurements	mm	%SL	mm	%SL	mm	%SL
Total length	168	124.4	160	125.0	163	125.4
Fork length	149	110.4	142	110.9	144	110.4
Standard length	135	100.0	128	100.0	130	100.0
Head length	47	35.1	44	34.3	43	33.1
Eye diameter	10	7.5	11	8.3	10	7.7
Pre-orbitary length	20	14.7	19	14.5	17	13.2
Post-orbitary length	19	13.7	17	13.6	17	13.4
Dorsal fin length	68	50.5	61	47.6	61	47.2
Pectoral fin length	8	5.9	6	4.6	7	5.3
Pelvic fin length	11	8.2	9	6.9	9	7.0
Anal fin length	29	21.4	23	18.1	22	17.2
Caudal fin length	15	11.3	14	11.3	14	10.5
Snout length	18	13.2	18	13.7	17	12.8
Body height	53	39.5	40	31.1	40	31.0
Pre-dorsal fin length	56	41.8	53	41.2	53	41.0
Pre-pectoral fin length	47	34.7	43	33.4	43	33.2
Pre-pelvic fin length	51	37.4	51	39.5	49	37.8
Pre-anal fin length	89	65.8	87	67.9	88	67.9
Length of the largest spine of the pectoral fin	34	25.3	30	23.5	30	23.4
Thickness	23	17.2	19	14.7	19	14.9
Meristic counts						
Lateral line scales	68		60		60	
Total number of vertebrae	27		24		24	
Dorsal fin rays	XI+12		XI+12		XIII+10	
Pectoral fin rays	14		13		13	
Pelvic fin rays	II+10		II+10		II+10	
Anal fin rays	III+10		III+10		III+10	
Caudal fin rays	19		20		20	
Total body weight (g)	68.6		48.3		48.4	

abnormal, to show if this latter was able to develop in the wild like other normal specimens. This LWR is TBW = aTL^b, and was converted into its linear regression, expressed in decimal logarithmic coordinates, correlations were assessed by least-squares regression as log TBW = log a + b log TL. The significance of constant b differences was assessed to the hypothesis of isometric growth if $b = 3$, positive allometry if $b > 3$, negative isometry if $b < 3$ (Pauly, 1983). These two latter tests were performed by using the logistic model STAT VIEW 5.0.

Fig. 2: *Lithognathus mormyrus* ***specimens from the northern Tunisian coast. A: Abnormal specimen. B: Normal specimen, scale bar = 40 mm.***
Sl. 2: Primerki ovčice iz severne tunizijske obale. A: Deformirani primerek. B: normalni primerek, merilo = 40 mm.

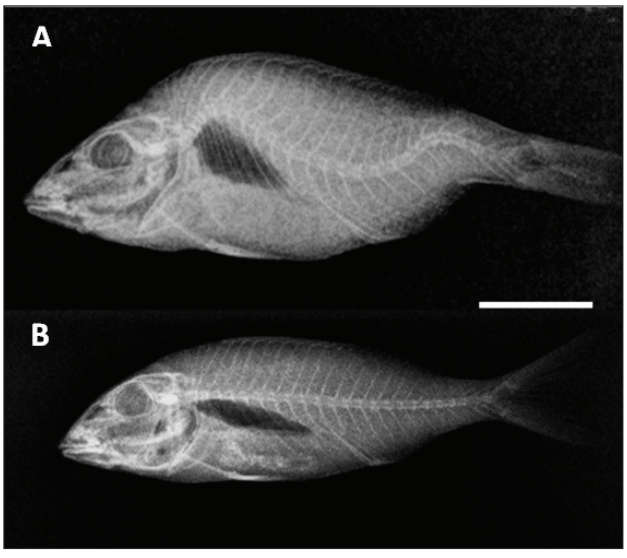

Fig. 3: An X-ray photograph of *Lithognathus mormyrus* ***from the northern Tunisian coast. A: Abnormal specimen. B: Normal specimen, scale bar = 30 mm.***
Sl. 3: Rentgenski posnetek ovčice iz severne tunizijske obale. A: Deformirani primerek. B: Normalni primerek, merilo = 30 mm.

RESULTS AND DISCUSSION

All collected specimens were identified as *L. mormyrus* following the combination of main morphological characters from Bauchot & Hureau (1986) and Engin *et al.* (2015), such as: body elongated, ovoid and compressed, snout elongate and pointed, posterior nostril an oblique slit, in front the of eyes, scales on check and opercle, preopercle broad, scaleless, livery with a fundamental silver-grey colouration, more or less dark, broken by a dozen of blackish or grey vertical lines. The abnormal specimen exhibited an upper margin developed and arched, forming a hump, and the upper profile of the head was strongly curved, the lateral obviously sinuous, while it was only slightly curved in the normal specimens, mainly in the caudal region (Fig. 2).

On an X-ray photograph, the abnormal specimen appeared to display three visible deformities. At the level of cephalic and caudal regions, the vertebral column was strongly arched, forming hyperkyphosis. The abdominal region displayed lordosis with a somewhat smaller arch than the other two deformities (Fig. 3). No scoliosis was observed in the abnormal specimen. The number of lateral line scales in the abnormal specimen was 68, significantly outnumbering those of the normal specimens, 60 (*t*-test = 16, df = 1, p = 0.03). Following Bauchot & Hureau (1986) the normal range is from 59 to 65. Similarly, the number of vertebrae in the abnormal specimen, 27, significantly outnumbered those of the normal specimens, 24, (*t*-test = 17, df = 1, p = 0.03). Such increased numbers are probably due to the curves of the lateral line and the deformities of the vertebral column. This also means that the vertebrae were not fused and the specimen did not display any signs of ankylosis.

Lateral line deformation is the main consequence of vertebral column malformation, as observed in the present specimen exhibiting hyperkyphosis. Similar patterns were reported by Jardas & Homen (1977) in the whiting *Merlangius merlangus* (Linnaeus, 1758) and the bogue *Boops boops* (Linnaeus, 1758). The same authors considered such anomalies not to be that rare in teleost species from the Adriatic, and suggested that parasitic infection could also be the cause of skeletal deformations.

Jawad *et al.* (2010) noted that anomaly in fins could hinder the performance of the specimen, especially affecting its capacity to obtain food and avoid predators. In the case presented herein, the deformities observed did not affect the life of the abnormal specimen in the wild, it functioned as well as other normal specimens from the same size class, as shown by the relation between total length *versus* total body weight (TM, in g) plotted in Fig. 4, with: log TBW = 3.150 * log TL +5.161; r = 0.973, n = 32, displaying a positive allometry. Similar patterns were observed by Khenfech *et al.* (2011) in the annular sea bream *Diplodus annularis* (Linnaeus, 1758). Conversely, Matsuoaka (1987) and Boglione *et al.* (2006) noted a

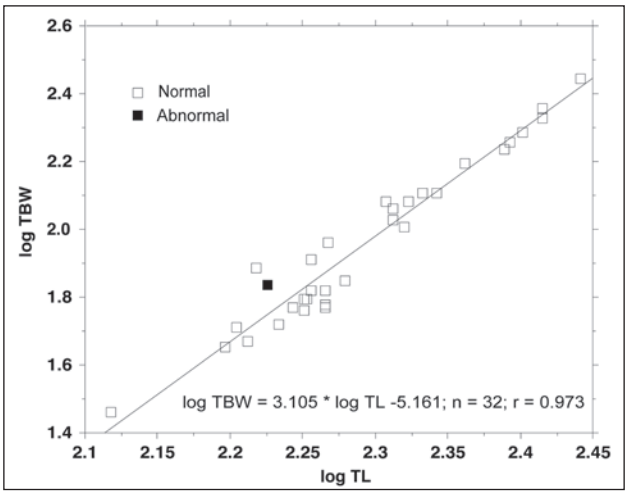

Fig. 4: The relation between total length (TL) and total body weight (TBM) in specimens of *Lithognathus mormyrus* ***from the northern Tunisian coast.***
Sl. 4: Odnos med totalno dolžino telesa (TL) in telesno težo (TBM) pri primerkih ovčice iz severne obale Tunizije.

lethal effect caused by severe skeletal deformities in teleost species living in natural conditions.

Abnormalities in fish species occur during the early stages of development and could have a genetic origin. A mechanical origin cannot be totally ruled out either. For instance, when specimens entangled in gillnets successfully escape, they can suffer morphological deformations and distortions of the normal vertebral shape, essentially a remodelling of the vertebral column, as a consequence of extrinsic forces (Jawad & Ibrahim, 2018). On the other hand, these deformities could constitute an important indicator of adverse environmental conditions and pollutants, and stress in the wild induced in other ways (Sfakianakis *et al.*, 2004). Several cases of abnormalities were described among the animal species collected in the Lagoon of Bizerte, a restricted brackish area polluted by both inorganic and organic nutriments and heavy metals (Mzoughi *et al.*, 2002).

The global warming of marine waters in the various seas throughout the world could also play a role in skeletal deformities (Jawad & Ibrahim, 2018). The entire Mediterranean has been facing this major problem for several decades (Francour *et al.*, 1994), including the Tunisian coast with the spread of alien species incoming from the Red Sea through the Suez Canal and/or from the eastern tropical Atlantic through the Strait of Gibraltar (Ounifi-Ben Amor *et al.*, 2016). The northern coast of Tunisia is progressively invaded by such species and cases of abnormalities in fish are more frequent than previously recorded in the area (Rafrafi-Nouira, 2016). However, thorough investigations are needed and should be conducted together with environmental monitoring to locally delineate the role of temperature in deformities among fish species.

MORFIOLOŠKE DEFORMACIJE PRI OVČICI *LITHOGNATHUS MORMYRUS* (OSTEICHTHYES: SPARIDAE) IZ SEVERNO TUNIZIJSKIH VOD (OSREDNJE SREDOZEMSKO MORJE)

Sihem RAFRAFI-NOUIRA
Université de Carthage, Unité de Recherches Exploitation des Milieux aquatiques, Institut Supérieur de Pêche et d'Aquaculture de Bizerte, BP 15, 7080 Menzel Jemil, Tunisia

Christian REYNAUD & Christian CAPAPÉ
Laboratoire d'Ichtyologie, case 104, Université de Montpellier, 34 095 Montpellier cedex 5, France
e-mail: capape@univ-montp2.fr

POVZETEK

Avtorji opisujejo anomalije v pobočnici in na hrbtenici, opažene na primerku ovčice Lithognathus mormyrus *(Linnaeus, 1758), ujete ob severni obali Tunizije. Kljub tem deformacijam je primerek uspel živeti v naravi skupaj z drugimi, normalnimi primerki. Avtorji nadalje razpravljajo o izvoru teh anomalij.*

Ključne besede: *Lithognathus mormyrus*, hiperkifoza, lordoza, onesnaževanje okolja, odnos med dolžino in težo

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ON A OCCURRENCE OF *GADELLA MARALDI* (OSTEICHTHYES: GADIFORMES: MORIDAE) ON THE TUNISIAN COAST (CENTRAL MEDITERRANEAN SEA)

Sihem RAFRAFI-NOUIRA
Unité de Recherches Exploitation des Milieux aquatiques, Institut Supérieur de Pêche et d'Aquaculture de Bizerte, Université de Carthage, BP 15, 7080 Menzel Jemil, Tunisia

Christian REYNAUD & Christian CAPAPÉ
Laboratoire d'Ichtyologie, case 104, Université de Montpellier, 34095 Montpellier cedex 5, France
e-mail: capape@univ-montp2.fr

ABSTRACT

A specimen of Gadella maraldi *(Risso, 1810) measuring 215 mm in total length, 192 mm in standard length and weighing 96.56 g was caught off the northern Tunisian coast. This capture constitutes the second Tunisian record of the species and confirms its occurrence in the area where it was previously considered as doubtful. The specimen is described, including morphological measurements, meristic counts and colour. Due to a lack of records, the real status of the species in Tunisian waters remains questionable.*

Key words: description, morphometric measurements, meristic counts, distribution, deep waters

RITROVAMENTO DI *GADELLA MARALDI* (OSTEICHTHYES: GADIFORMES: MORIDAE) LUNGO LA COSTA TUNISINA (MEDITERRANEO CENTRALE)

SINTESI

Un esemplare di Gadella maraldi *(Risso, 1810) di 215 mm di lunghezza totale, 192 mm di lunghezza standard e 96,56 g di peso è stato catturato al largo della costa tunisina settentrionale. Questa cattura costituisce il secondo ritrovamento tunisino della specie e conferma la sua presenza nell'area in cui era precedentemente considerata dubbia. Nell'articolo viene descritto l'esemplare, comprese le misurazioni morfologiche, i conteggi meristici ed il colore. A causa della mancanza di dati, lo stato reale della specie nelle acque tunisine rimane discutibile.*

Parole chiave: descrizione, misure morfometriche, conteggi meristici, distribuzione, acque profonde

INTRODUCTION

Gadella maraldi (Risso, 1810) is known in the eastern Atlantic from the Porcupine Bank, an area of the Irish shelf, located approximately 200 kilometres west of Ireland, to the northern continental shelf of Spain and the southern coast of Portugal (Ruiz-Pico *et al*., 2012). South of the Strait of Gibraltar, the species is reported from Madeira, the Josephine Bank, the Azores, the Great Meteor Bank and the Canary Islands (Bañon *et al*., 2010).

G. maraldi occurs in the western Mediterranean Basin, specifically, in the Adriatic Sea (Cohen, 1986). Eastward, the species is found in Turkish waters (Kabasakal, 1998), as far as the Levant Basin (Golani, 2005). Following Cohen (1986), it was reported throughout the Maghreb shore with the exclusion of the Tunisian coast. Conversely, it was reported in the latter area by Cohen *et al*. (1990), probably based on the single record made by Maurin (1962) at the level of Resgui Bank. However, such occurrence of *G. garaldi* remained questionable, due to the fact that no specimen had been available to date for confirmation.

A decade of routine monitoring in Tunisian waters and assistance from local fishermen aware of the fishing grounds have yielded a specimen of G. maraldi caught during a commercial trawling survey occurring off the northern Tunisian coast. The present paper provides a short description of the specimen, including morphometric measurements and meristic counts, and some comments about the real status of the species in the area.

MATERIAL AND METHODS

On 30 September 2019, a specimen of *G. maraldi* was collected by commercial trawl at a depth of 230 m, off Bizerte, northern Tunisian coast, at 37° 33′ 04.72″ N and 10° 06′ 07.62″ E (Fig. 1), on sandy-rocky bottom, together with labrid species, parrot seaperch *Callanthias ruber* (Rafinesque, 1810) and *Phycis phycis* (Linnaeus, 1766). It was measured to the nearest millimetre and weighed to the nearest gram (Fig. 2). The morphometric measurements and meristic counts follow Cohen (1986), Cohen *et al*. (1990), Kabasakal (1998) and Ruiz-Pico *et al*. (2012), and are summarized in Table 1. The standard length is abbreviated as SL and total length as TL. The number of gill rakers were counted on the first branchial arch, and the number of vertebrae from a X-ray photograph.

The specimen was fixed in 10% buffered formaldehyde, preserved in 75% ethanol and deposited in the Ichthyological Collection of the Institut Supérieur d'Acquaculture et de Pêche of Bizerte (ISPAB), Tunisia, under catalogue number ISPAB-Gad-mar-01.

RESULTS AND DISCUSSION

The Tunisian specimen of *Gadella maraldi* was identified based on the combination of the following main morphological characters: body elongate, slightly compressed, with a large head (4.3 times in SL), and tapering posteriorly; chin absent, mouth oblique, jaw in a narrow row 2-3 teeth, some teeth larger, pointed and strongly

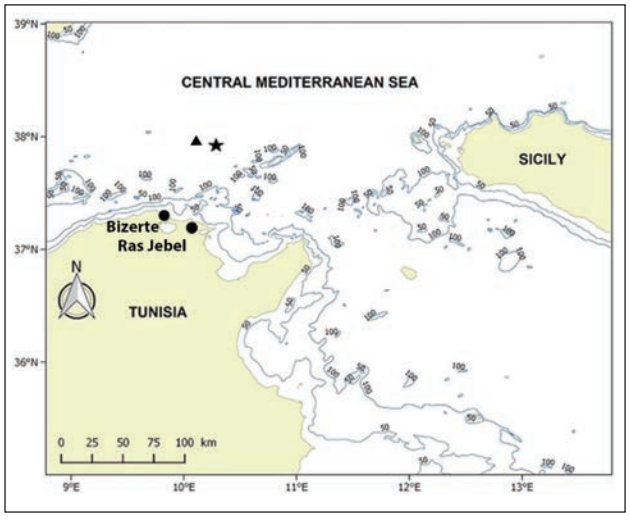

Fig. 1: Map of northern Tunisian waters, with the black triangle indicating the Resgui Bank and the black star indicating the capture site of the present specimen of *Gadella maraldi*.
Sl. 1: Zemljevid vod ob severni Tuniziji s črnim trikotnikom, ki označuje Resgui Bank in črno zvezdico, ki kaže na mesto ulova primerka vrste *Gadella maraldi*.

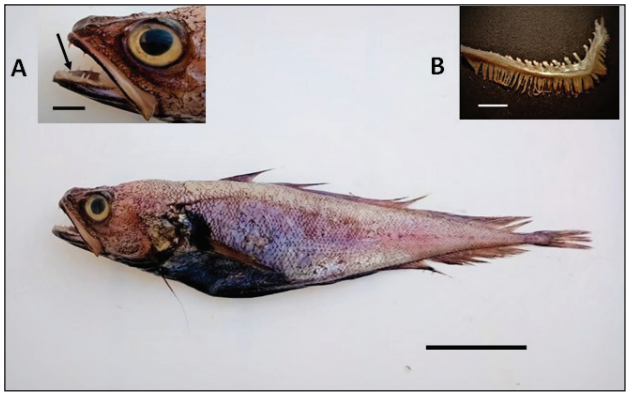

Fig. 2: The specimen of *Gadella maraldi* ***(Ref. ISPAB-Gad-mar-01) captured in northern Tunisian waters, scale bar = 40 mm. Insert A. Head of the specimen, the arrow pointing at the teeth, scale bar = 10 mm. Insert B. A gill raker of the first branchial arc removed from the same specimen, scale bar = 5 mm.***
Sl. 2: Primerek vrste *Gadella maraldi* ***(Ref. ISPAB-Gad-mar-01) ujet v severno tunizijskih vodah, merilo = 40 mm. Predel A. Glava primerka; puščica označuje zobe, merilo = 10 mm. B. Odstranjen škržni izrastek prvega škržnega loka, merilo = 40 mm.***

curved at distal end, none on vomer and palatines; large eye; two dorsal fins, the first slightly higher than the second; anal fin not indented, originating behind the origin of the first dorsal fin; caudal fin rounded at distal end; pectoral fins extending beyond the origin of pelvic fin; filamentous ray of pelvic fin extending slightly beyond the anal fin origin; body covered with small cycloid scales, including the head, except for cheeks and lips; light organ present as a small naked patch on the belly; colour brownish-black, pectoral bluish-black, oral cavity pale.

The general morphology, morphometric measurements, meristic counts and colour are in total agreement with previous descriptions of *G. maraldi* by Maul (1953), Aguiar & Pereira (1982), Cohen (1986), Cohen *et al.* (1990), Kabasakal (1998) and Ruiz-Pico *et al.* (2012). Therefore, this capture of *G. maraldi* constitutes the first well-documented record of the species from the Tunisian coast and confirms the occurrence of a species that should be included in the local ichthyofauna. This second record of *G. maraldi* extends the range of the species eastwards, along the Maghreb shore.

The present specimen measured 215 mm TL, 192 mm SL and its total body weight was 96.56 g. Following Cohen (1986) and Cohen *et al.* (1990), *G. maraldi* grow to a maximum length of 300 mm, and the first sexual maturity occurs at the size of 150 mm TL. The studied specimen was an adult female and some oocytes were observed in the ovaries. *G. maraldi* is a carnivorous species feeding on small benthic invertebrate and teleost species (Kabasakal, 1998), but the stomach of this specimen was empty.

Aguiar & Pereira (1982) noted that *G. maraldi* was locally abundant in the areas where it was reported. Conversely, records of the species were generally based on few specimens, 2-4 maximum, in Kabasakal (1998), Papaconstantinou (1990) and Ruiz-Pico *et al.* (2012), who considered it very rare. Cohen *et al.* (1990) noted there was no separate statistics concerning the species, which was probably counted among by-catch in fisheries, and added that it was only sporadically found in fish markets, concluding that the species did not display commercial importance. Additionally, *G. maraldi* inhabits deep-sea waters, which are, in general, poorly exploited by commercial fishing gears. This could explain why only two records were reported from Tunisian waters during a seventy-year research period. That being so, the occurrence of a viable population in the area remains questionable, although such pattern cannot be totally ruled out, as the scarce information prevents any conclusion regarding the real status of the species in the area.

Tab. 1: Absolute and relative biometric and meristic data recorded in the specimen of** Gadella maraldi **(Ref. ISPAB-Gad-mar-01) caught in northern Tunisian waters.
Tab. 1: Absolutni in relativni biometrični in meristični podatki, zabeleženi na primerku** Gadella maraldi **(Ref. ISPAB-Gad-mar-01), ki je bil ujet v vodah severne Tunizije.

Reference	**ISPAB-Gad-mar-01**	
Morphometric measurements	**mm**	**%SL**
Total length	215	111.98
Standard length (SL)	192	100.00
Pre-anal length	62	32.29
Predorsal fin length	60	31.25
Prepectoral fin length	57	29.69
First dorsal fin length	14	7.07
Second dorsal fin length	103	53.68
Anal fin length	120	62.55
Pectoral fin length	7	3.64
Pelvic fin length	2	1.00
Head length	45	23.51
Eye diameter	13	6.79
Body depth	37	19.46
Preorbitary length	13	6.52
Interorbital length	12	5.96
Length of upper jaw	27	13.98
Length of lower jaw	24	12.71
Length of right pelvic fin	18	9.30
Length of left pelvic fin	28	14.33
Meristic counts		
First dorsal fin rays	11	
Second dorsal fin rays	55	
Anal fin rays	60	
Pectoral soft fin rays	24	
Pelvic fin soft rays	7	
Number of scales of the lateral line	96	
Number of scale rows between the dorsal and the lateral line	10	
Number of gill rakers	12	
Number of vertebrae	54	
Total body weight in gram	97.56	

O POJAVLJANJU VRSTE *GADELLA MARALDI* (OSTEICHTHYES: GADIFORMES: MORIDAE) OB TUNIZIJSKI OBALI (OSREDNJE SREDOZEMSKO MORJE)

Sihem RAFRAFI-NOUIRA
Unité de Recherches Exploitation des Milieux aquatiques, Institut Supérieur de Pêche et d'Aquaculture de Bizerte, Université de Carthage, BP 15, 7080 Menzel Jemil, Tunisia

Christian REYNAUD & Christian CAPAPÉ
Laboratoire d'Ichtyologie, case 104, Université de Montpellier, 34095 Montpellier cedex 5, France
e-mail: capape@univ-montp2.fr

POVZETEK

Primerek vrste Gadella maraldi *(Risso, 1810), ki je meril 215 mm v dolžino in tehtal 96.56 g, je bil ujet ob severni tunizijski obali. Gre za drugi zapis o najdbi te vrste za Tunizijo, ki potrjuje njeno pojavljanje tudi na območju, za katerega so pred tem dvomili. Avtorji opisujejo primerek, navajajo morfometrične meritve in meristična štetja ter barvni vzorec. Zaradi pomanjkanja podatkov o tej vrsti je njen dejanski status v tunizijskih vodah še vedno nepojasnjen.*

Ključne besede: opis, morfometrične meritve, meristična štetja, razširjenost, globokomorsko okolje

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UNUSUAL RECORD OF ROUND FANTAIL STINGRAY *TAENIUROPS GRABATA* (CHONDRICHTHYES: DASYATIDAE) FROM THE TUNISIAN COAST (CENTRAL MEDITERRANEAN SEA)

Mohamed Mourad BEN AMOR & Marouène BDIOUI
Institut National des Sciences et Technologies de la Mer, port de pêche, 2025 La Goulette, Tunisia

Khadija OUNIFI-BEN AMOR
Université de Tunis El Manar, Faculté des Sciences de Tunis, Laboratoire de Biodiversité, Biotechnologie et Changement Climatique, LR11ES09, 1002, Tunis, Tunisia

Christian REYNAUD & Christian CAPAPÉ
Laboratoire d'Ichtyologie, Université de Montpellier, case 104, 34095 Montpellier cedex 5, France
e-mail: capape@univ-montp2.fr

ABSTRACT

This paper reports the capture of a specimen of round fantail stingray Taeniurops grabata *(Geoffroy Saint-Hilaire, 1817) on the northern coast of Tunisia, caught in deep waters, at a depth of 450 m. It was a large specimen of 1.12 m in disc width, 2.70 m in total length and 110 kg in total body weight. This is the largest and heaviest specimen known to date in Tunisian waters, and probably in the Mediterranean and even outside it. Additionally, comments are given about the distribution of the species, well-known in the eastern Mediterranean Basin and eastern tropical Atlantic, but unknown in the western Mediterranean Basin.*

Key words: Dasyatidae, distribution, expansion range, Mediterranean Sea, eastern tropical Atlantic

RITROVAMENTO INUSUALE DI TRIGONE AFRICANO *TAENIUROPS GRABATA* (CHONDRICHTHYES: DASYATIDAE) LUNGO LA COSTA DELLA TUNISIA (MEDITERRANEO CENTRALE)

SINTESI

L'articolo riporta la cattura di un esemplare di trigone africano, Taeniurops grabata *(Geoffroy Saint-Hilaire, 1817), lungo la costa settentrionale della Tunisia, catturato in acque profonde, ossia a 450 m di profondità. L'esemplare era molto grande, con 1,12 m di larghezza del disco, 2,70 m di lunghezza totale e 110 kg di peso corporeo totale. Si tratta dell'esemplare più grande e più pesante ritrovato fino ad oggi nelle acque tunisine, e probabilmente anche nel Mediterraneo e al di fuori di esso. Gli autori inoltre discutono la distribuzione della specie, ben nota nel bacino del Mediterraneo orientale e nell'Atlantico tropicale orientale, ma sconosciuta nel bacino del Mediterraneo occidentale.*

Parole chiave: Dasyatidae, distribuzione, area di espansione, mare Mediterraneo, Atlantico tropicale orientale

INTRODUCTION

Round fantail stingray *Taeniurops grabata* (Geoffroy Saint-Hilaire, 1817) is found off the west African coast from Mauritania to Angola, around the Sào Tiago and Cape Verde Islands (Capapé & Desoutter, 1990). It has also been reported from the Azores Islands, where large free-swimming specimens were observed in the wild in shallow coastal waters (Barreiros, *pers. comm.*, 2019). *T. grabata* occurs throughout southeastern Mediterranean (McEachran & Capapé, 1984), especially from Turkish waters (Bilecenoglu *et al.,* 2014) to the Levant Basin (Golani, 2005), with the Syrian coast constituting to date the easternmost extension of its range (Ali *et al.*, 2013).

Taeniurops grabata has been reported in southern Tunisia, mainly in the Gulf of Gabès where a viable population appears to be successfully established (Capapé, 1989; Bradai *et al.*, 2004). However, more recently, Boudaya *et al.* (2018) studied parasitic infestation occurring in specimens captured off Bizerte, a city located in northern Tunisia. Additionally, a large specimen of *T. grabata* was captured from the same area and landed at the fish market of Zarzouna-Bizerte, where it was observed and photographed. This specimen is described in the present paper and some comments are given about the species distribution in the local area, the Mediterranean Sea and in the eastern tropical Atlantic.

MATERIAL AND METHODS

On 28 September 2019, a female specimen of *Taeniurops grabata* was caught by biface bottom trawl in the coastal waters of northern Tunisia, off Bizerte at 37° 40′ N and 9° 90′ E (Fig. 1). The capture occurred at a depth of 450 m, on soft bottom, unfortunately no information was provided about the associated fauna. Some measurements were recorded to the nearest centimetre (cm) and total body weight to the nearest kilogram (kg). Other morphometric measurement could not be taken, because the specimen was cut into slices after landing to be sold at the fish market of Bizerte; its flesh is appreciated in the preparation and consumption of local dishes.

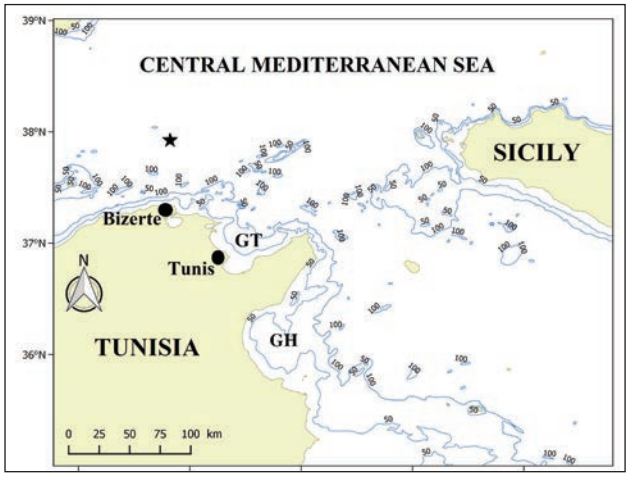

Fig. 1: Map of northern Tunisia with the black star indicating the capture site of *Taeniurops grabata*. ***GT = Gulf of Tunis; GH=Gulf of Hammamet.***
Sl. 1: Zemljevid severne Tunizije s črno zvezdico, ki označuje lokaliteto ulova vrste *Taeniurops grabata*. ***GT = tuniški zaliv; GH=hamameški zaliv.***

RESULTS AND DISCUSSION

The specimen was identified as *Taeniurops grabata* following Mc Eachran & Capapé (1984): disc rather circular, broader than long, tail short and compressed, with a membranous fold below; dorsal surface almost entirely rugose, with a row of spines from the middle of the disc to the spine; dorsal surface brown with dark blotches and irregular vermiculation, belly beige (Fig. 2).

McEachran & Capapé (1984) noted that the maximum disc width of *T. grabata* could reach 1 m, in total agreement with specimens recorded by Capapé (1989) from the Gulf of Gabès. The present specimen measured 1.12 m in disc width, 2.7 m in total length, and its total body weight reached 110 kg. This is therefore that largest and heaviest *Taeniurops grabata* recorded to date in Tunisian waters, probably throughout the Mediterranean and even outside this sea. Large elasmobranch species, generally sharks, occur off the northern coast of the Tunisian transitional area between the eastern and western basins (Soufi-Kechaou *et al.*, 2018; Capapé *et al.*, 2018), but this was the first time that as large a batoid species as *T. grabata* was found there, and furthermore, in deep waters. This species generally inhabits shallow coastal waters, not exceeding 50 m (Capapé, 1989). This capture of *T. grabata* at a depth of 450 m is rather unusual, probably occasional, but it could also explain the rarity of the species in deep areas that are poorly exploited by fisheries.

Taeniurops grabata used to be considered as a species having tropical affinities and only found in southern Tunisian regions (Postel, 1956). Conversely, Boudaya *et al.* (2018) studied parasitic infestation occurring in specimens of *T. grabata* captured northward from Bizerte. Such occurrence was probably due to migration toward northern regions. Similar patterns were reported for other elasmobranch species previously unknown in this latter area (El Kamel *et al.*, 2009; El Kamel-Moutalibi *et al.*, 2014; Rafrafi-Nouira *et al.*, 2015, Rafrafi-Nouira, 2016; Soufi-Kechaou *et al.*, 2018). These migrations are likely owed to the warming of the Mediterranean waters, including the Tunisian coast, due to global climate change (Francour *et al.*, 1994). Additionally, the present capture of a large specimen indicates that the occurrence of a northern population of *T. grabata* cannot be totally ruled out. It could be also considered as the species' northwesternmost extent of habitat range in the

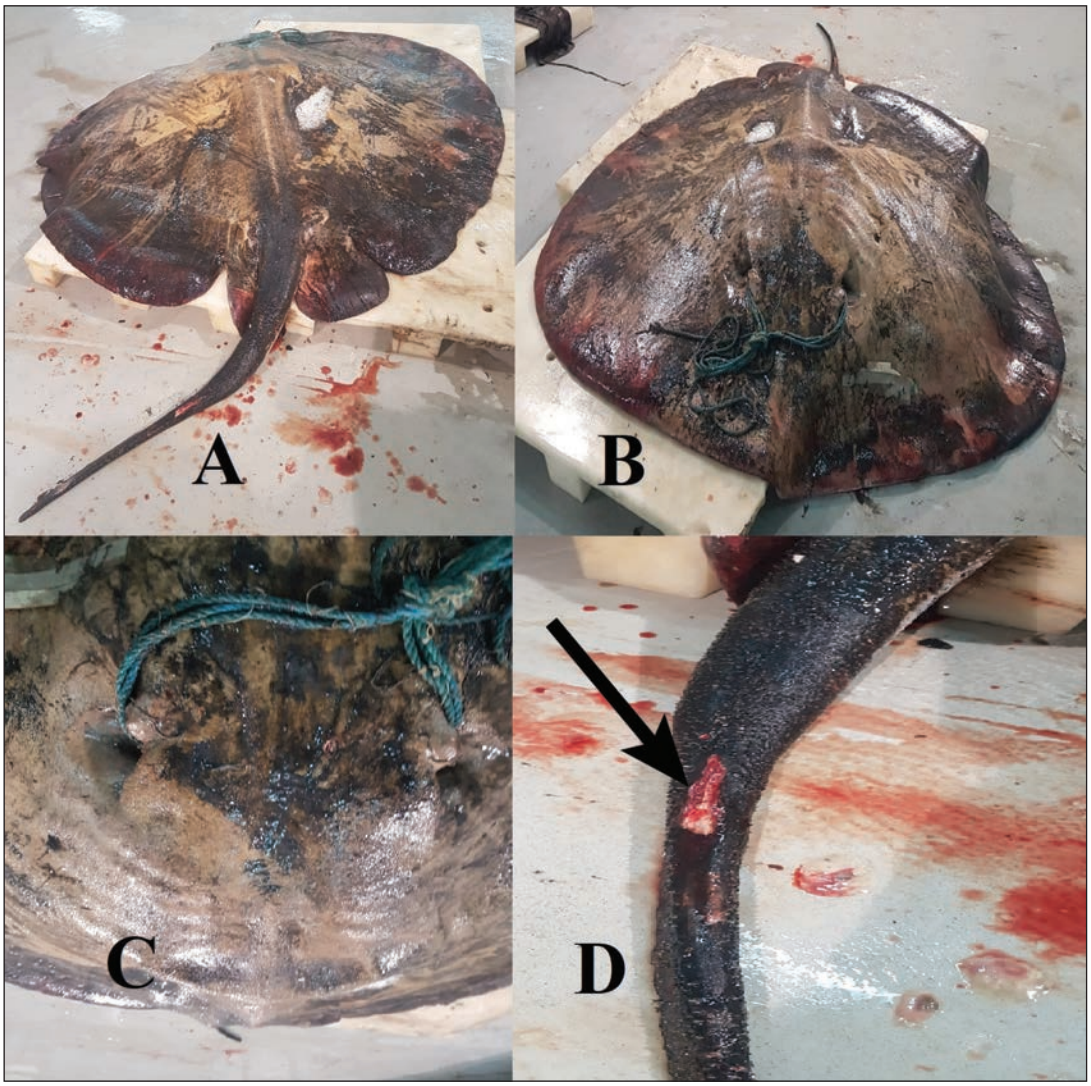

Fig. 2: The** Taeniurops grabata **captured from the northern coast of Tunisia. Dorsal surface = A. posterior view, B. anterior view, C. anterior margin view. D. tail, black arrow indicating the place of the sting removed by fishermen.
Sl. 2: Primerek vrste** Taeniurops grabata**, ujet ob severni tunizijski obali. Zgornja površina - A. pogled od zadaj, B. pogled od spredaj, C. pogled sprednjega roba. D. rep, črna puščica označuje predel, s katerega so ribiči odstranili trn.

Mediterranean Sea, as the species does not occur in the western Basin (Mc Eachran & Capapé, 1984) and is not reported northward off the coast of France (Capapé *et al*., 2006). Additionally, among Maghreb shores, *T. grabata* is unknown off the Algerian coast (Refes et *al*., 2010) and off the Moroccan coast (Lloris & Rucabado, 1998).

Boudaya *et al*. (2018) found the same anthocephalid species in *T. grabata* from the Tunisian coast and in those from the Senegalese coast. Additionally, three species belonging to the monogenean genus *Heterocotyle* Scoot 1904 parasitized the gills of *T. grabata* from these two distinct areas (Neifar *et al*., 1999). Such discoveries suggest that the distribution of *T. grabata* is not really fragmented and that the species' non-occurrence could be due to lack of sampling effort (Boudaya *et al*., 2018). *T. grabata* is known to inhabit shallow coastal waters (Capapé, 1989; Barreiros, *pers. comm*., 2019), however the capture of the studied specimen in deep waters confirms the opinion of Ajmenian & Powers (2014), who noted that batoid species are very mobile and prone to both large latitudinal and vertical migrations. Still, only molecular tools could indicate whether or not different populations of *T. grabata* occur in the Mediterranean Sea and in the eastern tropical Atlantic.

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NENAVADNI ZAPIS O POJAVLJANJU MORSKEGA BIČA VRSTE *TAENIUROPS GRABATA* (CHONDRICHTHYES: DASYATIDAE) IZ TUNIZIJSKIH VODA (OSREDNJE SREDOZEMSKO MORJE)

Mohamed Mourad BEN AMOR & Marouène BDIOUI
Institut National des Sciences et Technologies de la Mer, port de pêche, 2025 La Goulette, Tunisia

Khadija OUNIFI-BEN AMOR
Université de Tunis El Manar, Faculté des Sciences de Tunis, Laboratoire de Biodiversité, Biotechnologie et Changement Climatique, LR11ES09, 1002, Tunis, Tunisia

Christian REYNAUD & Christian CAPAPÉ
Laboratoire d'Ichtyologie, Université de Montpellier, case 104, 34095 Montpellier cedex 5, France
e-mail: capape@univ-montp2.fr

POVZETEK

Avtorji poročajo o ulovu morskega biča vrste Taeniurops grabata *(Geoffroy Saint-Hilaire, 1817) iz globine 450 m ob severni tunizijski obali. Gre za večji primerek, ki je meril 1,12 m v premeru telesnega diska in tehtal 110 kg. To je doslej največji in najtežji zabeleženi primerek te vrste v tunizijskih vodah in verjetno tudi v sredozemskih vodah in širše. Avtorji še razpravljajo o razširjenosti vrste, ki je sicer dobro raziskana v vzhodnem Sredozemskem morju in tropskem delu vzhodnega Atlantika, dokaj neznana pa v zahodnem delu Sredozemlja.*

Ključne besede: Dasyatidae, razširjenost, širjenje areala, Sredozemsko morje, vzhodni tropski Atlantik

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JADRANSKA MORSKA FAVNA

FAUNA MARINA ADRIATICA

ADRIATIC MARINE FAUNA

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HIPPOLYTE PRIDEAUXIANA LEACH, 1817: FIRST RECORD FOR THE NORTHERN ADRIATIC AND OBSERVATIONS ON MIMETIC COLOURATION

Roland R. MELZER
Zoologische Staatssammlung München, Münchhausenstr. 21, 81247 München, Germany
& Department Biologie II, Ludwig-Maximilians-Universität München, Großhaderner Straße 2, 82152 Planegg-Martinsried, Germany
e-mail: melzer@snsb.de

Martin HEß
Department Biologie II, Ludwig-Maximilians-Universität München, Großhaderner Straße 2, 82152 Planegg-Martinsried, Germany

Manuel A. STAGGL
Fakultät für Lebenswissenschaften, Universität Wien, Althanstr. 14, A-1090 Wien, Austria

Tihomir MAKOVEC & Borut MAVRIČ
Marine Biology Station, National Institute of Biology,Fornače 41, 6330 Piran, Slovenia

ABSTRACT

We present the first record of Hippolyte prideauxiana *Leach, 1816 for the northern Adriatic and the second record for the Adriatic Sea based on seven specimens we found during our faunistic inventory of the marine protected area of the Brijuni National Park, Croatia. Moreover, we give the first description of the appearance of 7 mm-juveniles and discuss the stage-specific traits of the crinoid mimesis of this species.*

Key words: *Hippolyte prideauxiana*, colouration, *Antedon mediterranea*, mimesis, Adriatic Sea

HIPPOLYTE PRIDEAUXIANA LEACH, 1817: PRIMO RITROVAMENTO PER L'ADRIATICO SETTENTRIONALE E OSSERVAZIONI SULLA COLORAZIONE MIMETICA

SINTESI

Gli autori presentano il primo ritrovamento di Hippolyte prideauxiana *Leach, 1816 per l'Adriatico settentrionale e il secondo per il mare Adriatico, in base a sette esemplari trovati durante l'inventario faunistico condotto nell'area marina protetta del Parco nazionale di Brioni, in Croazia. Nell'articolo viene inoltre riportata la prima descrizione dell'aspetto di giovani esemplari di 7 mm, e vengono discussi i tratti specifici della fase di mimesi crinoide di questa specie.*

Parole chiave: *Hippolyte prideauxiana*, colorazione, *Antedon mediterranea*, mimesi, mare Adriatico

INTRODUCTION

Species of *Hippolyte* Leach, 1814 are masters of camouflage that by virtue of their chromophores adapt to various substrates, e.g., algae and seaweed. *Hippolyte inermis* Leach, 1816 and a few other Mediterranean species exhibit seaweed mimesis, viz. they perfectly imitate the green colour of the seaweed. Even more sophisticated types of mimesis are found in species of *Hippolyte* that are epizoans of other marine invertebrates. *Hippolyte prideauxiana* Leach, 1817 is exclusively found on crinoids, e.g., *Antedon mediterranea* (Lamarck, 1816) (d'Udekem d'Acoz, 1996, 2007). These species match in appearance the same colouration as the crinoid. So far, females, immature females and males have been described by d'Udekem d'Acoz (1996, 2007). According to his observations, males and immature females have a dorsal red and yellow stripe, a ventrolateral red line, and two transvere red and yellow lines on the carapace. Adult females are similar, but the transverse lines are found all over the body. Until now there has been only one published record of this species for the Adriatic Sea (near Rijeka; Kirinčić, 2006), though its host, *A. mediterranea* is not a rare species in this part of the Mediterranean.

MATERIAL AND METHODS

While scuba diving off the coast of the Brijuni archipelago, we searched crinoids, *Antedon mediterranea*, for *Hippolyte prideauxiana*. Afterwards, we identified the *Hippolyte*s from underwater photos or took them together with their hosts to the lab to take aquarium photos of the living shrimp and observe their colouration and

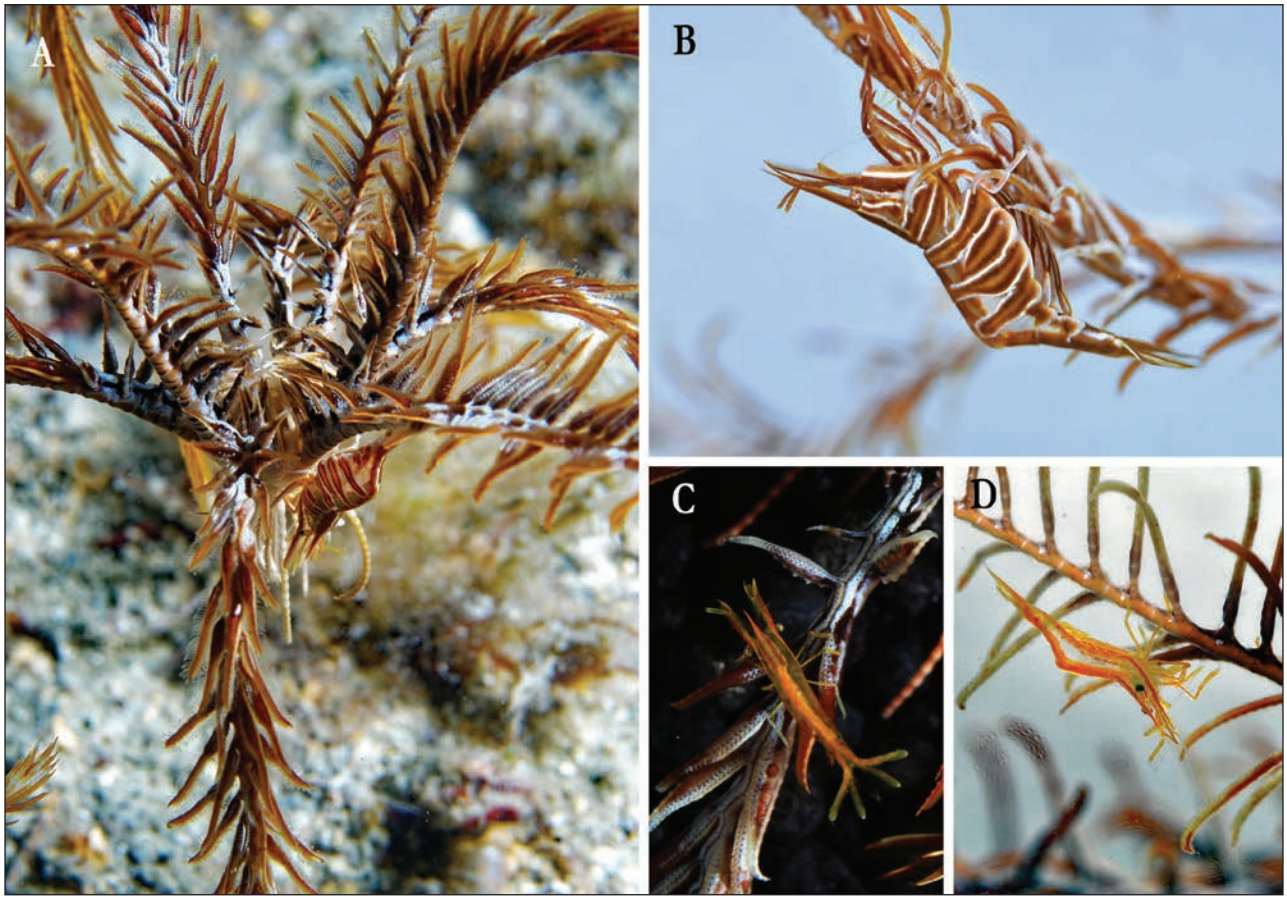

Fig. 1: *Hippolyte prideauxiana*. ***A) Adult female photographed in the wild at its usual resting place on the ventral side of an*** *Antedon mediterranea* ***near the cirri (photo: B. Mavrič). B) Another adult female showing a perfect*** *Antedon mimesis* ***(aquarium photo: M. Staggl). C) Juvenile on top of pinnules, dorsal view (aquarium photo: B. Mavrič). D) Lateral view showing that the transversal stripes are not yet present (aquarium photo: M. Staggl).***
Sl. 1: *Hippolyte prideauxiana*. ***A) Odrasla samica, fotografirana v naravi med mirovanjem na spodnji strani morske lilije blizu cirov (foto: B. Mavrič). B) Odrasla samica, ki se dobro prikriva na morski liliji (akvarijski posnetek: M. Staggl): C) Mladostni primerek na vrhu pinul, hrbtni pogled (akvarijski posnetek, foto: B. Mavrič). D) S strani je vidno, da prečnih prog še ni (akvarijski posnetek: M. Staggl).***

behaviour. For identification in the lab we used the key and detailed species description by d'Udekem d'Acoz (1996). We found *H. prideauxiana* at two localities, the south slope of Otok Gaz (44°56'8.33" N, 13°43'6.56" E) at a depth of about 23 m and off Rt Lansir (44°56'24.82" N, 13°44'33.39" E), also at about 20 m. Three of the specimens have been preserved in 75 % ethanol, one egg-carrying female (total length 22 mm), one female not carrying eggs (18 mm) and a juvenile (7 mm). They are stored in collns Arthropoda varia at the Bavarian State Collection of Zoology.

RESULTS

During our faunistic studies in the marine protected area in the Brijuni National Park (Melzer *et al*., 2016; Ceseña *et al*., 2017), we documented a specimen of *H. prideauxiana* on *A. mediterranea* at the south slope of Otok Gaz at a depth of about 23m in May 2018. In May 2019, we searched numerous crinoids in situ and found six more specimens of *H. prideauxiana*. Two of these, again, were documented off Otok Gaz, while the remaining four specimens were found off Lansir. In Figure 1A, a photo taken in the wild is shown; Figs. 1B, C and D show images captured in a photo aquarium in the lab. Five of the altogether seven observed specimens were adult females, and two were juveniles of about 7 mm length (Figs. 1C, D).

The females of *H. prideauxiana* had colourfull transverse bands covering the body including the pleon. They were white around the edges while the central area was red with a yellow midline. In addition, a red dorsal and yellow band was present. Conversely, in the juvenile specimens, the transverse bands were absent but the dorsal red and yellow stripe, as well as a ventrolateral red line on each side of the body were distinct. The adult shrimps very often sat at the base of the arms in such a way as to align their transverse stripes to the crinoids' pinnules. Conversely, the juvenile specimens spent a lot of time standing on top of pinnules oriented approximately in line with them in such a way that their longitudinal stripes were parallel to the pinnules. Otherwise, they moved around almost everywhere on the distal part of the arms.

DISCUSSION

Our records of this species are the second for the Adriatic and the first for the Northern Adriatic according to the biogeographic zones delineated by Bianchi (2004) and Relini (2010), where the southern border of biogeographic area "9", the northern Adriatic sector, is placed between Conero and Kamenjak.

In addition, our observations of our specimens' markings are of interest. Firstly, the colouration pattern of the females we observed corresponds very well with that described in d'Udekem d'Acoz (1996). Secondly, the 7 mm juveniles present another type of garb that is probably the ontogenetically earliest stage known to date and differs from those described earlier. These specimens had no transverse lines at all, but the longitudinal ones were already developed. We suggest that this stage is the forerunner of the colouration of the older shrimps, in other words, at some point during ontogeny, after a certain body size has been reached, the differentiation of transversal stripes begins, maybe first on the carapace (in males and/or immature females), and then all over the body (in mature females).

Looking at our photos of adults, it is very tempting to say that with respect to their colours, shape and size, the transverse stripes imitate pinnules, i.e., the side branches of the feather star's arms. Conversely, the longitudinal stripes of the much smaller juveniles could provide the same masquerade, but with a pattern twisted 90 degrees to that of the adults. There have been several detailed attempts to understand the mimetic colouration of species of *Hippolyte* (e.g., Hacker & Madin 1991; Duarte *et al*., 2016, 2017). We suggest that similar analyses of *H. prideauxiana* could be very interesting.

It seems that the abundance of *H. prideauxiana* in the Northern Adriatic is relatively low, since we searched numerous *Antedon*s during our campaigns in 2018 and 2019, and found altogether the seven specimens mentioned in this paper. Nevertheless, it's difficult to say whether our *Hippolyte*s are hard to find because their camouflage technique is so close to perfection that they have been overlooked until present, or if the number of faunistic studies has been too low to detect them, or if they are really rare, indicating that the Brijuni MPA is a sanctuary for this species. Interesting to note is the fact that some of the authors have been studying the northern Adriatic benthos off Piran and Rovinj for decades using both scuba diving and dredges without finding a single individual of *H. prideauxiana*.

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HIPPOLYTE PRIDEAUXIANA LEACH, 1817: PRVI ZAPIS O POJAVLJANJU V SEVERNEM JADRANU S PODATKI O BARVNEMU PRIKRIVANJU

Roland R. MELZER
Zoologische Staatssammlung München, Münchhausenstr. 21, 81247 München, Germany
& Department Biologie II, Ludwig-Maximilians-Universität München, Großhaderner Straße 2, 82152 Planegg-Martinsried, Germany
e-mail: melzer@snsb.de

Martin HEß
Department Biologie II, Ludwig-Maximilians-Universität München, Großhaderner Straße 2, 82152 Planegg-Martinsried, Germany

Manuel A. STAGGL
Fakultät für Lebenswissenschaften, Universität Wien, Althanstr. 14, A-1090 Wien, Austria

Tihomir MAKOVEC & Borut MAVRIČ
Marine Biology Station, National Institute of Biology,Fornače 41, 6330 Piran, Slovenia

POVZETEK

Avtorji poročajo o prvi najdbi vrste Hippolyte prideauxiana *Leach, 1816 v severnem Jadranu in drugem zapisu za celotno Jadransko morje. Podatki temeljijo na najdbah sedmih primerkov, najdenih med inventarizacijo favne v morskem zavarovanem območju v okviru Nacionalnega Parka Brijoni na Hrvaškem. Poleg tega avtorji podajajo prvi opis 7 mm dolgega juvenilnega primerka in razpravljajo o značilnostih prikrivanja različnih stadijev te kozice na morskih lilijah.*

Ključne besede: *Hippolyte prideauxiana*, barvni vzorec, *Antedon mediterranea*, prikrivanje, Jadransko morje

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BIOMETRY AND POPULATION GENDER STRUCTURE OF THREE CRAB SPECIES (CRUSTACEA: DECAPODA) FROM SANDY BOTTOM IN THE NORTHERN ADRIATIC SEA

Mona REZAEI
Faculty of Natural sciences and Mathematics, University of Maribor, Koroška cesta 160, SI-2000 Maribor, Slovenia
e-mail: mona13831383@yahoo.com

Al VREZEC
Department for Organisms and Ecosystems Research, National Institute of Biology, Večna pot 111, SI-1000, Ljubljana, Slovenia

Borut MAVRIČ & Lovrenc LIPEJ
Marine Biology Station, National Institute of Biology, Fornače 41, Piran, Slovenia

ABSTRACT

The aim of the study was to investigate the distribution and population structure of three species of crabs (Decapoda: Crustacea), Medorippe lanata*,* Liocarcinus depurator *and* Liocarcinus vernalis *for their biometric relationships. A total of 1100 specimens of three species were caught from waters off the northern Adriatic Sea in December 2013. Biometric relationships and condition factor (Fulton's coefficient index) were measured for all the studied species. Size dimorphism was also observed in* M. lanata *with females showing significantly larger carapace size than males without significant difference in wet weight. The studied species did not differ significantly in the results of the condition index.*

Key words: *Medorippe lanata*, *Liocarcinus depurator*, *Liocarcinus vernalis*, biometry, condition factor, Adriatic Sea

BIOMETRIA E STRUTTURA DI GENERE NELLE POPOLAZIONI DI TRE SPECIE DI GRANCHI (CRUSTACEA: DECAPODA) DI FONDI SEDIMENTARI DELL'ADRIATICO SETTENTRIONALE

SINTESI

Lo scopo dello studio era quello di verificare la distribuzione e la struttura della popolazione di tre specie di granchi (Decapoda: Crustacea), Medorippe lanata, Liocarcinus depurator *e* Liocarcinus vernalis, *per evidenziare le relazioni biometriche. Un totale di 1100 esemplari appartenenti alle tre specie sono stati catturati nelle acque al largo della costa dell'Adriatico settentrionale, nel dicembre 2013. Le relazioni biometriche e il fattore di condizione (indice del coefficiente di Fulton) sono stati calcolati per tutte le specie studiate. Il dimorfismo dimensionale è stato osservato anche in* M. lanata*, dove le femmine hanno dimensioni del carapace significativamente maggiori rispetto ai maschi, senza differenza significativa nel peso umido. Le specie studiate non differivano significativamente nei risultati dell'indice di condizione.*

Parole chiave: *Medorippe lanata*, *Liocarcinus depurator*, *Liocarcinus vernalis*, biometria, fattore di condizione, mare Adriatico

INTRODUCTION

Measurement and analysis of biometric parameters could assist in understanding the biological and physiological status of crustaceans. One such importance has been previously shown for fecundity of *Potamon kooloosense* (Rawat *et al.*, 2016). The morphometric and allometric analyses or relation amongst different body segments is functionally significant in biology (Huber, 1985). Investigation of length-weight relationship is widely performed and used to study different aspects of animal and aquatic population such as maturity and health (Patil & Patil, 2012). In this context, the condition factor is used to study and compare the ecological and health characteristics of any species. Condition index differs from growth in that it shows weight for a given length and it is hypothesised that improved condition is achieved through increased weight at a given length (Bolger & Connolly, 1989).

Sex ratio is an assessment of animals and aquatic population condition which has been defined as an indicator of population behaviour and fecundity (Pantulu, 1961). Sex ratio gives important information on separation or disappearance of either sexes in any given ecosystem. This information may be used to investigate possible influence of the environment or human activity on the sex imbalance in the population (if any). However, the imbalance in sex ratio may be simply attributed to the natural behaviour of the population such as seasonal migration of females for spawning (Carlino *et al.*, 2014).

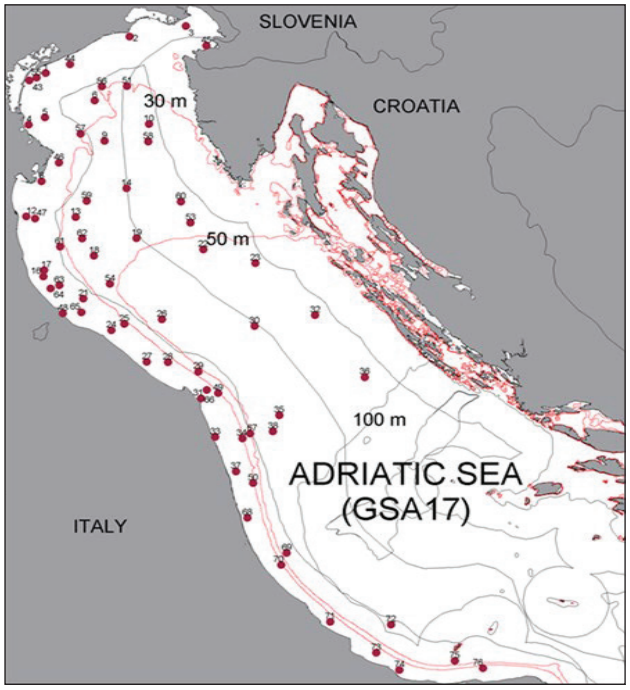

Fig. 1: The area covering the sampling stations.
Sl. 1: Zemljevid obravnavanega območja z vzorčevalnimi postajami.

Crustaceans are the most numerous groups of invertebrates in marine ecosystem, with many species facing population decline (Bellido *et al.*, 2011). Our study focuses on brachyuran decapods (Crustacea: Decapoda: Brachyura) since many crab species are endangered by environmental and human factors such as by-catch, where many non-target animals are also killed, causing a decline in crab populations (Bellido *et al.*, 2011). However, many other factors can cause species declines, which are poorly studied in marine crabs.

The aim of the paper is to explore biometry of three crab species populations in the northern Adriatic Sea, namely the species *Liocarcinus depurator* (Linnaeus, 1758), *Liocarcinus vernalis* (Risso, 1816) and *Medorippe lanata* (Linnaeus, 1767), which are all characteristic for sandy soft bottoms (Manning *et al.*, 1981; Abelló *et al.*, 1991). Although these crabs are frequently caught in fishermen nets as bycatch (Ingle, 1997; Bergmann & Moore, 2001), they are relatively poorly studied. Information provided by this study will give valuable insight into their ecology and could facilitate future sustainable management of these species in the Adriatic Sea.

MATERIAL AND METHODS

Study area

The 67 sampling stations were distributed over the area shown in Figure 1. Stations occurred at different depths (0–30 m: 39 stations; 30–50 m: 17 stations; 50–100 m: 11 stations). Crabs of the three studied species were obtained as a by-catch of fishery nets. Sampling took place in the waters off the northern Adriatic Sea in December 2013 as a part of fishery expedition.

Studied species

Liocarcinus depurator is distributed in bottoms of the North Sea, Atlantic Ocean, Mediterranean Sea, and also in the Black Sea (Ateş, 1999). It grows up to 50 mm in width and 40 mm in length (Hill, 2007) and can be distinguished from other crabs by the curved rows of white spots on its carapace (Telnes, 2012). It is a predominant brachyuran in the by-catch in Mediterranean demersal fisheries, as deep as 200 m (Sarda & Palomera, 1981). *L. depurator* constitutes a main fraction of the cast-off species in many marine fisheries (Bergmann & Moore, 2001). Crabs often inhabit harbours with the proximity to anchored fishing vessels and feed on trash thrown off the board.

The grey swimming crab *Liocarcinus vernalis* is a crab inhabiting shallow waters. It is present in the Mediterranean Sea and from West Africa to the southern North Sea (McCarthy *et al.*, 2005).

The distribution of benthic crab *Medorippe lanata* extends from Atlantic Ocean to the Mediterranean (Man-

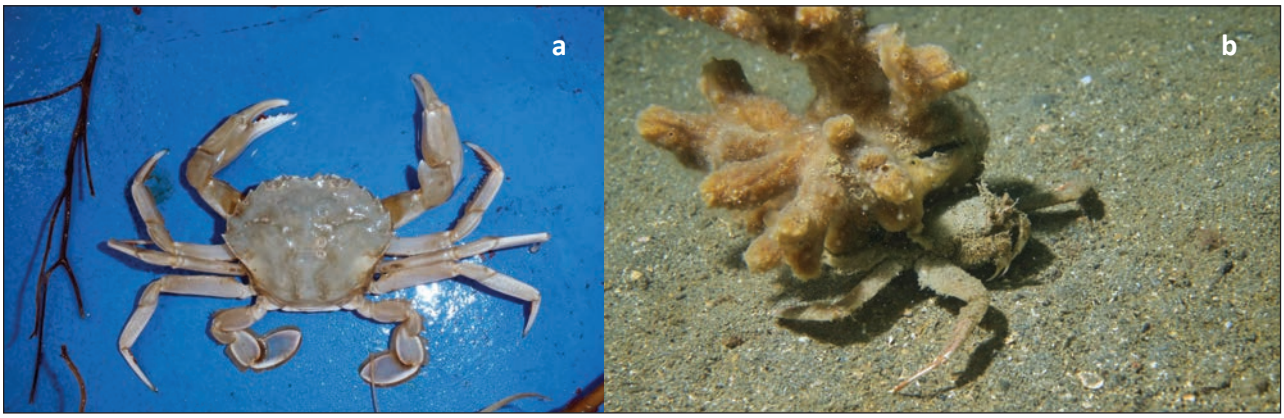

Fig. 2: The image of two studied crab species: (a) *Liocarcinus depurator* ***(Risso, 1816) and (b)*** *Medorippe lanata* ***(Linnaeus, 1767).***
Sl. 2: Raziskane vrste rakovic: (a) *Liocarcinus depurator* ***(Risso, 1816) in (b)*** *Medorippe lanata* ***(Linnaeus, 1767).***

ning *et al.*, 1981) in depths from 9 to 952 m of muddy bottoms (D'Udekem d'Acoz, 1999). Carapace length in females and males has been reported to range from 10-29 and 9-29 mm respectively (Rossetti *et al.*, 2006). This crab is subjected to trawling and eventually discarded due to the lack of commercial value (Biagi *et al.*, 2002). Occasionally it is caught in significant numbers in trawls of fishing vessels and in squid or crab/lobster pots (Ingle, 1997).

Biometric measurements

Crab specimens were measured by Vernier calliper with accuracy up to 0.01 mm. The biometric parameters which were measured are the carapace length and width. All crabs were sexed and their wet weight was measured by using digital balance (Palmscale 8; 300g x 0.01 Capacity) (Lara *et al.*, 2013). Due to the damage occurred during sampling, gender could not be identified in four crab specimens, all of *L. vernalis*. These crabs were excluded from analysis where males and females were compared.

Data analysis

Analysis of data was performed using SigmaPlot 13 for Windows (Systat Software Inc. CA, USA). Normal distribution of data was confirmed by the Kolmogorov–Smirnov test. The mean values of two groups (*e.g.* female and male) of normally distributed data were compared by a Student's t test. The median values of two groups of data that were not normally distributed were compared using the non-parametric Mann–Whitney *U* test. Moreover, non-normally distributed data were subjected to Kruskal–Wallis test by ranks followed by the Wilcoxon rank-sum test. *Chi*-square test was performed to compare the rates. A *P*-value of 0.05 or less was considered as significant.

In addition, regression analysis was performed to investigate the relationship between carapace weight and length. To compare condition among species in question, Fulton's condition factor (Fulton, 1904) was calculated as:

$K=100W/CL^3$

where *W* was weight (g) and *CL* carapace length (cm).

RESULTS

Overall survey of the studied populations

All specimens of crabs were collected from 32 sampling stations. The number per station varied from 1 to 92 specimens. Out of 922 crabs, 451 individuals were *L. vernalis*, 317 *L. depurator* and 154 *M. lanata* (Tab. 1).

Except for *M. lanata*, the number of males in other species was higher than that of females (Tab. 2). The sex ratio in all species (except for *M. lanata*) was found to be significantly different from 1:1 (*chi*-square test).

Tab. 1: The number of analysed males (M) and females (F) per crab species.
Tab. 1: Število analiziranih samcev (M) in samic (F) raziskanih vrst rakovic.

Species	Sex	Number of individuals
Liocarcinus depurator	M ♂	192
	F ♀	125
Liocarcinus vernalis	M ♂	301
	F ♀	150
Medorippe lanata	M ♂	68
	F ♀	86

Tab. 2: Sex ratio in population of examined three crab species. Significant difference from 1:1 ratio was indicated by chi-squared test. Legend: 1 - Regardless of gender in the whole population, 2 - P-values indicate significant difference from hypothetical ratio of 1:1.
Tab. 2: Delež samic in samcev pri treh raziskanih vrstah rakovic. Signifikantni odklon od razmerja 1:1 smo preverjali s Hi- kvadrat testom. Legenda: 1 - Delež vrste ne glede na spol, 2 – P-vrednost kaže signifikantni odklon od hipotetičnega razmerja med spoloma 1:1.

	Ratios in the population					*Chi*-square test	
Species	**N Females**	**N Males**	**Proportion of population[1]**	**% Females**	**% Males**	**χ^2**	**P-Value[2]**
L. depurator	125	192	34.4	0.39	0.61	6.75	0.009
L. vernalis	150	301	48.9	0.33	0.67	25.35	<0.001
M. lanata	86	68	16.7	0.56	0.44	1.35	0.25

No effect of depth was found on the distribution of the studied crabs.

Wet weight

Wet weight was compared among the three studied species (Fig. 3). Non-parametric analysis revealed significantly higher wet weight in males than in females of *L. vernalis* (Mann–Whitney *U* test: *U*=18377, *P*=0.012). The males of *L. vernalis* were also significantly larger than males of *L. depurator* and *M. lanata*. The difference among females across species was not significant (Wilcoxon rank-sum test: *P*=0.63).

Carapace width-carapace length relationships

Liocarcinus depurator

Carapace length was on average larger than carapace width in *L. depurator*. Carapace width ranged from 13.7 to 29.0 mm in males and 14.7 to 27.2 mm in females. Carapace length ranged from 11.2 to 42.3 mm in males and 17.9 to 39.4 mm in females. No statistically significant differences were found between females and males of *L. depurator* in carapace width and length. There was a significant correlation between carapace width and length for males and females combined (Fig. 4).

Liocarcinus vernalis

Carapace length was on average larger than carapace width. The latter ranged from 10.5 to 26.5 mm in males and 14.7 to 27.2 mm in females. Carapace length ranged from 14.8 to 43.1 mm in males and 14.0 to 37.3 mm in females. No statistically significant differences were found between females and males of *L. vernalis* in carapace width and length. There was significant correlation between carapace width and length for males and females combined (Fig. 5).

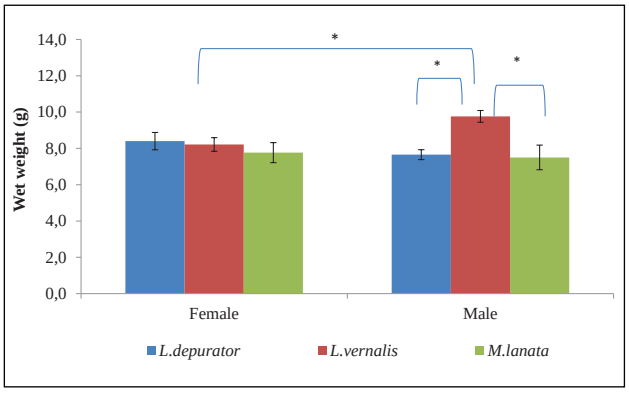

Fig. 3: Comparison of wet weight among different species and between genders within species. Asterisk indicates a statistical difference (* P<0.05).
Sl. 3: Primerjava mokre teže pri različnih vrstah in spolih. Zvezdica označuje statistično razliko (* P<0.05).

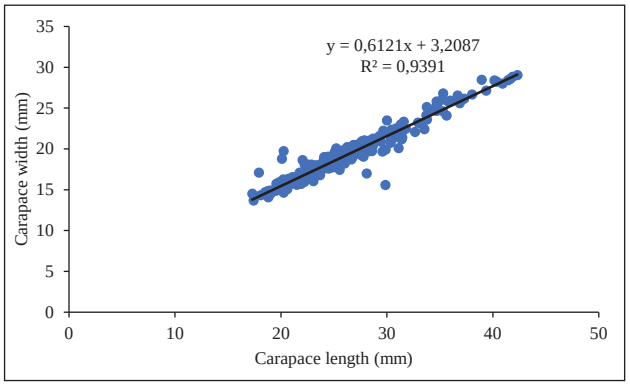

Fig. 4: Scatterplot and relationship between carapace width and length in* Liocarcinus depurator *(t=69.2; P<0.001).
Sl. 4: Razpršeni diagram in odnos med širino in dolžino karapaksa pri vrsti* Liocarcinus depurator *(t=69.2; P<0.001).

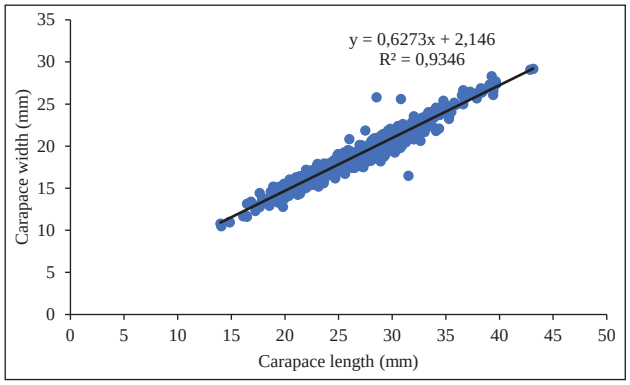

Fig. 5: Scatterplot and relationship between carapace width and length for the whole population of *L. vernalis* ***(t=79.6; P<0.001).***
Sl. 5: Razpršeni diagram in odnos med širino in dolžino karapaksa pri vrsti *L. vernalis* ***(t=79.6; P<0.001).***

Medorippe lanata

Carapace length was on average larger than carapace width. Carapace width ranged from 7.0 to 17.35 mm in males and 7.8 to 17.3 mm in females. Carapace length ranged from 10.0 to 35.5 mm in males and 12.7 to 37.8 mm in females. Carapace width, length and height in females of *M. lanata* were significantly greater than those of males (Mann–Whitney *U* test: U_{width}=2126, P_{width}=0.01, $U_{length=}$2107, P_{length}=0.008, U_{height}=1967, P_{height}=<0.001) (Fig. 6).

There was significant correlation between carapace width and length for males and females combined (Fig. 7).

Fulton's condition index

The differences between males and females in condition index were not statistically significant (Mann-Whitney U test) within and between any of the species (Tab. 3).

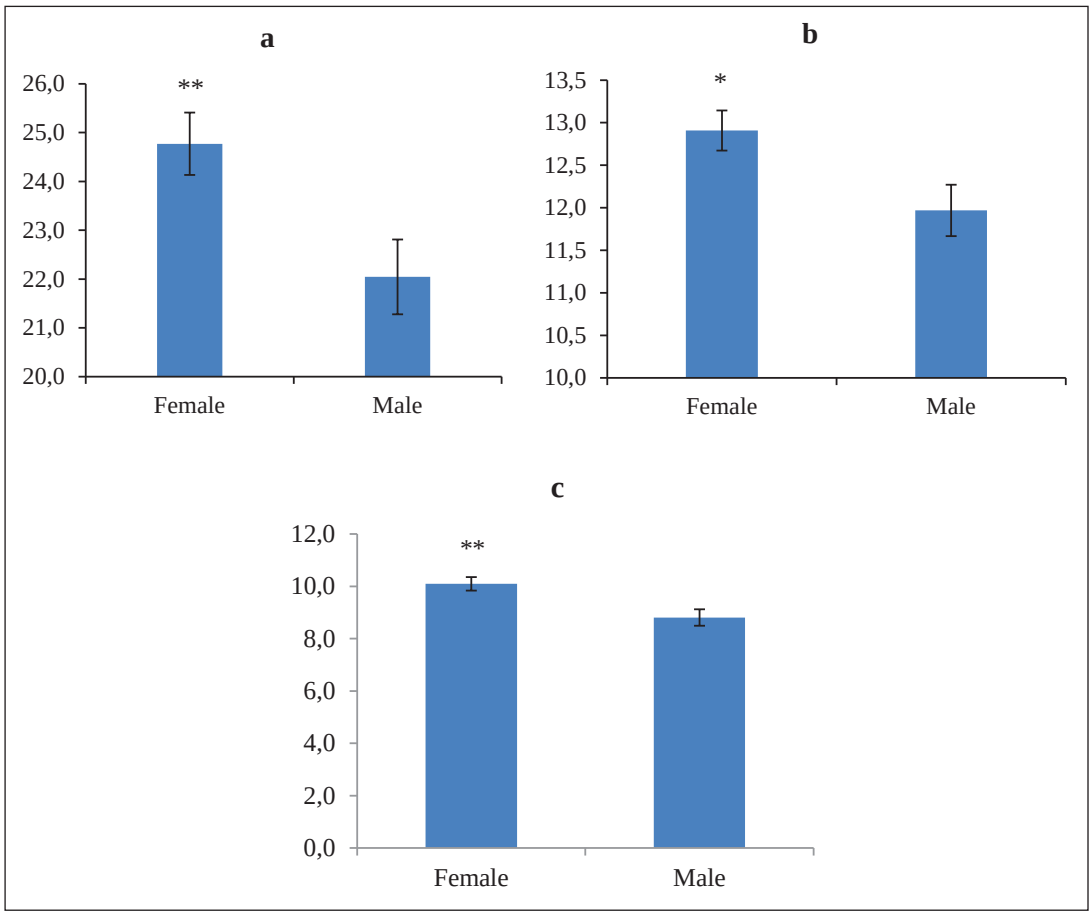

Fig. 6: Carapace width (a), length (b) and height (c) of females (n=86) and males (n=68) of *M. lanata*. ***Asterisk indicates a statistical difference (* P<0.05; ** P<0.01). Values (in mm) represent means ± standard error (SE).***
Sl. 6: Širina (a), dolžina (b) in višina (c) karapaksa pri samicah (n=86) in samcih (n=68) vrste *M. lanata*. ***Zvezdica označuje statistično razliko (* P<0.05; ** P<0.01).***
Vrednosti (v mm) predstavljajo povprečje in standardni odklon (SE).

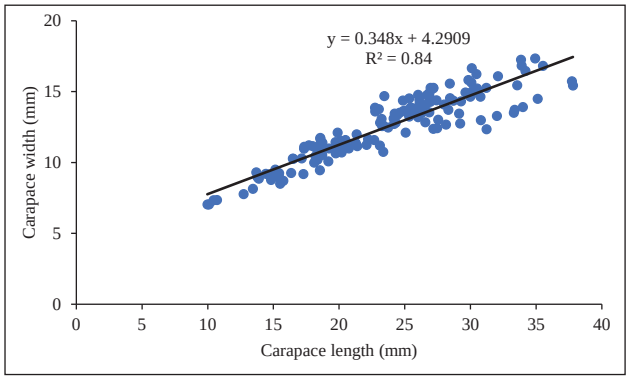

Fig. 7: Scatterplot and relationship between carapace width and length for the whole population of** M. lanata **(t=28.1; P<0.001).
Sl. 7: Razpršeni diagram in odnos med širino in dolžino karapaksa pri vrsti** M. lanata **(t=28.1; P<0.001).

DISCUSSION

Crab populations

L. vernalis and *L. depurator* were caught in higher numbers, which could be a possible indication of their dominance in the ecosystem of the northern Adriatic Sea. These two species represent 70% of all collected individuals. *L. vernalis* has also been shown previously to be one of the dominant species in Spanish Bay of Cadiz (Drake *et al.*, 1998). One reason for dominance could be the environmental conditions such as depth. It has been shown that *L. depurator* density is highest at depths between 51–100 m in Iberian Peninsula (Rufino *et al.*, 2005). However, in this study *L. depurator* and *L. vernalis* distribution was not affected by depth. Other factor affecting population could be the impact of predators which could not be controlled and measured in this study.

The maximum density of *L. depurator* was reported to occur in depths below 100 m (Rufino *et al.*, 2005) corresponding to this study's range of depths. The distribution of *L. vernalis* has been reported to occur in regions as deep as 130 m in the Mediterranean Sea (Koch & Ďuriš, 2016) and the maximum recruitment of *M. lanata* has been found within 20-100 m depth (Abelló *et al.*, 1988) which corresponds to the depth range in this study.

Higher ratio of males to females is evident in both studied *Liocarcinus* species. This is in agreement with Sartor *et al.* (2006) who reported higher vulnerability of males to fishing and sorting operations compared with females. One alternative explanation to the higher ratio of males to females may be the migration of females to other regions for spawning during the sampling period as shown previously for Atlantic blue crab *Callinectes sapidus* (Carlino *et al.*, 2014).

Biometry

Males of *L. vernalis* were significantly larger than females, however this was not associated with significant differences in carapace dimensions between males and females. No other scientific report was found to confirm sexual dimorphism in *L. vernalis*. The weight of females of *M. lanata* were found to be larger than that in males numerically, however, the difference was not statistically significant. The sexual dimorphism is observed in *M. lanata* at carapace level with the dimensions of carapace being significantly larger in females. Sexual dimorphism in size of chelae was reported previously in *M. lanata* (Rossetti *et al.*, 2006). The range of carapace length of *L. depurator* in this study was close to that reported previously by Ungaro *et al.* (2000).

Strong relationship between carapace width and length is observed for all species in females and males. The relationship between carapace width and length is used to indicate health and physiological conditions within the population (Bolger & Connolly, 1989).

Fulton's condition index

The condition factor is used as an indicator of health and biomass which is found to change in response to crabs' alterations in weight. This may occur under different feeding, growth and physiological conditions (Bolger & Connolly, 1989). Condition index of *L. depurator* in this study is similar to those obtained by Aydin (2018). No significant difference in this parameter between female and male of all studied crabs could

Tab. 3: Fulton's condition index of the studied crab species. Values represent means ± standard error (SE).
Tab. 3: Fultonov kondicijski indeks pri treh vrstah rakovic. Vrednosti predstavljajo srednjo vrednost in standardni odklon (SE).

Species		Total	Female	Male	Gender effect	
	n (total)	Mean±SE	Mean±SE	Mean±SE	P-value	U-test
L. depurator	298	50.4±2.5	51.0±3.0	49.8±2.0	0.46	15499
L. vernalis	442	55.7±2.4	57.6±2.9	53.9±1.9	0.31	27559
M. lanata	149	55.8±3.8	51.7±3.6	59.9±4.1	0.06	4954

indicate that there were no environmental, nutritional and physiological effect on body condition between both sexes.

The information on the biometry and population profile of three species of crabs in northern Adriatic Sea can be useful in the future studies to evaluate and monitor any changes in the population of crabs. Further, the obtained data in this study could be helpful when performing research on various crab predators in the shallow area of the northern Adriatic Sea such as sharks and rays.

The specimens which are killed as bycatch in fisheries provide a valuable source of data for studying the ecology of such species. Thus, it is important to obtain as much as possible data regarding these crabs and other organisms due to the collateral damage imposed by fisheries. Further studies are needed to study how environmental and human factors may affect crab populations and their biometrical features in northern Adriatic Sea. One such environmental effect could be the seasonal change in water quality and/or temperature. The knowledge in population structure and biometry can be used to adjust regulation leading to protection of crabs and overall benthic fauna in the region.

ACKNOWLEDGEMENTS

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BIOMETRIJA IN SPOLNA STRUKTURA PRI TREH VRSTAH RAKOVIC (CRUSTACEA: DECAPODA) IZ SEDIMENTNEGA DNA SEVERNEGA JADRANA

Mona REZAEI
Faculty of Natural sciences and Mathematics, University of Maribor, Koroška cesta 160, SI-2000 Maribor, Slovenia
e-mail: mona13831383@yahoo.com

Al VREZEC
Department for Organisms and Ecosystems Research, National Institute of Biology, Večna pot 111, SI-1000, Ljubljana, Slovenia

Borut MAVRIČ & Lovrenc LIPEJ
Marine Biology Station, National Institute of Biology, Fornače 41, Piran, Slovenia

POVZETEK

Cilj raziskave je bil raziskati razširjenost in populacijsko strukturo treh vrst rakovic (Decapoda: Crustacea), Medorippe lanata*,* Liocarcinus depurator *in* Liocarcinus vernalis *ter biometrične meritve. V decembru 2013 je bilo v severnem Jadranu ujeto skupno 1100 primerkov, ki so pripadali trem vrstam. Avtorji so opravili biometrične meritve in izračunali Fultonov kondicijski indeks za vse tri vrste. Pri vrsti* M. lanata *je bila izražena spolna dvoličnost, ki se je kazala v večjih karapaksih samic, čeprav ta ni bila signifikantna v telesni teži. Raziskane vrste se glede kondicijskega indeksa niso statistično razlikovale.*

Ključne besede: *Medorippe lanata*, *Liocarcinus depurator*, *Liocarcinus vernalis*, biometrija, kondicijski indeks, Jadransko morje

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ONESNAŽEVANJE OKOLJA

INQUINAMENTO DELL'AMBIENTE

ENVIRONMENTAL POLLUTION

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BELONE BELONE (LINNAEUS, 1760) AND *SPICARA SMARIS* (LINNAEUS, 1758) ENTANGLED IN PLASTIC COLLARS IN THE DARDANELLES STRAIT, TURKEY

Sezginer TUNÇER
Çanakkale Onsekiz Mart University, Faculty of Marine Sciences and Technology, Terzioğlu Campus, 17100 Çanakkale, Turkey

Sedat GÜNDOĞDU & Cem ÇEVIK
Faculty of Fisheries, Department of Basic Sciences, Cukurova University, 01330, Balcalı Adana, Turkey

Aytuğ ZILIFLI
Graduate School of Natural and Applied Sciences, Çanakkale Onsekiz Mart University, Çanakkale, Turkey
e-mail: aytugzilifli@stu.comu.edu.tr

ABSTRACT

One of the main causes of injury and mortality in marine life is entanglement in plastic litter. Marine plastic waste can affect marine organisms in several ways: causing serious injury or death (resulting from entanglement in or ingestion of plastic items), enabling chemical and microbial transfer (by acting as a vector for the transport of biota), and producing changes in species communities. In this study, two adult individuals from the Spicara smaris *and* Belone belone *species caught in pelagic longlines at the Dardanelles Strait were found with plastic collars around their operculum and trunk, respectively. The plastic waste items were identified as security rings of plastic bottle caps. Both species displayed several degrees of injury. After removing the gastrointestinal tract of* B. belone*, a plastic filament was also found. This study shows that the impact of plastic debris on marine life is worsening.*

Key words: *Belone belone*, *Spicara smaris*, plastic collar, Dardanelles strait, plastic pollution

BELONE BELONE (LINNAEUS, 1760) E *SPICARA SMARIS* (LINNAEUS, 1758) INTRAPPOLATI IN COLLARI DI PLASTICA NELLO STRETTO DEI DARDANELLI, TURCHIA

SINTESI

Una delle principali cause di lesioni e mortalità nell'ambiente marino è l'intrappolamento nei rifiuti di plastica. Tali rifiuti marini possono nuocere agli organismi marini in diversi modi: causando lesioni e morte (derivanti dall'intrappolamento o dall'ingestione di oggetti in plastica), consentendo il trasferimento di sostanze chimiche e microbiche (agendo da vettore per il trasporto) e producendo cambiamenti nelle comunità. In questo studio sono stati trovati due individui adulti di Spicara smaris *e* Belone belone *catturati in palangari pelagici nello Stretto dei Dardanelli, con colletti di plastica attorno al loro opercolo e tronco. I rifiuti di plastica sono stati identificati come anelli di sicurezza di tappi di bottiglie di plastica. Entrambe le specie hanno mostrato diversi gradi di lesione. Nel tratto gastrointestinale di* B. belone *è stato trovato anche un filamento di plastica. Questo lavoro indica che l'impatto dei rifiuti di plastica sulla vita marina sta peggiorando.*

Parole chiave: *Belone belone, Spicara smaris,* collare di plastica, stretto dei Dardanelli, inquinamento da plastica

INTRODUCTION

Marine plastic pollution has become an epic issue for marine environment. The most recent estimates show that 275 million tons (MT) of plastic garbage were generated worldwide in 2010, with 4.8 to 12.7 MT dumped into marine environments (Jambeck *et al.*, 2015). As a result, over 250,000 tons of plastics are floating in the sea (Eriksen *et al.*, 2014; Jambeck *et al.*, 2015). The intensive presence of plastic litter in marine environment poses serious risks to marine life: entanglement, ingestion and colonization (Amaral-Zettler *et al.*, 2015; Fazey and Ryan, 2016; Gündoğdu *et al.*, 2017; Votier *et al.*, 2011). Entanglement in plastic rubbish is one of the major causes of injury and mortality in a wide range of marine life (marine mammals, fish, birds and reptiles) (Gregory, 2009; Ryan *et al.*, 2009; Schrey and Vauk, 1987; Votier *et al.*, 2011). According to Litterbase, a compilation of data based on scientific publications, entanglement is the third most frequent type of interaction with litter (23.88%) for marine life (Tekman *et al.*, 2019).

Marine plastic pollution affects marine biota and ecosystems at many different levels. The impact of plastics on marine life is in parallel with the level of plastic pollution in the marine environment. Due to its semi-enclosed nature and intense coastal pressures, the Mediterranean Sea is under heavy impact from plastic contamination. It is estimated that between 1000-3000 tons of plastic litter is floating in the surface waters of the Mediterranean (Cozar *et al.*, 2015; Bray *et al.*, 2019). Many researchers have stated that the Mediterranean Sea is an important plastic accumulation area and can be considered as the sixth garbage patch (Lebreton *et al.*, 2012; Cozar *et al.*, 2015; Suaria *et al.*, 2016). According to many researchers, the Mediterranean coasts of Turkey are among the most plastic-polluted coasts (Gündoğdu, 2017; Liubartseva *et al.*, 2018; Tunçer *et al.*, 2018). Consequently, the high level of plastic pollution poses important risks for the local marine life. Some of the previous studies have reported the various kinds of impact of plastics (ingestion, entanglement, colonization and habitat occupation) on marine life in the Mediterranean coasts of Turkey (Ayaz *et al.*, 2006; Tonay *et al.*, 2007; Triessnig *et al.*, 2012; Gündoğdu *et al.*, 2017; Güven *et al.*, 2017; Acar & Ates, 2018; Gündoğdu *et al.*, 2019).

We report herein on plastic debris collars attached to two adult fish specimens (*Belone belone* (Linnaeus, 1760) and *Spicara smaris* (Linnaeus, 1758)) in the Dardanelles Strait and comment on their incidence and damage to the fish.

MATERIALS AND METHODS

Two adult specimens of *S. smaris* and *B. belone* were caught in longlines in the Çardak Lagoon and Kumkale, locations situated at the Dardanelles Strait (Fig. 1). *B. belone* was caught on 11 April 2019 by local fishermen (commercial) operating in Cardak/Lapseki. *S. smaris* was caught by a small-scale fisherman in the Kumkale region on 20 April 2019.

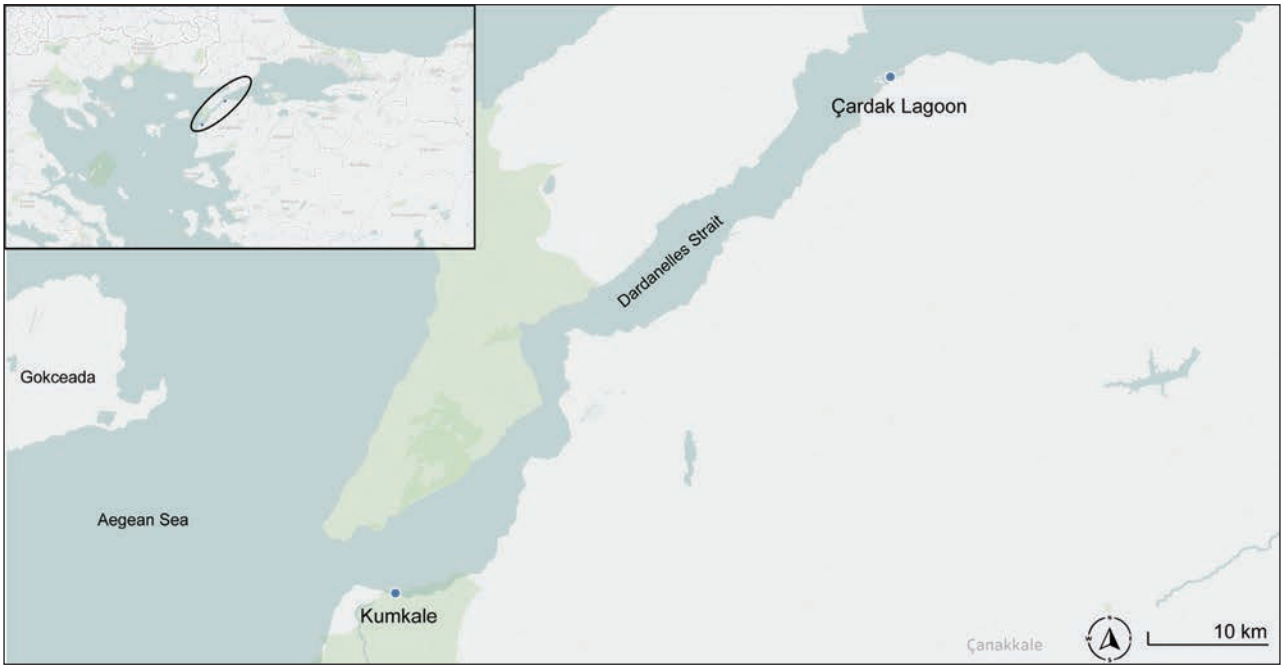

Fig. 1: Sampling locations, where the two species were caught.
Sl. 1: Zemljevid obravnavanega območja, kjer sta bila ujeta primerka obeh vrst.

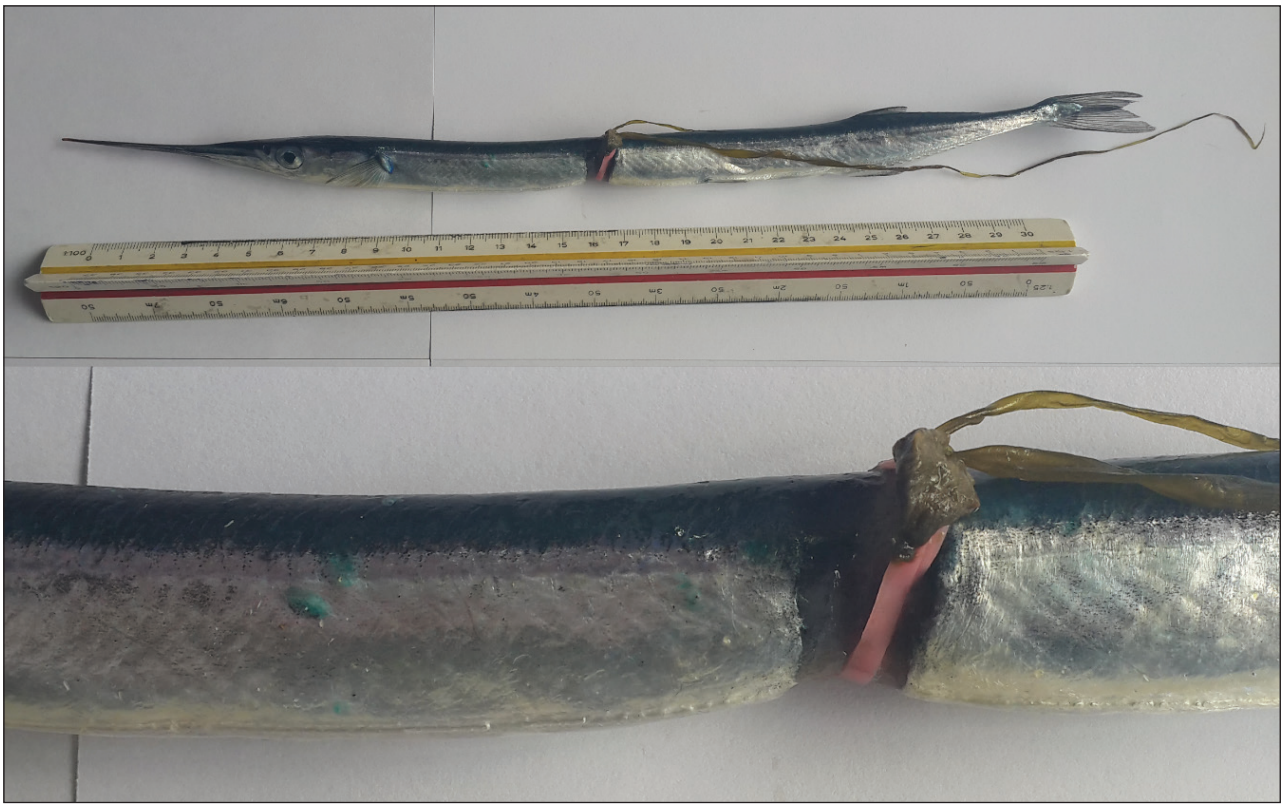

Fig. 2: The** Belone belone **specimen from the Dardanelles Strait, Cardak Lagoon, still with the plastic collar covered in Chorda filum.
Sl. 2: Primerek iglice iz dardanelske ožine (Cardak Lagoon) s plastičnim ovojem.

The Çardak Lagoon is located on the northeastern coast of the Dardanelles Strait. The sand spit on the coast of this settlement is 4.3 km long and comprises an area of 3.5 square kilometres. The average depth is 2 m. Due to its location (close to a local port, one of the mixing points of Mediterranean water with the Marmara Sea), the Çardak Lagoon is a potential accumulation area for marine debris. Kumkale is relatively more remote from human activity than Çardak.

Before the investigation, the length and weight parameters were recorded. The collars were photographed and measured by ImageJ software. Stomach content analyses were conducted for both species. The stomachs and intestines were excised, and their respective contents separately placed inside a pre-cleaned glass petri dish. Microplastic particles, if any, were visually counted.

RESULTS AND DISCUSSION

It was determined that the first specimen (*B. belone*), caught by longlines in the Cardak Lagoon, close to the Sea of Marmara, was a female, measuring 34.3 cm in total length (TL) and 278 g in total weight (TW), and the second specimen (*S. smaris*), caught by longlines in Kumkale, a location close to the Aegean Sea, was a male with 24.9 cm TL and 439 g TW.

The specimens were found with plastic debris collars around their gills and trunk, respectively (Figs. 2 and 3). The collars were identified as the detachable parts of plastic bottle caps. The plastic debris collar found on *B. belone* was covered by *Chorda filum* (Fig. 2). The length of *C. filum* was 8.90 cm. The internal diameters of the collars measured, respectively, 2.25 cm (*B. belone*) and 2.68 cm (*S. smaris*). Only *B. belone* had one plastic filament in its stomach (Fig. 4).

Plastic debris entanglements were previously reported by Sazima *et al.* (2002) for *Rhizoprionodon lalandii* (Müller & Henle, 1839), by Wegner & Cartamil (2012) for *Isurus oxyrhincus* Rafinesque (1810), and by Nunes *et al.* (2018) for several coral reef fishes. According to these studies, feeding behaviours and other behavioural characteristics, such as neophilia, are likely to make these species vulnerable to entanglement in plastic collars. The two species reported herein are commonly found in the Dardanelles Strait. *S. smaris* inhabits *Posidonia* beds and muddy bottoms and mostly feeds on zooplankton (Karachle and Stergiou, 2014). *B. belone* lives close to the surface and feeds mostly on small fish

Fig. 3: The specimen of** S. smaris **from Kumkale, Dardanelles Strait, with the plastic collar.
Sl. 3: Primerek girice iz Kumkale v dardanelski ožini s plastičnim ovojem.

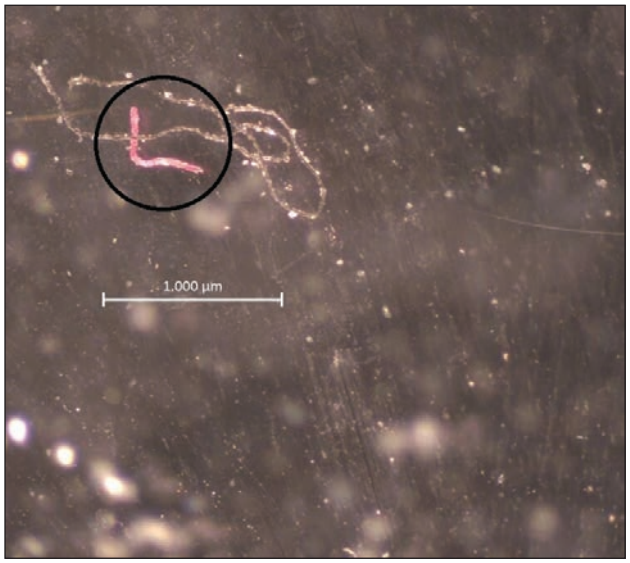

Fig. 4: Plastic filament found in the stomach of** B. belone**.
Sl. 4: Plastični filament iz želodca iglice.

(Dorman, 1991). Thus, their feeding behaviour may be a factor in this entanglement.

The occurrence of plastic collars in marine environment is possibly related to in situ littering activities and poor waste management system. In fact, landfilling is the main waste management practice in Turkey. This increases the wind and/or stormwater runoff transportation levels of such litter from land to marine environment. Especially disposable plastic waste ends up in the sea and may cause serious harm to marine life, as established and demonstrated in this study.

The increasing occurrence of plastics in the marine environment poses significant risks to marine life (Barreto *et al.*, 2019). Particularly the plastic debris that might cause entanglements among marine fauna increases the significance of this risk. Our results indicate that plastic waste, such as collars and rings, may cause severe tissue damage and breathing difficulties in fish.

IGLICA, BELONE BELONE (LINNAEUS, 1760), IN GIRICA, *SPICARA SMARIS* (LINNAEUS, 1758), ZAPLETENI V PLASTIČNI OVOJ V OŽINI DARDANELE, TURČIJA

Sezginer TUNÇER
Çanakkale Onsekiz Mart University, Faculty of Marine Sciences and Technology, Terzioğlu Campus, 17100 Çanakkale, Turkey

Sedat GÜNDOĞDU & Cem ÇEVIK
Faculty of Fisheries, Department of Basic Sciences, Cukurova University, 01330, Balcalı Adana, Turkey

Aytuğ ZILIFLI
Graduate School of Natural and Applied Sciences, Çanakkale Onsekiz Mart University, Çanakkale, Turkey
e-mail: aytugzilifli@stu.comu.edu.tr

POVZETEK

*Eden izmed glavnih virov poškodb in smrtnosti v morskem okolju je zapletanje v plastične odpadke. Plastični odpadki v morju lahko morskim organizmom povzročajo težave na več načinov; povzročajo poškodbe ali smrt (zaradi zapletanja v mrežo ali zaužitja plastičnih delov), omogočajo kemične in mikrobne prenose (kot prenašalec v živem svetu), in povzročajo spremembe v združbah vrst. Avtorji v pričujoči študiji poročajo o dveh odraslih primerkih girice (*Spicara smaris*) in iglice* (Belone belone), *ujetih s parangalom v ožini Dardanel, ki so se pri prvi vrsti zapletle v plastični ovoj okoli škržnega poklopca, v drugem pa okoli trupa. Plastični ovoj je bil v obeh primerih varnostni obroč plastenk. Pri obeh primerkih so bile vidne poškodbe. V prebavnem traktu iglice je bil najden plastični filament. Sodeč po izsledkih te študije se vpliv plastičnih odpadkov na morski živelj stopnjuje.*

Ključne besede: *Belone belone*, *Spicara smaris*, plastični ovoj, Dardanele, onesnaževanje s plastiko

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DETERMINATION OF HEAVY METAL CONTENT IN A *DAPHNE GNIDIUM* L. PLANT USING ATOMIC ABSORPTION SPECTROSCOPY

Jamila FLIOU, Ali AMECHROUQ, Mohammed ELHOURRI, Ouassima RIFFI & Mostafa EL IDRISSI
Laboratory of Molecular Chemistry and Natural Substance, Moulay Ismail University, Faculty of Science,
B.P. 11201 Zitoune, Meknes, Morocco
e-mail: flioujamila@gmail.com

ABSTRACT

The objective of this study was to determine the content of heavy metals in a Daphne gnidium *L. plant collected in the Middle Atlas (Ribat El Kheir). This plant is used in traditional medicine for its antioxidant effects and antigenotoxic, antiseptic and healing properties. This study is partly based on a differential thermal analysis (DTA), which indicated mass losses in three temperature regions. To explain this phenomenon, a sample of* D. gnidium *was heated in an oven at different temperatures: 100 °C, 300 °C and 600 °C for 6 hours, and after the calcination the sample was analysed by Fourier-transform infrared spectroscopy. The results of the study show that the plant* D. gnidium *contains several metals, with increased levels of Fe and Mg. These values are alarming because they are a major danger to the users of this plant.*

Key words: *Daphne gnidium*, heavy metals, AAS, DTA, GTA

DETERMINAZIONE DEL CONTENUTO DI METALLI PESANTI IN PIANTE DI *DAPHNE GNIDIUM* L. CON L'USO DI SPETTROSCOPIA DI ASSORBIMENTO ATOMICO

SINTESI

Lo studio si prefiggeva di determinare il contenuto di metalli pesanti in piante di Daphne gnidium *L. raccolte nel Medio Atlante (Ribat El Kheir). Questa specie è utilizzata nella medicina tradizionale per i suoi effetti antiossidanti e le proprietà antigenotossiche, antisettiche e curative. La ricerca in parte si basa su un'analisi termica differenziale (DTA), che ha indicato perdite di massa in tre regioni di temperatura. Per spiegare questo fenomeno, un campione di* D. gnidium è stato riscaldato in un forno a diverse temperature: 100 ° C, 300 ° C e 600 ° C per 6 ore, e *a seguito della calcinazione il campione è stato analizzato mediante spettroscopia in trasformata di Fourier. I risultati dello studio mostrano che* D. gnidium *contiene diversi metalli, con alti livelli di Fe e Mg. Questi valori sono allarmanti perché rappresentano un grave pericolo per l'utilizzo di questa specie a scopo curativo.*

Parole chiave: *Daphne gnidium*, metalli pesanti, AAS, DTA, GTA

INTRODUCTION

For a long time, people have used plants for their medicinal properties (Ivanova *et al.*, 2005), and in recent years the search for new substances based on natural products has increased. These can be beneficial to humans as natural cures for certain diseases (Roh *et al.*, 2004). The subject of this study is *Daphne gnidium* L., a spontaneous plant species common in semi-arid and subhumid areas of the Mediterranean region. The flowers appear during March–October. It is mainly used in traditional medicine as a remedy for hepatitis, toothache and skin diseases; the methanol extract of *D. gnidium* is known for its antibacterial and antifungal properties and good skin tolerance (Iauk *et al*., 1996; Iauk *et al*., 1997). Unfortunately, the industrial development and the introduction of new inputs into agriculture, such as fertilizers and pesticides, which can be transported by wind or water, have compromised the quality of these plants, some of which are now becoming unfit for human use due to the concentrations of heavy metals they contain. Today, much research is directed towards the study of the impact of heavy metals (Cd, Cu, Pb, Zn) on the germination and growth of plants. Mihoub *et al.* (2005) showed, during the germination of pea beans (*Pisum sativum* L.), that the cotyledons in stressed grains gradually accumulate Cd and Cu and retain high levels of Fe, Mg, and Zn. Remarkably, under conditions of heavy metal stress, some higher plants are able to focus the excess metal in certain organs (Sbartai *et al.*, 2012). Several factors may be responsible for the content of heavy metals in plants: the solubility of metals in the soil, soil properties (pH, redox potential), climate change, fertilizers, pesticides, and root systems (Kabelitz & Barbin, 1999). Khan *et al.* (2008) have shown that large amounts of heavy metals, such as Ni, Cd, Cr and Pb, are introduced into the soil through agricultural and industrial activities.

Fig. 1: Geographical map of the region of Ribat El Kheir. Sl. 1: Zemljevid območja Ribat El Kheir.

Other studies have shown the influence of temperature on the release of Cd, Pb, Cu, and Zn from the branches and leaves of *Populus nigra* L. at temperatures ranging between 653 and 873 °K, in conditions of slow steam-assisted pyrolysis (Grottolaa *et al.*, 2019).

While some metals may exist naturally in plants (Ca, Fe, Na, etc.), others are present in the plant heritage because of air pollution, agricultural activities and industrial discharges (Al, Cd, Pb). Several studies have been conducted with the prospect of their results proving useful to the development of phytoremediation techniques to decontaminate the soils of abandoned industrial sites (Garcia *et al.*, 2003). Although many metals, such as copper (Cu), iron (Fe), manganese (Mn), nickel (Ni), and zinc (Zn), are essential for cells in low concentrations, but toxic in high amounts (Millaleo *et al.* 2010), there are also metals that have not been proven as necessary for the development of living organisms and are toxic even in very low concentrations (Hg, Pb, Cd) (Todeschini *et al.*, 2011).

MATERIAL AND METHODS

Plant material

The sample of *D. gnidium* was harvested from Ribat El Kheir (33° 49′ N, 4° 25′ W) located in the Middle Atlas of Morocco (Fig. 1). The climate in this region is varied, but experts consider it Mediterranean: average annual temperature 28 °C, maximum temperature close to 43 °C, minimum temperature between 4 and 6 °C, frosts observed in January and February. The annual rainfall average is 500 mm. Fog is infrequent. The prevailing winds are from east to southwest or from southwest to northeast.

DTA/TGA

Five milligrams of *D. gnidium* powder were used to conduct a differential thermal analysis (DTA) with a 60 Shimadzu workstation, performing simultaneously DTA/TGA at a heating speed of 20 °C/min for 29 min15s; note that this process is linear. DTA is generally associated with thermal gravimetric analysis (TGA), which measures mass loss versus temperature. This analysis determines the temperature intervals in which the sample undergoes changes due to the heat treatment applied. The results of DTA are presented in the form of a curve: DT (in microvolts) = f (T) (in °C).

Infrared

The same sample was analysed, in the presence of ground potassium bromide, with the Fourier-transform infrared spectroscopy (FTIR) technique, using a JASCO 4100 device and recording spectra over the range of 4000 cm^{-1} to 500 cm^{-1}.

Atomic absorption spectroscopy (AAS)

The ash recovered after the calcination of the plant at 600 °C in a muffle furnace, was mineralized with

concentrated nitric acid and filtered with Whatman 0.45 mm filter paper to obtain a solution ready for the determination of metals by atomic absorption spectroscopy.

The AA-7000 series of atomic absorption spectrophotometers produced by the Japanese group Shimadzu is able to measure many different metals. It is composed of an atomizer, which prepares the sample for analysis, a radiant lamp, and a detector. The detection limit in this case was 0.03 ppb. The result of the AAS is presented in the form of a curve: A=f(C), where A = absorption of metal, and C = concentration of metal in ppm

RESULTS AND DISCUSSION

Before performing DTA, we analysed the raw plant by infrared spectroscopy (Fig. 2). The infrared spectrum showed a frequency around 3437 cm^{-1} dominated by the vibration n(OH) of aromatic and aliphatic structures, and a band around 2925 cm^{-1} corresponding to the valence vibration strip n(C-H). The spectrum also showed a defined band at 1630 cm^{-1} that could be assigned to the valence vibration n(C=C) of the aromatic structure. A remarkable band at a frequency of 1382 cm^{-1} was attributed to the n(C-O-C) vibration of aryl-alkyl ether. The band that appeared around 1038 cm^{-1} indicated the presence of a (Si-O) group (Fig. 2).

In order to understand the molecular composition of the plant, 5 mg of *D. gnidium* were used for a thermal analysis (DTA). The results of this analysis are shown in Figure 3. The DTA allowed us to identify three temperature intervals at which we observed significant mass loss.

As shown in Table 1, significant losses of mass were observed from 160 °C onwards, and all of the organic material was lost at 600 °C.

To explain this weight loss at different temperature ranges, the sample was heated in a muffle furnace at different temperatures: 110 °C, 300 °C and 600 °C for

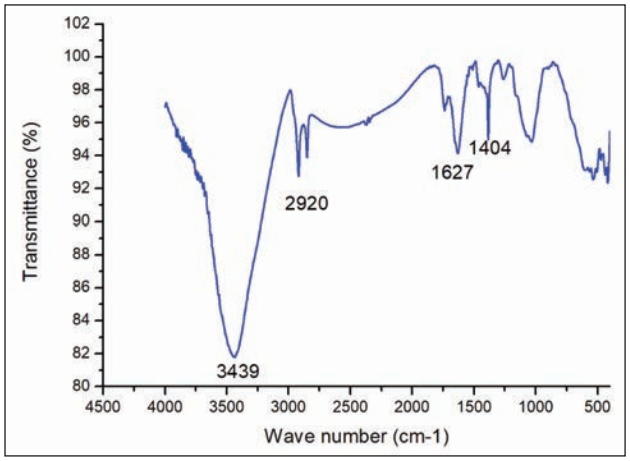

Fig. 2: IR spectrum of *D. gnidium.*
Sl. 2: IR spekter vrste *D. gnidium.*

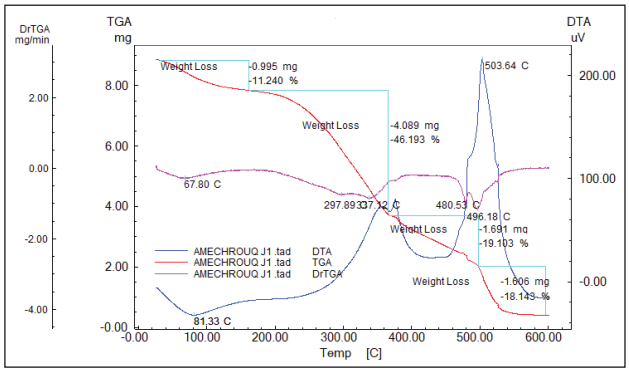

Fig. 3: DTA/TGA spectrum of *D. gnidium.*
Sl. 3: DTA/TGA spekter vrste *D. gnidium.*

calcination. After cooling in a desiccator, the samples were analysed by IR spectroscopy (KBr). Table 2 shows mass loss at each temperature range.

Tab. 1: Mass losses of *D. gnidium* ***in DTA.***
Tab. 1: Masne izgube vrste *D. gnidium* ***na diferencialni termalni analizi (DTA).***

Temperature (°C)	Mass losses in %	Total losses (%)
0-160 °C	11.24%	11.24
160-365 °C	46.19%	57.43
365-600 °C	18.14%	94.68

The results of the calcination confirmed those of the DTA. We noted that more than half of the organic material was lost at 300 °C, and another important loss occurred at 600 °C.

Figure 4 shows the superposed IR spectra of the calcined samples. At 110°C, we noted the persistence of vibration valence bands of the n(OH), n(C-H), and n(C=C) bonds. At 300°C, we noted the disappearance of (OH), the appearance of a vibration band of the

Tab. 2: Mass losses in the calcining *D. gnidium* ***(m_i: the initial mass, m_f: the final mass).***
Tab. 2: Masne izgube pri žganju vrste *D. gnidium* ***(m_i: začetna masa, m_f: končna masa).***

Temperature (°C)	m_i (g)	m_f (g)	Loss (%)
110	5.44	4.66	14.34
300	5.32	2.20	58.64
600	10.73	1.11	89.65

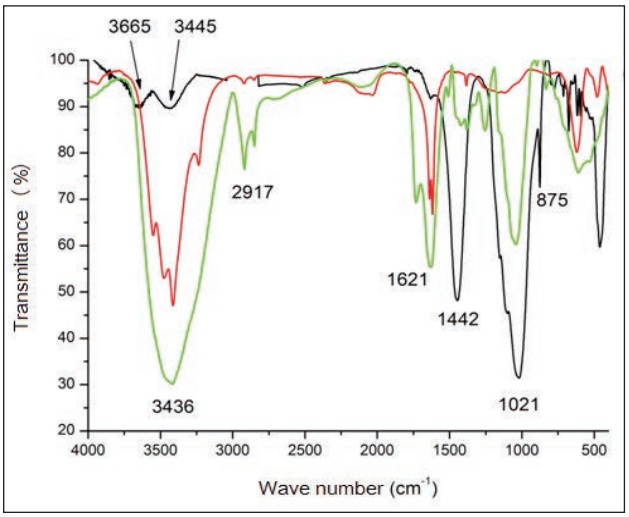

Fig. 4: Superposed IR spectra of the samples carried on ignition.
Sl. 4: Krovni IR spekter žganih vzorcev.

n(N-H) bond at 3436 cm^{-1} corresponding to secondary amines, this latter was accompanied by the appearance of a deformation valence band of the d(N-H) bond. The spectrum also recorded decreases in band intensities of n(C-H) and n(C=C) bonds, which indicated the beginning of disappearance of the organic matter.

At 600 °C, we noticed the disappearance of the vibration band of the n(N-H) bond and the band related to organic matter, and bands related to other mineral elements, such as kaolinite, smectite, quartz, and calcite (Fig. 5) appearing instead. These results were in good agreement with the literature (Hachi *et al.*, 2002).

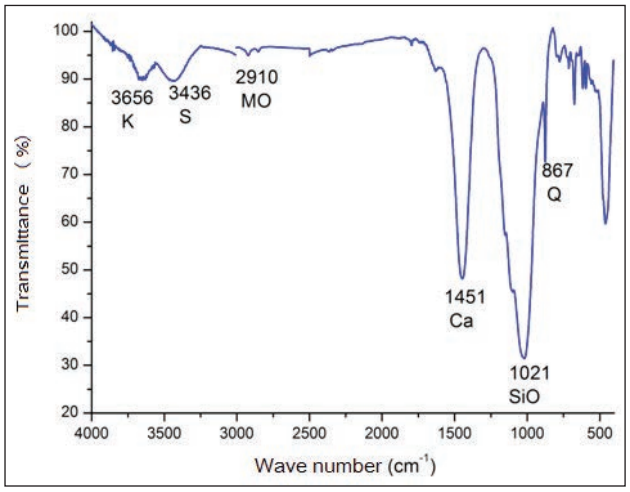

Fig. 5: IR spectrum of the sample calcined at 600 °C (K: kaolinite, S: smectite, CA: calcinite, Q: quartz, MO: organic material).
Sl. 5: IR spekter vzorca segretega na 600 °C (J: kaolinit, S: smektit, CA: kalcinit, Q: kremen, MO: organska snov).

The sample that was calcined at 600 °C and treated with concentrated nitric acid was subsequently analysed by AAS. The results showed a very high Fe and Mg content (1207.7906 mg/kg). These values are alarming, indicating a serious health threat to potential users of this plant (Koumolou *et al.*, 2012). Sathiamoorthy *et al.* (2003) conducted comparative studies on 42 medicinal plants from the Negev desert. The highest iron concentrations were recorded in *Gundelia tournefortii* (3020 ppm) and *Anchusa strigosa* (2485 mg/kg). The concentration of Cu in *D. gnidium* was 0.2738 mg/kg. This value is below the limit concentration in raw plant material provided by the World Health Organization (WHO), which is 150 mg/kg (World Health Organization, 2007). The value of Li was 0.0083 mg/kg. These values show that the copper and lithium levels in the plant posed no risk for its users.

In relation to Zn, the limit value in *D. gnidium* was 1.7683 mg/kg), which is within the standards (1 to mg/kg). This means that in terms of Zn, the plant was not a significant threat to its consumers, who use it as an antiseptic or healing agent (Koumolou *et al.*, 2012). Not so the leaves of *Populus euphratica* and *Z. geslini* from the mentioned comparative study, which registered Zn concentrations well above the norm: 113 mg/kg and 119.10 mg/kg respectively (Sathiamoorthy *et al.*, 2003).

While the concentration of Pb in *D. gnidium* was 0.5148 mg/kg – below the WHO limit (10 mg/kg) (Boulila Zoghlami *et al.*, 2006), Cd concentration was 0.3787 mg/kg – exceeding the WHO tolerance limit (0.3 mg/kg) by 26.23% (World Health Organization, 2007). Regarding Al, atomic absorption spectroscopy showed that it was not present in *D. gnidium,* while the value for Ca was 32.5020 mg/kg. Studies conducted by Boulila Zoghlima *et al.* (2006) on tomato (*Lycopersicon esculentum*) showed that the negative impact of cadmium on certain growth and development processes can be mitigated by an adequate calcium intake in the culture medium, and that the addition of Ca to a culture medium containing Cd (growth inhibitor) improves the production of plant biomass.

CONCLUSIONS

In the present study, we have tried to assess the toxicity of the plant *D. gnidium* through the determination of the heavy metals in it that could harm the health of the plant's consumers. The results of the analyses conducted revealed high concentrations of Fe, Mg, and Cd, thus confirming the concerns which had prompted this study. This contamination by heavy metals could be the cause of many diseases among the population consuming this plant, hence the need to seek the origin of these metals (soil, water, agricultural activities) and of the process of contamination, especially since *D. gnidium* bark powder is also used orally in the treatment of syphilis and venereal diseases.

DOLOČEVANJE VSEBNOSTI TEŽKIH KOVIN V VOLČINU VRSTE *DAPHNE GNIDIUM* L. Z UPORABO ATOMSKE ABSORBCIJSKE SPEKTROSKOPIJE

Jamila FLIOU, Ali AMECHROUQ, Mohammed ELHOURRI, Ouassima RIFFI & Mostafa EL IDRISSI
Laboratory of Molecular Chemistry and Natural Substance, Moulay Ismail University,
Faculty of Science, B.P. 11201 Zitoune, Meknes, Morocco
e-mail: flioujamila@gmail.com

POVZETEK

Cilj raziskave je bil določiti vsebnost težkih kovin v volčinu vrste Daphne gnidium *L., nabranem v osrednjem Atlasu (Ribat El Kheir). To rastlino uporabljajo v medicini kot antioksidant in zaradi antigenotoksičnih, antiseptičnih in zdravilnih učinkovin. Raziskava delno temelji na diferencialni termalni analizi (DTA), ki pokaže izgubo mase v treh temperaturnih regijah. Da bi razložili ta pojav so vzorec vrste* D. gnidium *segrevali v pečici na različnih temperaturah: 100 °C, 300 °C in 600 °C za 6 ur, in ga po segrevanju analizirali s Fourierjejevo infrardečo spektroskopijo. Rezultati so pokazali, da vsebuje volčin številne kovine, še posebej visok nivo Fe in Mg. Te vrednosti so alarmantne, saj lahko povzročijo nevarnost pri uporabnikih.*

Ključne besede: *Daphne gnidium*, težke kovine, AAS, DTA, GTA

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DELO NAŠIH ZAVODOV IN DRUŠTEV

ATTIVITÀ DEI NOSTRI ISTITUTI E SOCIETÀ

ACTIVITIES BY OUR INSTITUTIONS AND ASSOCIATIONS

NACIONALNI INŠTITUT ZA **BIOLOGIJO**
NATIONAL INSTITUTE OF **BIOLOGY**

MORSKA BIOLOŠKA POSTAJA PIRAN
MARINE BIOLOGY STATION PIRAN
1969 2019

POL STOLETJA DELOVANJA MORSKE BIOLOŠKE POSTAJE PIRAN

Četrtek, 10. oktobra 2019, je bil prav posebno slovesen dan. V portoroškem Avditoriju smo prisostvovali uradni svečanosti ob častitljivi obletnici obstoja Morske biološke postaje Piran (MBP), ki deluje v okviru Nacionalnega inštituta za biologijo. Edina slovenska ustanova, ki preučuje morje in spremlja njegovo kakovost, letos praznuje že 50. rojstni dan! Gre za 50 let neprekinjenih raziskav, ki nam pomagajo razumeti slovensko morje, njegove prebivalce, vidne in nevidne, ter številne procese v tej – globalno gledano – skorajda neznatni »lužici«. A vendar je morje z le 213 km^2 površine, ki je v povprečju globoko okrog 19 m in niti na najgloblji točki ne preseže 40 m, po vsebini zelo veliko in biotsko izjemno pestro. V tem majhnem delu svetovnega morja je bilo namreč opaženih več kot 2.260 različnih vrst živih bitij ali kar 35 % vseh v Jadranskem morju živečih vrst. Raziskovanje

HALF A CENTURY OF THE MARINE BIOLOGY STATION PIRAN

Thursday, October 10, 2019 was a very special day. In the Portorož Auditorium, the official ceremony for the anniversary of Marine Biology Station Piran (MBS), which operates within the National Institute of Biology (NIB), was held. This year, the only Slovenian institution that studies the sea and monitors its quality is celebrating its 50th birthday! 50 years of continuous research, which has helped us understand the Slovenian sea, its inhabitants, visible and invisible ones, and many processes in this - globally - almost insignificant "puddle". However, this sea, with only 213 km2 of surface area and an average depth of some 19 m, which never, not even in its deepest spot, exceeds 40 m, is large in content and extremely biodiverse. In this small part of the world, more than 2,260 different species of living creatures or 35% of all living species in the Adriatic

Slavnostni govorniki / Invited speakers: mag. Robert Turk, prof. dr. Tamara Lah Turnšek, mag. Dejan Židan, prof. dr. Alenka Malej, prof. dr. Matjaž Kuntner & prof. dr. Patricija Mozetič (Foto / Photo: Marko Alpner).

ekologije in varovanje morja je osnovno poslanstvo in prvenstvena naloga MBP, a ta se je uveljavila predvsem (ali pa prav zato) kot interdisciplinarna znanstveno-raziskovalna ustanova, kjer se prepletajo biološke, kemijske, fizikalne in mikrobiološke vsebine in pristopi. Dejstvo je, da je severni del Jadrana med najbolje raziskanimi morskimi območji sveta, kar je zasluga (ob predhodnikih, pionirjih raziskav morja pri nas) zlasti zdajšnjih in nekdanjih zaposlenih sodelavcev MBP.

Slovesna prireditev s kulturno-umetniškim navdihom (ob sodelovanju glasbene skupine Pop Outlet), ki jo je odlično povezovala Katja Pišot Maljevac, je bila seveda posvečena slavljencem. Slednji tudi neposredno soustvarjajo in osmišljajo delovanje te ugledne ustanove in s svojim predanim delom postavljajo in nadgrajujejo strokovne temelje za trajnostni razvoj morskega in obmorskega prostora. Pa vendar moramo na tem mestu posebej podčrtati, da MBP presega »zgolj« poslanstvo predstavnikov alme mater. Pomen delovanja MBP je precej širši in večplasten; nikakor ne naslavlja samo tistih, ki z morjem in/ali od morja živimo, temveč – vsaj posredno – vse državljane Republike Slovenije. Saj smo se vsi že v vrtcu učili, da je morje okno in cesta

Sea have been identified. The main mission and priority of MBS is ecology and marine protection research, however (or, perhaps, precisely for that reason), it has established itself mainly as an interdisciplinary scientific and research institution where biological, chemical, physical and microbiological contents and approaches intertwine. In fact, the northern part of the Adriatic is one of the most explored marine areas in the world, and the credit goes to MBS (along with its predecessors, the pioneers of marine exploration in our country), especially to current and former MBS employees.

The ceremony, enriched by an artistic input by the *Pop Outlet* band and excellently moderated by Katja Pišot Maljevac, was, of course, dedicated to the many 'guests of honour'. Those who directly co-create and design the activities of this eminent institution and through their dedicated work provide professional foundations for the sustainable development of marine and maritime spaces. Nevertheless, it is important to emphasize that the mission of MBS goes beyond being a "mere" alma mater representative. Its importance is much broader and more complex; it addresses not only those who live by and/or from the sea, but - at least indirectly – all citizens

Mag. Robert Turk je navdušil z izjemnim predavanjem: "Pod plaščem navidezne nespremenljivosti" / Robert Turk, MSc, impressed the audience with a remarkable lecture: "Under the mantle of virtual immutability" (Foto / Photo: Marko Alpner).

v svet, in država z morjem je zato še kako v prednosti. Da je morje državotvorni element posebnega pomena, se vedno bolj zavedajo tudi predstavniki oblasti, kar je s svojo prisotnostjo in slavnostnim nagovorom potrdil tudi predsednik Državnega zbora RS, mag. Dejan Židan.

Nadejali smo se morda še kakšnega visokega državnega gosta, a bolj moteča je bila nepričakovana odsotnost povabljenih županov (oziroma zastopnikov) dveh od štirih obmorskih občin. Vpetost MBP v regijo in njeno povezovanje z lokalnim okoljem je namreč vsaj tako pomembno, kot je v državnem merilu. To je v uvodnem pozdravnem nagovoru izpostavil tudi dr. Matjaž Kuntner, direktor Nacionalnega inštituta za biologijo, ki je sicer »naravno« in edino logično lokacijo MBP ob morju, torej izven Ljubljane, označil kot prispevek k decentralizaciji slovenske znanosti. Hkrati je delovanje programske raziskovalne skupine MBP opisal kot izrazito mednarodno, večkrat potrjeno tako skozi partnerstva v evropskih projektih kot tudi v dvostranskih raziskovalnih izmenjavah. Slednje še najbolj živahno potekajo s sosednjimi partnerskimi ustanovami v Trstu in Rovinju. Vodja MBP, dr. Patricija Mozetič, je v svojem nagovoru, slikovitem orisu razvoja MBP, izpostavila ključne akterje, ki so pripravili teren za širok spekter delovanja ustanove s temeljnimi

of the Republic of Slovenia. We have been taught since kindergarten that the sea is a window and a pathway into the world, and that a country with a sea is therefore geographically advantaged. There is a growing awareness among the representatives of state authorities that the sea is a state-building element of special importance, as it was confirmed by the speech of the President of the National Assembly of the Republic of Slovenia, MSc Dejan Židan.

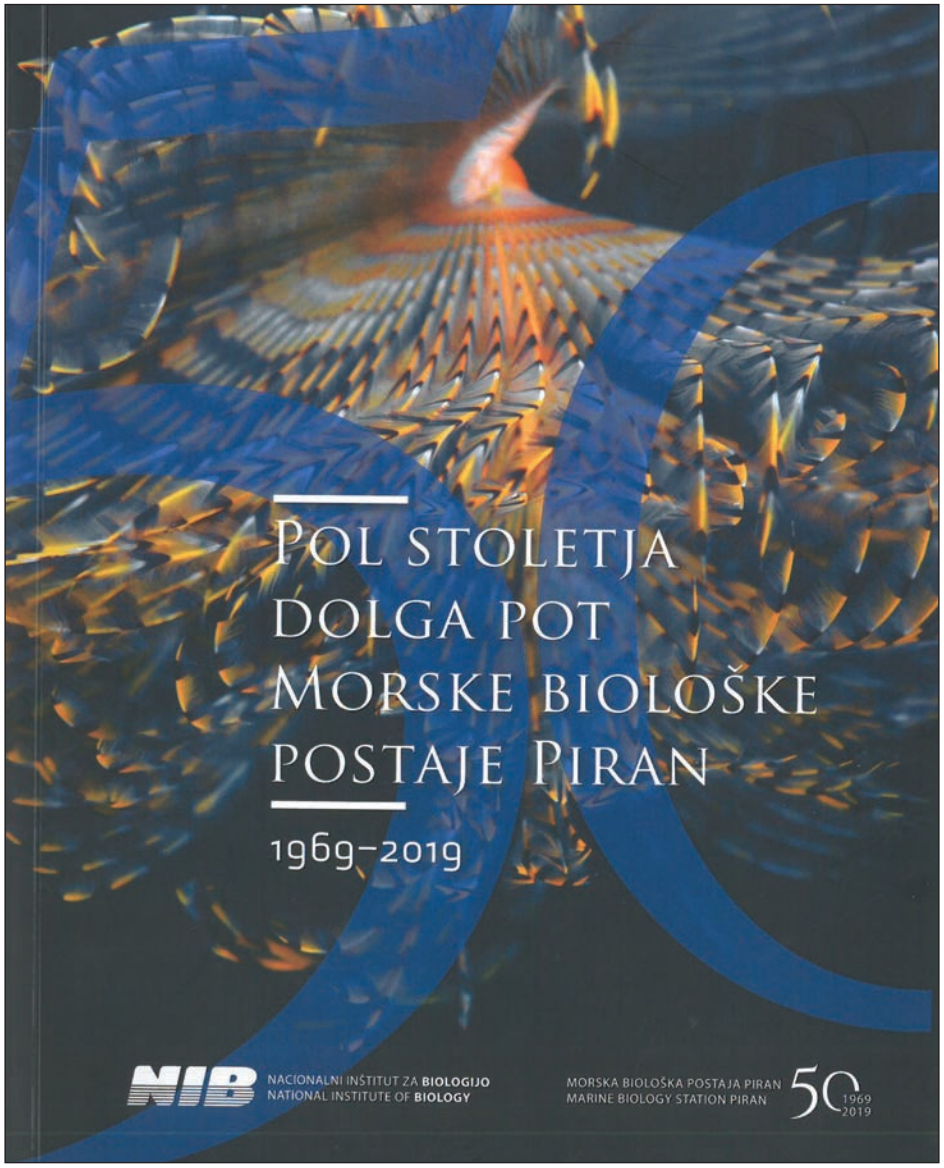
One might have expected the presence of several high-ranking statesmen, but more disappointing was the unexpected absence of invited mayors (or their representatives) of two of the four coastal municipalities. The engagement of MBS at the regional level and its integration with the local environment is at least as important as its value at a national level. This was stressed in the introductory address of Dr Matjaž Kuntner, director of the National Institute of Biology, who saw the "natural" and only logical location of MBS by the sea, outside Ljubljana, as a contribution to the decentralization of Slovenian science. He outlined the work of the MBS program research group as distinctly international, repeatedly validated both through partnerships in European projects and through bilateral research exchanges. The latter are the most vibrant in relation to the neighbouring partner

Dogodek je pritegnil veliko množico udeležencev. / The event attracted a large crowd of attendees (Foto / Photo: Marko Alpner).

in aplikativnimi raziskavami, številnimi objavami strokovnih in znanstvenih publikacij ter s posledično popularizacijo in posredovanjem znanja širši javnosti, zlasti šolajoči se mladini in študentom (sodelavci MBP poučujejo na vseh slovenskih univerzah). V tem kontekstu bi lahko posebej omenili še koga od izstopajočih raziskovalcev, ki so se na svečanosti znašli nekoliko v ozadju dogajanja, toda fokus je bil vendarle na kolektivu, na odgovornih in povabljenih nastopajočih.

Posebno vlogo na slovesni prireditvi je imel mag. Robert Turk, vodja Zavoda RS za varstvo narave - Ob-

institutions in Trieste and Rovinj. The Head of MBS, Dr Patricija Mozetič, in her address (a picturesque overview of MBS's development), highlighted the key players who prepared the ground for a wide range of the institution's activities through basic and applied research, numerous editions of professional and scientific publications, as well as through popularisation of knowledge and its dissemination to the public, especially to school youth and university students (MBS staff teach at all Slovenian universities). In this context, one could have pointed out some of the outstanding researchers who found them-



Ob jubileju petdesete obletnice Morske biološke postaje Piran so izdali tudi zajetno publikacijo o ustanovi in njeni dejavnosti od prvih začetkov do danes. / On the occasion of the jubilee of the fiftieth anniversary of the Marine Biology Station Piran, they also published a comprehensive publication about the institution and its activities from its beginnings to the present day.

močne enote Piran. S predavanjem, ki ga je naslovil »Pod plaščem navidezne nespremenljivosti«, je prisotne opozoril na (sicer večini znan) privid oz. varljiv občutek nespremenljivosti morja, ki ga v resnici vse bolj izčrpavamo, morsko dno pa je marsikje degradirano v svojevrstno puščavo.

Prireditev je zaokrožil nekoliko bolj sproščen, a zato nič manj svečan zaključek, ko sta bili na oder povabljeni prof. dr. Alenka Malej, nekdanja sodelavka in dolgoletna vodja MBP, ter prof. dr. Tamara Lah Turnšek, nekdanja dolgoletna direktorica Nacionalnega inštituta za biologijo. S svojim znanjem in delom sta delovanju in razvoju MBP vtisnili neizbrisen pečat in za svoj dragoceni prispevek prejeli posebno zahvalo.

Slavnostnemu dogodku je sledil ustrezen epilog, ko smo se udeleženci zadržali v preddverju Avditorija Portorož ob prijetnem druženju. Vsi, ki smo kakorkoli povezani z MBP, smo nazdravili na naslednjih 50 uspešnih let. Ta bodo zagotovo vznemirljiva, a hkrati tudi zelo nepredvidljiva. Obiskovalci smo ob odhodu domov prejeli priložnostno publikacijo »Pol stoletja dolga pot Morske biološke postaje Piran: 1969–2019«. Prežema jo tako razmislek o preteklosti in sedanjosti kot tudi o prihodnosti MBP, kar v svojih prispevkih reflektirajo zaposleni. Vsekakor zelo pohvalno.

Simon Kerma
Fakulteta za turistične študije – Turistica,
Univerza na Primorskem

selves somewhat out of the limelight at the ceremony, but the focus was nevertheless on the collectivity, on the 'point men' and on invited speakers.

A special role was given to MSc Robert Turk, Head of the Institute of the Republic of Slovenia for Nature Conservation - Regional Unit Piran. In his lecture titled "Under the Coat of Apparent Invariability" (Pod plaščem navidezne nespremenljivosti), he reminded the audience of the illusion or deceptive sense of immutability of the sea, which is, in reality, increasingly depleted, and has in many cases already degraded into a sea desert.

At the end of the ceremony, Prof Alenka Malej, a former associate and longtime head of MBS, and Prof Tamara Lah Turnšek, a former longtime director of NIB, were invited to the stage. With their knowledge and work they left an indelible mark on the development of MBS Piran and received special thanks for their invaluable contribution.

The formal event ended with a proper epilogue, when the participants and guests lingered in the lobby of the Portorož Auditorium and toasted to another 50 successful years. These will certainly be exciting, but also very unpredictable. On departure, the participants received an extremely informative publication entitled "Half a Century Long Path of the Marine Biology Station Piran: 1969-2019" (*Pol stoletja dolga pot Morske biološke postaje Piran: 1969-2019*). The book gives us an insight into the past and the present as well as the future of MBS, which is reflected in the contributions of its employees. Highly commendable indeed.

Simon Kerma
Faculty of Tourism Studies – Turistica,
University of Primorska

NAVODILA AVTORJEM

1. Revija ANNALES (*Anali za istrske in mediteranske študije* Series, Historia Naturalis) objavlja **izvirne znanstvene** in **pregledne članke** z naravoslovnimi vsebinami, ki obravnavajo posebnosti različnih podpodročij sredozemskega naravoslovja: morska biologija in ekologija, ihtiologija, geologija s paleontologijo, krasoslovje, oljkarstvo, biodiverziteta Slovenije, varstvo narave, onesnaževanje in varstvo okolja, fizična geografija Istre in Mediterana idr. Vključujejo pa tudi **krajše** znanstvene prispevke o zaključenih raziskovanjih., ki se nanašajo na omenjeno področje.

2. Sprejemamo članke v angleškem, slovenskem in italijanskem jeziku. Avtorji morajo zagotoviti jezikovno neoporečnost besedil, uredništvo pa ima pravico članke dodatno jezikovno lektorirati.

3. Članki naj obsegajo do 48.000 znakov brez presledkov oz. 2 avtorski poli besedila. Članek je mogoče oddati na e-naslov annales@mbss.org (zaželjeno) ali na elektronskem nosilcu (CD) po pošti na naslov uredništva.

Avtor ob oddaji članka zagotavlja, da članek še ni bil objavljen in se obvezuje, da ga ne bo objavil drugje.

4. Naslovna stran članka naj vsebuje naslov članka, ime in priimek avtorja (avtorjev), ime in naslov inštitucije, kjer je (so) avtor(ji) zaposlen(i) oz. domači naslov in naslovom elektronske pošte (samo prvi oz. korespondenčni avtor).

5. Članek mora vsebovati **povzetek** in **izvleček.** Izvleček je krajši (cca. 10 vrstic) od povzetka (cca. 30 vrstic).

V *izvlečku* na kratko opišemo namen, metode dela in rezultate. Izvleček naj ne vsebuje komentarjev in priporočil.

Povzetek vsebuje opis namena in metod dela ter povzame analizo oziroma interpretacijo rezultatov. V povzetku ne sme biti ničesar, česar glavno besedilo ne vsebuje. V povzetku se avtor ne sklicuje na slike, tabele in reference, ki so v članku.

6. Avtorji naj pod izvleček članka pripišejo ustrezne **ključne besede** (največ 6). Zaželjeni so tudi angleški (ali slovenski) prevodi izvlečka, povzetka, ključnih besed, podnapisov k slikovnemu in tabelarnemu gradivu. V nasprotnem primeru bo za prevode poskrbelo uredništvo.

7. Glavni del besedila naj vključuje sledeča poglavja: Uvod, Material in metode, Rezultati, Razprava ali Rezultati in razprava, Zaključki (ali Sklepi), Zahvala (če avtor želi), Literatura. Dele besedila je možno oblikovati v podpoglavja (npr. Pregled dosedanjih objav v Uvodu, Opis območja raziskav v Material in metode). Podpisi k slikam so priloženi posebej za poglavjem Literatura.

8. Tabele avtor priravi posebej na ločenih straneh v programu Word, tako kot rokopis, jih zaporedno oštevilči in opremi z naslovom – kratkim opisom. V glavnem delu besedila se sklicuje na tabele tako, da jih na ustreznem mestu označi z npr. "(Tab. 1)".

9. Slikovno gradivo (grafi, zemljevidi, fotografije, table) avtor posreduje v ločenih datotekah (jpeg, tiff) z najmanj 300 dpi resolucije pri želeni velikosti. Največja velikost slikovnega gradiva je 17x20 cm. Vsa potrebna dovoljenja za objavo slikovnega gradiva (v skladu z Zakonom o avtorski in sorodnih pravicah) priskrbi avtor sam in jih predloži uredništvu pred objavo članka. Slike je potrebno tudi podnasloviti in zaporedno oštevilčiti (glej točko 7). V glavnem delu besedila se avtor sklicuje na slike tako, da jih na ustreznem mestu označi z npr. "(Sl. 1)".

10. Bibliografske opombe, s čimer mislimo na **citat** – torej sklicevanje na druge publikacije, sestavljajo naslednji podatki v oklepaju: *avtor* in *leto izida*; npr. (Novak, 2007). Če sta dva avtorja, se izpišeta oba (Novak & Kranjc, 2001), če so trije ali več pa se izpiše samo prvi, ki mu sledi okrajšava *et al*. (Novak *et al*., 1999). Več citatov je med seboj ločenih s podpičjem in si sledijo kronološko - z naraščajočo letnico izdaje, npr. (Novak *et al*., 1999; Adamič, 2001; Kranjc & Zupan, 2007). Osebno informacijo (ustno, pisno) izpišemo prav tako v oklepaju z navedbo kratice imena in priimka posredovalca informacije, za vejico pa dodamo "osebno sporočilo", npr. (J. Novak, *osebno sporočilo*).

11. Celotni **bibliografski podatki** so navedeni v poglavju Literatura v abecednem vrstnem redu. Pri tem avtor navede izključno dela, ki jih je v članku citiral. Če ima isti avtor več bibliografskih podatkov, se najprej kronološko izpišejo tisti, kjer je edini avtor, sledijo dela v soavtorstavu še z enim avtorjem in dela v soavtorstvu z več avtorji. Imena revij, v katerih so izšla citirana dela, se izpišejo okrajašano (splošno priznane okrajšave revij). Članki, ki še niso bili publicirani, se lahko citirajo le, če so bili dokončno sprejeti v tisk, pri čemer se na koncu bibliografskega podatka doda beseda "v tisku". Člankov, ki so šele bili poslani v recenzijo, se ne sme citirati.

Primeri navajanje različnih tipov bibliografskih podatkov:

članki v revijah:

Klock, J.-H., A. Wieland, R. Seifert & W. Michaelis (2007): Extracellular polymeric substances (EPS) from cyanobacterial mats: characterisation and isolation method optimisation. Mar. Biol., 152, 1077-1085.

Knjige in druge neserijske publikacije (poročila, diplomska dela, doktorske disertacije):

Wheeler, A. (1969): The fishes of the British Isles and North-West Europe. McMillan, London, 613 p.

Poglavje v knjigi:
McEachran, J. D. & C. Capapé (1984): Myliobatidae. In: Whitehead, P. J. P., M. L. Bauchot, J.-C. Hureau, J. Nielsen & E. Tortonese (eds.): Fishes of the North-eastern Atlantic and the Mediterranean, Vol. 1. Unesco, Paris, pp. 205-209.

12. Drugo: latinski izrazi kot npr. *in vivo*, *in situ*, *e.g.*, *i.e.*, ter rodovna (*Myliobatis* sp.) in vrstna (*Myliobatis aquila*) imena se izpišejo v fontu italic. Kadarkoli je možno, se uporabljajo enote iz sistema SI (Système international d'unités).

13. Prvi odtis člankov uredništvo pošlje avtorjem v **korekturo.** Avtorji so dolžni popravljeno gradivo vrniti v enem tednu. Besedilo popravljamo s korekturnimi znamenji, ki jih najdemo na koncu Slovenskega pravopisa (2001), Ljubljana, ZRC SAZU, 24–25.

Širjenje obsega besedila ob korekturah ni dovoljeno. Druge korekture opravi uredništvo.

14. Za dodatna pojasnila v zvezi z objavo člankov je uredništvo na voljo.

UREDNIŠTVO

ISTRUZIONI PER GLI AUTORI

1. La rivista ANNALES (*Annali per gli studi istriani e mediterranei*, Series Historia Naturalis) pubblica **articoli scientifici originali** e **compendii** dai contenuti scientifici relativi ai vari settori della storia naturale e pertinenti l'area geografica del Mediterraneo: biologia marina, ecologia, ittiologia, geologia, paleontologia, carsologia, olivicoltura, biodiversità della Slovenia, tutela della natura, inquinamento e tutela dell'ambiente, geografia fisica dell'Istria e del Mediterraneo ecc. La rivista pubblica anche articoli scientifici **brevi** relativi a ricerche concluse pertinenti a tali settori.

2. La Redazione accetta articoli in lingua inglese, slovena e italiana. Gli autori devono garantire l'ineccepibilità linguistica dei testi, la Redazione si riserva il diritto di una revisione linguistica.

3. Gli articoli devono essere di lunghezza non superiore alle 48.000 battute senza spazi, ovvero 2 fogli d'autore. Possono venir recapitati all'indirizzo di posta elettronica annales@mbss.org (preferibilmente) oppure su supporto elettronico (CD) per posta ordinaria all'indirizzo della Redazione.

L'autore garantirà l'originalità dell'articolo e si impegnerà a non pubblicarlo altrove.

4. Ogni articolo deve essere corredato da: **titolo**, nome e cognome dell'autore (autori), denominazione ed indirizzo dell'ente di appartenenza o, in alternativa, l'indirizzo di casa, nonché l'indirizzo di posta elettronica (solo del primo autore o dell'autore di corrispondenza).

5. I contributi devono essere corredati da un **riassunto** e da una **sintesi**. Quest'ultima sarà più breve (cca. 10 righe) del riassunto (cca 30 righe).

Nella *sintesi* si descriveranno brevemente lo scopo, i metodi e i risultati delle ricerche. La sintesi non deve contenere commenti e segnalazioni.

Il *riassunto* riporterà in maniera sintetica lo scopo, i metodi delle ricerche e l'analisi ossia l'interpretazione dei risultati. Il riassunto non deve riferirsi alle tabelle, figure e alla bibliografia contenuta nell'articolo.

6. Gli autori sono tenuti ad indicare le **parole chiave** adeguate (massimo 6). Sono auspicabili anche le traduzioni in inglese (o sloveno) della sintesi, del riassunto, delle parole chiave, delle didascalie e delle tabelle. In caso contrario, vi provvederà la Redazione.

7. Il testo principale deve essere strutturato nei seguenti capitoli: Introduzione, Materiali e metodi, Risultati, Discussione o Risultati e discussione, Conclusioni, Ringraziamenti (se necessari), Bibliografia. Il testo può essere strutturato in sottocapitoli (ad es. sottocapitolo Rassegna delle pubblicazioni nell'Introduzione; sottocapitolo Descrizione dell'area di ricerca nel capitolo Materiali e metodi). Le didascalie devono essere presentate separatamente, a seguito del capitolo Bibliografia.

8. Le tabelle saranno preparate in forma elettronica come il manoscritto (formato Word) e allegate in fogli separati alla fine del testo. Gli autori sono pregati di contrassegnare ogni tabella con un numero e il titolo ossia una breve descrizione. Nel testo la tabella viene richiamata come segue: (Tab. 1).

9. Il materiale grafico (grafici, carte geografiche, fotografie, tavole) va preparato in formato elettronico (jpeg o tiff) e consegnato in file separati, con una definizione di 300 dpi alla grandezza desiderata, purché non ecceda i 17x20 cm. Prima della pubblicazione, l'autore provvederà a fornire alla Redazione tutte le autorizzazioni richieste per la riproduzione del materiale grafico (in virtù della Legge sui diritti d'autore). Tutto il materiale grafico deve essere accompagnato da didascalie (vedi punto 7) e numerato.. Nel testo i grafici vengono richiamati come segue: (ad es. Fig. 1).

10. I riferimenti bibliografici (citazioni) richiamano un'altra pubblicazione (articolo). La nota bibliografica, riportata nel testo, deve contenere i seguenti dati tra parentesi: *cognome dell'autore*, *anno di pubblicazione*, ad es. (Novak, 2007). Se gli autori sono due, verranno indicati entrambi (Novak & Kranjc, 2001), nel caso di tre o più autori verrà indicato soltanto il primo, seguito dall'abbreviazione *et al.* (Novak *et al.,* 1999). Vari riferimenti bibliografici in una stessa nota vanno divisi dal punto e virgola e segnalati in ordine cronologico, ad. es. (Novak *et al.*, 1999; Adamič, 2001; Kranjc & Zupan, 2007). La testimonianza (orale, scritta) verrà indicata tra parentesi con l'abbreviazione del nome e con il cognome di chi l'ha trasmessa, seguiti dalla virgola e la dicitura "informazione personale", ad es. (J. Novak, *informazione personale*).

11. La bibliografia completa va inserita in ordine alfabetico nel capitolo Bibliografia. L'autore indicherà esclusivamente i lavori e le edizioni citati nell'articolo. Se si citano più lavori dello stesso autore, verranno indicati prima in ordine cronologico i lavori in cui l'autore appare solo, poi quelli in cui l'autore compare assieme ad un secondo coautore, seguiti infine da quelli in cui egli compare tra più coautori. I nomi delle riviste in cui sono pubblicati i lavori citati saranno indicati nella forma abbreviata (abbreviazioni ufficialmente riconosciute). Gli articoli inediti si possono citare soltanto se sono in corso di pubblicazione, facendo loro seguire la dicitura "in corso di pubblicazione". Gli articoli, non ancora recensiti non possono essere citati.

Esempio di lavoro bibliografico:

Articoli in riviste:

Klock, J.-H., A. Wieland, R. Seifert & W. Michaelis (2007): Extracellular polymeric substances (EPS) from cyanobacterial mats: characterisation and isolation method optimisation. Mar. Biol., 152, 1077-1085.

Libri ed altre pubblicazioni non periodiche (relazioni, tesi di laurea, dissertazioni di dottorato):

Wheeler, A. (1969): The fishes of the British Isles and North-West Europe. McMillan, London, 613 p.

Capitoli di libro:

McEachran, J. D. & C. Capapé (1984): Myliobatidae. In: Whitehead, P. J. P., M. L. Bauchot, J.-C. Hureau, J. Nielsen & E. Tortonese (eds.): Fishes of the North-eastern Atlantic and the Mediterranean, Vol. 1. Unesco, Paris, pp. 205-209.

12. Altro: Le espressioni latine come ad es. *in vivo*, *in situ*, *e.g.*, *i.e.*, i nomi dei generi famiglie (*Myliobatis* sp.) e delle specie (*Myliobatis aquila*) si scrivono con il carattere italic. Quando possibile saranno utilizzate le unità del sistema SI (*Système international d'unités*).

13. Gli autori ricevono le **prime bozze** di stampa per la revisione. Le bozze corrette vanno quindi rispedite entro una settimana alla Redazione. In questa fase, i testi corretti con segni adeguati (indicazioni in merito si trovano alla fine della pubblicazione "Slovenski pravopis" (2001), Ljubljana, ZRC SAZU, 24-25, non possono essere più ampliati. La revisione delle bozze è svolta dalla Redazione.

14. La Redazione rimane a disposizione per eventuali chiarimenti.

LA REDAZIONE

INSTRUCTIONS TO AUTHORS

1. The journal ANNALES (*Annals for Istrian and Mediterranean Studies,* Series Historia Naturalis) publishes **original scientific** and **review articles** in the field of natural studies related to the specifics of various subfields of Mediterranean natural studies: marine biology and ecology, ichthyology, geology with paleontology, karst studies, olive growing, biodiversity of Slovenia, nature protection, pollution and environmental protection, physical geography of Istria and the Mediterranean, etc. It also publishes **short** scientific papers on completed research projects related to the above-mentioned subfields.

2. The articles submitted can be written in the English, Slovene or Italian language. The authors should ensure that their contributions meet acceptable standards of language, while the editorial board has the right to have them language edited.

3. The articles should be no longer than 48,000 characters (spaces excluded) or 32 typewritten double-spaced pages. They can be submitted via e-mail annales@mbss.org (preferably) or regular mail, with the electronic data carrier (CD) sent to the address of the editorial board.

Submission of the article implies that it reports original unpublished work and that it will not be published elsewhere.

4. The **title page** should include the title of the article, the name and surname of the author(s), their affiliation (institutional name and address) or home address, and e-mail address (of the first author or the corresponding author only).

5. The article should contain the **summary** and the **abstract,** with the former (c. 30 lines) being longer than the latter (c. 10 lines).

The *abstract* contains a brief description of the aim of the article, methods of work and results. It should contain no comments and recommendations.

The *summary* contains the description of the aim of the article and methods of work and a brief analysis or interpretation of results. It can contain only the information that appears in the text as well. It should contain no reference to figures, table and citations published in the main text.

6. Beneath the abstract, the author(s) should supply appropriate **keywords** (max 6) and, if possible, the English (or Slovene) translation of the abstract, summary, keywords, and captions to figures and tables. If unprovided, the translation will be provided by the editorial board.

7. The **main text** should include the following chapters: Introduction, Material and Methods, Results, Discussion or Results and Discussion, Conclusion, Acknowledgement (not obligatory), References. Individual parts of the text can form a sub-chapter (e.g. Survey of Previous Studies under Introduction; Description of Research Area under Material and Methods). Captions to figures should appear on a separate page beneath References.

8. Each **table** should be submitted on a separate page in Word programme (just like the main text). It should be numbered consecutively and supplied with the title – brief description. When referring to the tables in the main text, use the following style: (Tab. 1).

9. Illustrative matter (diagrams, maps, photographs, plates) should be submitted as separate files (in jpeg or tiff format) and saved at a minimum resolution of 300 dpi per size preferred, with the maximum possible publication size being 17x20 cm. Prior to publication, the author(s) should obtain all necessary authorizations (as stipulated by the Copyright and Related Rights Act) for the publication of the illustrative matter and submit them to the editorial board. All figures should be captioned and numbered consecutively (cf. Item 7). When referring to the figures in the main text, use the following style: (Fig. 1).

10. **Bibliographic notes** or **citations** – i.e. references to other articles or publications – should contain the following data: *author* and *year of publication,* e.g. (Novak, 2007). If there are two authors, include both surnames (Novak & Kranjc, 2001); if there are more than two authors, include the surname of the first author followed by a comma and the abbreviation *et al.* (Novak *et al.*, 1999). If there is more than one reference, separate them by a semicolon and list them in ascending chronological order, e.g. (Novak *et al.*, 1999; Adamič, 2001; Kranjc & Zupan, 2007). When citing information obtained through personal communication (oral, written), provide the initial letter of the name and full surname of the informant followed by a comma and the phrase *personal communication,* e.g. (J. Novak, *personal communication*).

11. The entire list of **bibliographic data** should be published under References in alphabetical order. The author(s) should list only the works cited in the article. If you are listing several works by the same author with some of them written in co-authorship, first list those written by the author him/herself, then those written in co-authorship with another author, and finally those written in co-authorship with more than one author, with the entries listed in chronological order. The names of journals in which the works cited were published should be abbreviated (cf. list of official journal abbreviations). Unpublished articles can be cited only if they have been

approved for publication, which should be indicated by adding the phrase *in press* to the end of the relevant bibliography entry.

Some examples of how to cite different types of bibliographical data:

Articles published in serial publications:

Klock, J.-H., A. Wieland, R. Seifert & W. Michaelis (2007): Extracellular polymeric substances (EPS) from cyanobacterial mats: characterisation and isolation method optimisation. Mar. Biol., 152, 1077-1085.

Books and other non-serial publications (reports, diploma theses, doctoral dissertation):

Wheeler, A. (1969): The fishes of the British Isles and North-West Europe. McMillan, London, 613 p.

Chapters published in a book:

McEachran, J. D. & C. Capapé (1984): Myliobatidae. In: Whitehead, P. J. P., M. L. Bauchot, J.-C. Hureau, J. Nielsen & E. Tortonese (eds.): Fishes of the North-eastern Atlantic and the Mediterranean, Vol. 1. Unesco, Paris, pp. 205-209.

12. Miscellaneous: Latin phrases such as *in vivo*, *in situ*, *e.g.*, *i.e.*, and names of genera (*Myliobatis* sp.) and species (*Myliobatis aquila*) should be written in italics. Whenever possible, use the SI units (Système international d'unités).

13. The authors are sent the **first page proofs**. They should be returned to the editorial board within a week. When reading the proofs, the authors should use the correction signs listed at the end of the book Slovenski pravopis (2001), Ljubljana, ZRC SAZU, 24–25.

It is not allowed to lengthen the text during proof-reading. Second proof-reading is done by the editorial board.

14. For additional information regarding article publication contact the editorial board.

EDITORIAL BOARD

KAZALO K SLIKAM NA OVITKU

SLIKA NA NASLOVNICI:
Veliki seržant (*Abudefduf saxatilis*) je pogosta tropska riba, ki domuje v Atlantiku. Ime seržant je dobila po petih črnih trakovih, ki nekoliko spominjajo na vojaški čin narednika. (Foto: Borut Furlan)
Sl. 1: Spričo višjih temperatur v zadnjih desetletjih je prišlo do razširjanja mnogih ribjih vrst iz Atlantskega oceana v Sredozemsko morje. Ena izmed njih je veliki seržant (*Abudefduf saxatilis*), ki je bila pred kratkim prvič potrjena tudi v Tržaškem zalivu in v Jadranskem morju nasploh. (Foto: Borut Furlan)
Sl. 2: V okviru inventarizacije favne v zavarovanem območju Narodnega parka Brioni (Hrvaška, severni Jadran) je bila v severnem Jadranu prvič najdena vrsta kozice *Hippolyte prideauxiana*. Ta mojstrica kamuflaže v popolnosti oponaša barvni vzorec morske lilije *Antedon mediterranea*. (Foto: Borut Mavrič)
Sl. 3: Favna mahovnjakov (Bryozoa) je bila doslej deležna le malo raziskovalne pozornosti v slovenskem obrežnem morju. Pred kratkim so raziskovalci odkrili vrsto tujerodnega mahovnjaka *Tricellaria inopinata* kot del obrasti na vseh slovenskih gojiščih morskih školjk. (Foto: Ana Fortič)
Sl. 4: Med šestimi tujerodnimi vrstami rib koralnic (Pomacentridae), ki so bile doslej potrjene v Sredozemskem morju, je tudi indo-pacifiški seržant (*Abudefduf vaigiensis*). Ta vrsta, ki je na moč podobna velikemu seržantu, je v Sredozemsko morje prišla skozi Sueški prekop. (Foto: Borut Furlan)
Sl. 5: Ovčica (*Lithognathus mormyrus)* je cenjena vrsta šparov, ki se pojavlja v obalnih in somorniških vodah Sredozemlja. Iz tunizijskih vod poročajo o primerku, ki je imel deformacije v pobočnici in hrbtenici. Kljub temu mu je uspelo živeti v divjini skupaj z normalnimi predstavniki svoje vrste. (Foto: Borut Furlan)
Fig. 6: Tujerodni mahovnjak vrste *Watersipora subtorquata* je zelo odporen na bakrove premaze proti obraščanju in ga zato pogosto najdemo kot obrast na plovilih. (Foto: Ana Fortič)

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FRONT COVER:
The sergeant major (*Abudefduf saxatilis*) is a common tropical fish inhabiting the Atlantic Ocean. The species takes its name from its five black lateral stripes reminiscent of the rank insignia of sergeant major. (Photo: Borut Furlan)
Fig. 1: Higher temperatures during the last decades have favoured the spreading of numerous fish species of Atlantic origin into the Mediterranean Sea. One of them is the sergeant major (*Abudefduf saxatilis*), recently found for the first time in the Gulf of Trieste and in the Adriatic Sea in general. (Photo: Borut Furlan)
Fig. 2: During the compilation of a faunistic inventory of the marine protected area of the Brijuni National Park (Croatia, northern Adriatic), the feather star shrimp *Hippolyte prideauxiana* was found for the first time in the northern Adriatic. This master of camouflage can perfectly mimic the colouration of the crinoid *Antedon mediterranea*. (Photo: Borut Mavrič)
Fig. 3: Bryozoan fauna has been poorly investigated in the Slovenian coastal sea. An alien bryozoan species *Tricellaria inopinata* has only recently been discovered as part of the epifauna at all Slovenian mussel farm sites. (Photo: Ana Fortič)
Fig. 4: One of the six alien species of damselfish (Pomacentridae) reported to date in the Mediterranean is the Indo-Pacific sergeant *Abudefduf vaigiensis*. The species, very similar to the sergeant major, migrated to the Mediterranean through the Suez Canal. (Photo: Borut Furlan)
Fig. 5: The striped sea bream (*Lithognathus mormyrus)* is a valuable sparid fish occurring in coastal and brackish areas of the Mediterranean. A specimen with abnormalities of the lateral line and the vertebral column has been found in Tunisian waters. Despite these deformities, the specimen was able to live in the wild together with the normal members of the species. (Photo: Borut Furlan)
Fig. 6: The alien bryozoan species *Watersipora subtorquata* belongs to a genus that is highly tolerant to copper-based antifouling coatings and is therefore often found on boat hulls. (Photo: Ana Fortič)

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