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REVIEW OF THE SHARPNOSE SEVENGILL SHARK *HEPTRANCHIAS PERLO* (CHONDRICHTHYES: HEXANCHIDAE) IN THE MEDITERRANEAN: HISTORICAL AND RECENT DATA

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ABSTRACT

This paper presents a thorough literature review of the sharpnose sevengill shark Heptranchias perlo *(Bonnaterre, 1788) in the Mediterranean Sea, creating a database with information on its distribution. Moreover, it provides some biological information on a female specimen of this rare and near threatened shark, caught during experimental sampling in the Myrtoon Sea, southwestern Aegean archipelago, Greece. The aim of this study is to provide a synopsis of the existing information on the species in the Mediterranean Sea for future updates of the assessments of the species conservation status in this area.*

Key words: elasmobranchs, diet, fecundity, Mediterranean distribution

REVISIONE DELLO SQUALO MANZO *HEPTRANCHIAS PERLO* (CHONDRICHTHYES: HEXANCHIDAE) IN MEDITERRANEO: DATI STORICI E RECENTI

SINTESI

L'articolo presenta una revisione approfondita della letteratura inerente lo squalo manzo Heptranchias perlo *(Bonnaterre, 1788) nel mare Mediterraneo, creando una banca dati contenente informazioni sulla sua distribuzione. Fornisce inoltre alcune informazioni biologiche su un esemplare femmina di questa rara specie, quasi minacciata, catturato durante un campionamento sperimentale nel mare Myrtoon, arcipelago dell'Egeo sud-occidentale, in Grecia. Lo scopo di questo studio è fornire una sinossi delle informazioni esistenti sullo squalo manzo nel Mediterraneo per futuri aggiornamenti delle valutazioni dello stato di conservazione delle specie in quest'area.*

Parole chiave: elasmobranchi, dieta, fecondità, distribuzione in Mediterraneo

INTRODUCTION

The sharpnose sevengill shark *Heptranchias perlo* (Bonnaterre, 1788) is a shark species of circumglobal distribution, found in tropical and temperate seas excluding the northeast Pacific (Froese & Pauly, 2019). In the literature it is often acknowledged as a rare species, and quite a few records of its presence have been reported in Mediterranean waters (e.g., Papaconstantinou, 2014; Guallart *et al.*, 2019a; 2019b and references therein).

The sharpnose sevengill shark is considered a “near threatened” species according to the IUCN red list, yet this assessment is rather old and needs to be updated (Paul & Fowler, 2003). In the Mediterranean, the species is “data deficient” (Soldo & Bariche, 2016). Indeed, information regarding its biology and population status is very scarce, making any assessment very difficult. In their analysis of data gaps in the biological knowledge concerning the Mediterranean, Dimarchopoulou *et al*. (2017) list the species under the least studied ones. Moreover, as it is considered a by-catch of deep-sea trawling fisheries (Paul & Fowler, 2003), the official capture data as presented in the FAO statistics (http://www.fao.org/fishery/statistics/global-capture-production/en; accessed 22 June 2020) are almost nonexistent. In fact, the only landing reports in the aforementioned global statistics cite 2 tons per year for the years 2008, 2009, 2010 and 2014, and are provided solely by Malta. It is a common practice in Mediterranean fisheries (especially in the bottom trawling industry) that when shark species are caught, the head, fins and internal organs are removed and discarded overboard, and quite often the body is skinned in order to facilitate its sale. Thus, it is not possible to taxonomically identify the “fish” that is landed in the fishing markets, which leads to the mislabeling of the species (Jacquet & Pauly, 2003; Bornatowski *et al.*, 2013), and therefore the landings are underreported.

Due to the sporadic records of the species in Mediterranean waters, very little information exists on its biology. Apart from the work of Capapé (1980), who thoroughly studied the biology of the species in Tunisian waters, there is almost no other related information. In this work we present additional data on the presence of the species in the Myrtoon Sea, southwestern Aegean archipelago, Greece, and provide information on its fecundity, including ovarian

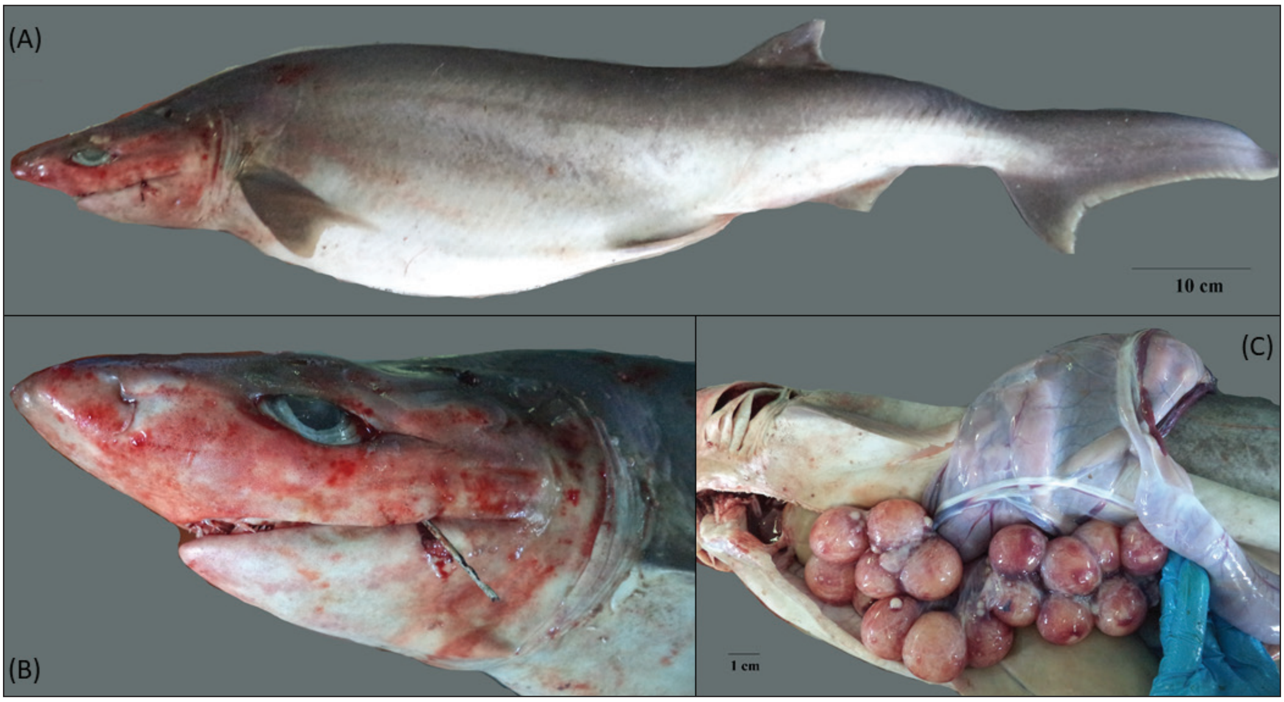

Fig. 1: (A) The female sharpnose sevengill shark** Heptranchias perlo **caught in the Myrtoon Sea, Greece, 4 August 2019 (scale bar = 10 cm); (B) detail of the head where the longline hook can be seen; and (C) the viscera, with eggs as seen in the ovary and the stomach of the fish (scale bar=1 cm).

Sl. 1: (A) Samica morskega psa sedmeroškrgarja** Heptranchias perlo**, ujeta 4. avgusta 2019 v mirtonskem morju (Grčija) (merilo = 10 cm); detajl glave z vidnim parangalskim trnkom: in (C) drobovina, jajca v ovariju in želodec ribe (merilo = 1 cm).

follicle (hereafter referred to as "egg") morphometry, and diet. Finally, a literature review is provided to summarise the records/information on the species in the Mediterranean as retrieved from literature, using as a starting point the work by Guallart *et al*. (2019a; 2019b) and elaborating further on additional data. The aim of this note is to (a) provide data on the species that could help elucidate its biology and ecology and fill in the knowledge gaps, (b) clarify the species' distributional status in the Mediterranean, and (c) provide a review-report that could be useful in future updates of the assessments of the species status in the Mediterranean.

MATERIAL AND METHODS

On 4 August 2019 a female sharpnose sevengill shark individual (Fig. 1) was caught during the experimental Mediterranean Trawl Survey sampling (MEDITS; Bertrand *et al*., 2002), conducted in the frame of the Greek National Data Collection Framework (DCF) programme, in the area of Myrtoon Sea (coordinates: 37.36833333N, 22.98027778E) at a depth of 550 m. When landed the shark was already dead and the MEDITS protocol on data recording was applied. According to this protocol (Spedicato *et al*., 2019) target species are divided into two groups, with *H. perlo* being included in the G1 list; hence, the measurements taken according to the protocol were as follows: total number of individuals, total weight and individual length, and biological parameters including sex, maturity, and individual weight. Following the identification, the fish was measured for total length with the tail in a natural position (TL; in cm) and weighed (W; in g), as well as sexed, and the horizontal and vertical mouth openings were measured (HMO and VMO, respectively; with an accuracy of 0.01 mm). After dissection the ovaries were removed, the eggs were measured (maximum egg diameter [ED], in 0.01 mm) using a digital calliper, and weighed (egg weight [OW], in g), and the stomach was kept in a deep-freezer for further examination. Finally, the liver was weighed (LO, in g). In the laboratory, stomach contents were examined, identified to the lowest possible taxon, and each prey was weighed (in 0.001 g). Based on the % weight (% WF) contribution of each prey category, the fractional trophic level (TROPH) of the species was estimated using TrophLab (Pauly *et al*., 2000). In order to assess the feeding preferences of the species, a literature review was performed. Data were extracted and tabulated, and TROPHs were estimated.

Furthermore, as the recent review of Guallart *et al*. (2019a, 2019b) on the presence of the species in the Mediterranean was missing records from the Hellenic Seas, an extensive literature review was conducted for the entire Mediterranean basin. For this purpose, the aforementioned works were used as a basis and further elaborated through GoogleSearch. The keywords of "*Heptranchias perlo*" and "Mediterranean" were used, and all the papers retrieved were examined and tabulated. In addition, a second table was created including secondary references of the species (i.e., previous and old records of the species within the papers examined, but the original references were not available to the authors).

RESULTS AND DISCUSSION

In this account, information on the biology and distribution of the sharpnose sevengill shark *Heptranchias perlo* in the Mediterranean Sea is compiled. The species is considered by-catch in the fisheries in Greece (mainly in longlines targeting tuna and swordfish, as well as in trawlers), but at times it is marketed rather than discarded (*e.g*., Damalas & Vassilopoulou, 2011). In the case of the individual examined, there were clear indications that the specimen had already been caught some time in the past, as a large hook was found in the lower jaw (Fig. 1B), like those traditionally used in longline fisheries targeting large pelagic fish (e.g., tuna, swordfish) in the country. Thus the fish had been caught and released by a professional fisher in the past, a practice that was also documented by Megalofonou *et al*. (2005) and Vassilopoulou *et al*. (2007).

Tab. 1: Measurements taken on a female sharpnose sevengill shark* Heptranchias perlo*, caught in Myrtoon Sea, SouthWest Aegean Archipelago, Greece, August 4th 2019.
Tab. 1: Meritve, opravljene na samici morskega psa sedmeroškrgarja* Heptranchias perlo*, ujete 4. avgusta 2019 v mirtonskem morju (jugozahodno Egejsko morje, Grčija).

Measurement	**Value**
Total length (in cm)	114
Total weight (in g)	6730
Horizontal mouth opening (in mm)	51.99
Vertical mouth opening (in mm)	40.74
Liver weight (in g)	788
Ovary total weight (in g)	425
Number of eggs	22
Mean egg diameter (in mm) ±standard error (range)	34.30±0.58 (29.03-38.44)
Mean egg weight (in g)±standard error (range)	19.82±0.78 (11-26)

Tab. 2: Review of studies on feeding habits of the sharpnose sevengill shark *Heptranchias perlo*. **LT= length type; TL=total length; LR=length range; n=number of individuals; F = frequency of occurrence, N= numerical percentage, W = percentage by weight; IRI=index of relative importance.**

Tab. 2: Pregled raziskav o prehranjevalnih navadah morskega psa sedmeroškrgarja *Heptranchias perlo*. **LT= tip dolžine; TL=celotna dolžina; LR=razpon dolžine; n=število osebkov; F = frekvenca pojavljanja, N= številčni delež, W = biomasni delež; IRI=indeks relativne pomembnosti plena.**

Area	Date	LT	LR (cm)	n	Method	Main prey	contribution of prey [W or (N)]	TROPH	SE	Reference
Cuba						Fish, benthic Crustacea	-	-		Sierra *et al.* (1994) in Froese & Pauly (2019)
coast off Namibia	1980-1984					Myctophidae, Cephalopoda	-	-		Macpherson (1989)
Scilly Isles	8/1999	TL	101	1	F, N, W	Cephalopoda (*Illex coindetii*)	100 (100)	4.50	0.37	Henderson & Williams (2001)
east coast of southern Africa				10	F	Cephalopoda, fish		4.50	0.48	Bass *et al.* (1975) in Cortés (1999)
South Africa				8	F, N, W, IRI	Cephalopoda, fish	53, 47 (50, 50)	4.50	0.61	Ebert (1990)
South Africa				12	F, N, W, IRI	Cephalopoda, fish		4.50	0.61	Barnett *et al.* (2012)
Taiwan		TL	63.5-118.5	28	F, N, W, IRI	Fish (*Trichiurus lepturus, Trachurus japonicus*, Myctophidae), Crustacea (Brachyura, Macrura Reptantia), Cephalopoda	98, 1, 1 (65, 27, 8)	4.49	0.80	Ebert (1990)
Taiwan				36	F, N, W, IRI	Fish		4.50	0.80	Barnett et al. (2012)
Victoria, Australia	2-5/2003	TL	48.5-90.0	67	F, N, W, IRI	Fish (*Lepidorhynchus denticulatus, Apogonops anomalus*, Trichiuridae), Cepalopoda (*Nototodarus gouldi*), shrimps	86.4, 12.8, 0.8 (87.2, 10.7, 2.1)	4.49	0.76	Braccini (2008)
Victoria, Australia	2-5/2003	TL	90.1-136.5	49	F, N, W, IRI	Fish (Trichiuridae, Gempylidae, *Lepidorhynchus denticulatus, Paraulopus nigripinnis*, Centrolophidae), Cepalopoda, shrimps	96.9, 2.6, 0.5 (90, 8.3, 1.7)	4.50	0.79	Braccini (2008)
Central Atlantic	4/8-17/9/1998	TL	39.0-116.0	60	F, N, W	Fish (*Heptranchias perlo*, Congridae), Cephalopoda (Octopoda)	57.5, 28.4 (45.9, 31.5)	4.34	0.67	Frentzel-Beyme & Koster (2002)
Tunisia				9	F	Fish, Crustacea, Cephalopoda		4.22	0.69	Capapé (1975a) in Cortés (1999)
Tunisia				125	F, N	Fish (*Gadiculus argenteus, Hoplostethus mediterraneus, Trachyrhynchus trachyrhynchus*), Decapoda (*Nephrops norvegicus*), Cephalopoda (*Sepietta oweniana*)	(72.1, 16.3, 11.6)	4.33	0.74	Capapé (1980)
Myrtoon Sea	4/8/2019	TL	114	1	N, W	Cephalopoda (*Octopus vulgaris, Loligo vulgaris*)	100 (100)	4.50	0.46	present study

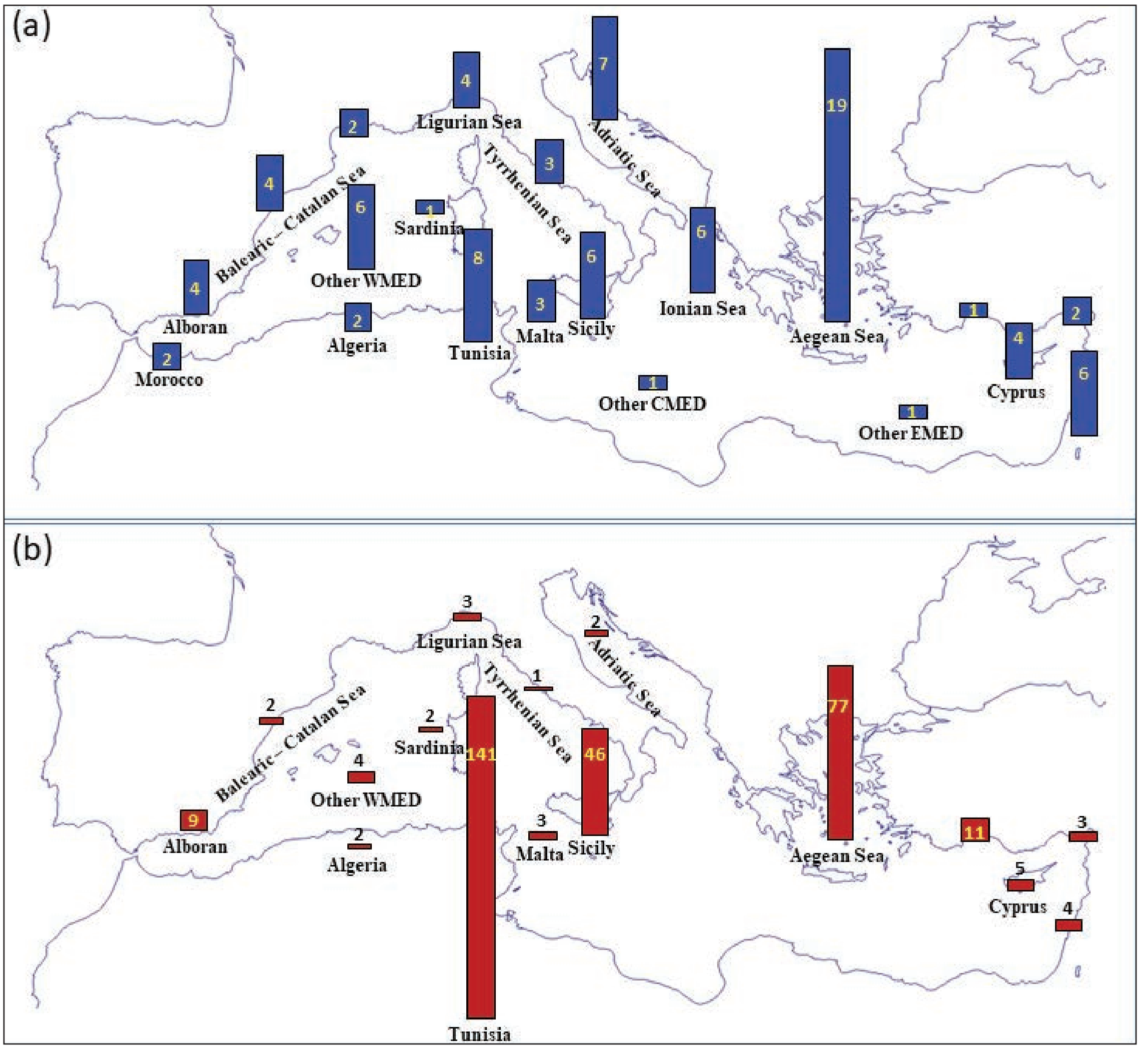

Fig. 2: The sharpnose sevengill shark Heptranchias perlo***. (a) Number of publications with references to the presence of the species in the Mediterranean; and (b) number of individuals reported in the Mediterranean. For more details, see Appendix 1 & 2.***

Sl. 2: Morski pes sedmeroškrgar Heptranchias perlo***. (a) Število objavljenih del, ki se nanašajo na prisotnost te vrste v Sredozemskem morju; in (b) število primerkov, o katerih so poročali v Sredozemlju. Za bolj natančne podatke glej Prilogi 1 & 2.***

Following the recommendations of Dimarchopoulou *et al.* (2017) and Karachle & Stergiou (2017), effort was made to obtain as much information possible even from a single specimen. However, the examination of only one individual allows very little potential for analysis, virtually just a presentation of morphological measurements (Tab. 1) and a limited insight into its biology. A detailed description of the morphology and anatomy of the species, as well as various aspects of its biology (e.g., morphometric relations, reproduction, feeding) is given in Capapé (1980) based on 154 specimens from Tunisian waters. To date, the work of Capapé (1980) is the only in-depth scientific account on the species in the Mediterranean, covering a wide range of biological aspects.

The sharpnose sevengill shark is a viviparous aplacental lecithotrophic species *sensu* Hamlett *et al.* (2005). According to a visual examination of the reproductive system, the specimen was a female (Fig. 1C), its maturity stage was classified under category 3b (ICES [2013] maturity scale), i.e., that of mature individual. This is also in accordance with the findings of Capapé (1980), who identified the length at maturity for the species at 93 cm for males and 105 cm for females. Overall, 22 eggs were counted and measured, exhibiting a mean diameter of 34.30±0.58 mm and a mean weight of 19.82±0.78 g. These values, even slightly underweight, are above the limit of 2.5 cm and 25 g identified by Capapé (1980) as with important vitellogenic activity. Taking into consideration the dimensions for the characterization of the vitellogenic stage proposed by Correa de Carvalho *et al.* (2020), the female individual examined here was in intermediate vitellogenesis (stage III). In the Mediterranean Sea, the reported fecundity of the species ranges between 6 to 20 eggs (Capapé, 1980 and references therein), thus making the number of eggs reported herein the highest recorded for the species in the basin.

The diet of the sharpnose sevengill shark has been studied in various areas of its distribution, both in the Atlantic and Pacific Oceans, as well as in the Mediterranean (Tab. 2). In all studies, the prey items were the same, with fish and Cephalopoda dominating the diet of the species, although in different ratios. It is noteworthy that in the study by Frentzel-Beyme & Koster (2002), conducted at the Great Meteor Seamount, central-east Atlantic, cannibalism was recorded (Tab. 2). In the present study the stomach of the shark contained exclusively two species of Cephalopoda (one individual of *Octopus vulgaris* [60.1 % WF] and one of *Loligo vulgaris* [39.9 % W]) and the estimated TROPH was 4.50±0.46. In general, this TROPH value was estimated in the majority of the diet studies concerning the species (Tab. 2). The lowest value, however, was estimated based on the diet composition of the specimens in Tunisia (4.22±0.69 [Capapé, 1975] and 4.33±0.74 [Capapé, 1980]). These lower values should be attributed to the fact that crustaceans contributed more to the diet of the species than in other studies, where they were negligible or even not recorded. Nevertheless, all TROPH values estimated classify the species as an apex predator, a carnivore with preference for fish and cephalopods (*sensu* Stergiou & Karpouzi [2002] and Karachle & Stergiou [2017]).

Overall, the presence of *H. perlo* in the Mediterranean Sea basin has been demonstrated in more than 90 published papers (Fig. 2a; Appendix 1 & 2). Most of the publications are from the eastern and western parts of the basin (31 and 28 publications, respectively), followed by the central part (21 publications), whereas only 7 publications make reference to the species in the Adriatic (Fig. 2a; Appendix 1 & 2). However, we recognize that the scarcity of data or the absence of records related to specific areas of the basin may well indicate a lack of reports rather than an actual absence of the species. The number of specimens caught was only provided in half of the publications, with the sex reported even more rarely (Fig. 2b; Appendix 1 & 2). Moreover, cases in which the number of specimens recorded exceeded 5 individuals per report were extremely rare (N>5 in 8 publications [8.6%]), and there was only one publication (Capapé, 1980) with an extraordinary number of 120 individuals reported. Records with the highest numbers of specimens reported are from the East and Central Mediterranean, and this should be attributed to the work conducted in the Aegean Sea (e.g., Ismen *et al.*, 2007, 2009; Damalas & Vassilopoulou, 2011) and in the coasts of Tunisia (e.g., El Kamel-Moutalibi *et al.*, 2014; Rafrafi-Nouira *et al.*, 2015; Capapé *et al.*, 2018), with respect to the morphometry, the establishment of length-weight relationships, and the study of the biology of the species (Appendix 1).

In conclusion, despite the literature review, the authors of the present article strongly believe that there might exist more records of the species, mainly in unpublished/unavailable survey data. It is therefore essential for data, especially those related to species that urgently need conservation actions, and even more so those collected through public funding, to be open and available to the scientific community, so that the status of the species can be adequately assessed and conservation measures can be based on most comprehensive scientific information. It is of high priority to investigate and report biological data of species when specimens are available, in particular with those found in small numbers and species lacking such information, to fill the gaps in essential knowledge and, as a result, improve our conservation efforts.

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The sample examined within this research was collected during the MEDITS action of the EU Data Collection Framework Program.

Appendix 1: List of records of* Heptranchias perlo *in the Mediterranean (literature examined by the authors; in blue references also included in Guallart et al., 2019a, b). F=female, M=male, N=number of individuals, LWR=length-weight relationship parameters, SEb=standard error of slope b, R2=correlation coefficient.

Priloga 1: Seznam zapisov o pojavljanju vrste* Heptranchias perlo *v Sredozemskem morju (pregledana literatura s strani avtorjev; v modrem so reference, ki so bile že vključene v Guallart s sod., 2019a, b). F=samica, M=samec, N=število primerkov, LWR=odnos med dolžino in težo, SEb=standardna napaka naklona b, R2=korelacijski koeficient.

Reference	Date	locality	depth	Sex	N	length range (in cm)		weight range (in g)		LWR				comments
						min	max	min	max	a	b	SE$_b$	R^2	
East Mediterranean														
Ben-Tuvia (1953)	1951-1953	Israel					250							record from a photo, length measurement in approximation
Fredj & Maurin (1987)		E Mediterranean												presence of the species (depths from 0 up to >1000 m)
Labropoulou & Papaconstantinou (2000)		N Aegean Sea												presence of the species in the area
Baino *et al.* (2001)	1994-1999	E Aegean Sea												data from MEDITS expedition (biomass index 1.4 kg/km^2)
Filiz & Mater (2002)	7/1999-3/2000	Edremit Bay, Gulbahce Bay, and Sigacik Bay, N Aegean Sea, Turkey												presence of the species in the area
Golani (2006)		Israel												list of cartilagenous species in Israeli coasts. *H. perlo* is characterised as "prevalent"
Megalofonou *et al.* (2005)	1998-2001	Greek seas			1		104							as bycatch in swordfish and albacore longlines
Öziç & Yılmaz (2006)	7/2003-3/2004	Gökova Bay, Aegean Sea												presence of the species
Saad *et al.* (2006)	2001-2004	Syrian coasts												
Ismen *et al.* (2007)	2/2005-4/2006	Saros Bay, Turkey	28-370		14	68.6	105	920	3388	0.004	2.927	0.174	0.959	
Kabasakal & Ince (2008)	15/9/2008	Kömür Cape, SW tip of Saroz Bay, Turkey		F	1		85		1700					refers to a stranded individual
Damalas & Vassilopoulou (2009, 2011)	1993-2000	Central Aegean Sea			41									research on by-catches and discards. CPUE, % weight and numbers discarded are given in the 2011 paper
Ismen *et al.* (2009)	3/2005-6/2008	Saros Bay, Turkey	5-500		18	68.6	105	920	3388	0.005	2.904		0.958	
Ismen *et al.* (2009)	3/2005-6/2008	Saros Bay, Turkey	5-500	M	5	68.6	84	920	1960	0.000	3.558		0.986	
Ismen *et al.* (2009)	3/2005-6/2008	Saros Bay, Turkey	5-500	F	13	69.2	105	1170	3388	0.008	2.786		0.957	
Damalas & Megalofonou (2012)	1998–2001	Antikithyra strait, Greece	382		1		104							
Güven *et al.* (2012)	10/2009-12/2010	Antalya Bay, Turkey	200-800		11	31.1	105.3	80.2	3560	0.002	3.080		0.998	
Papaconstantinou (2014)		Aegean Sea												review of Greek ichthyofauna
Lteif (2015)	1-8/2013	South Lebanese coasts	0-300		1		115		6000					
Lteif (2015)	1-8/2013	Central Lebanese coasts	200-400		3									

Ergüden & Bayhan (2015) in Crocetta *et al.* (2015)	27/6/2014	Mersin Bay, Turkey	601	M	1		105		3600					includes morphological measurements
Başusta (2016)	4/5/2015	NE Mediterranean (off Iskederun Gulf)	360-400	F	1		32.3		106.9					includes morphological measurements
Başusta (2016)	4/5/2015	NE Mediterranean (off Iskederun Gulf)	360-400	M	1		32.5		101.8					includes morphological measurements
Eronat & Özaydın (2014)	2008-2009	Izmir Bay and Sığacık Bay		F	1		99.6		4382					
Alkusairy & Saad (2018)	11/2014-10/2016	Syrian coasts		M		27	117							the species is overfished in the area
Alkusairy & Saad (2018)	11/2014-10/2016	Syrian coasts		F		20	124							female catches (common) mainly juveniles. The species is overfished in the area
Follesa *et al.* (2019)	2012-2015	Aegean Sea and Crete, Greece	200-800											data from MEDITS expedition (GSAs 22, 23). Frequency of occurrence is given
Follesa *et al.* (2019)	2012-2015	Cyprus	200-800											data from MEDITS expedition (GSA 25). Frequency of occurrence is given
Central Mediterranean														
Quignard & Capapé (1971)		Tunisia	400-600											from an inventory of species in Tunisian waters
Capapé (1975b)		Tunisia												presence of the species in the Tunisian waters
Capapé (1980)		Tunisia		M	36					0.016	2.502		0.963	the relationship refers to juveniles. In the paper it was provided in its linear form.
Capapé (1980)		Tunisia		M	32		118			0.429	1.178		0.995	the relationship refers to adults. In the paper it was provided in its linear form
Capapé (1980)		Tunisia		F	40					0.001	3.447		0.984	the relationship refers to juveniles. In the paper it was provided in its linear form
Capapé (1980)		Tunisia		F	12		139			0.347	2.359		0.983	the relationship refers to adults. In the paper it was provided in its linear form
Bradaï *et al.* (2002)	4/2/1999	Gulf of Gabès, Tunisia		M	1		39		138					
Bradaï *et al.* (2002)	19/1/2001	Gulf of Gabès, Tunisia	80	F	2	69.5	98	688	4000					
Bradaï *et al.* (2002)	1-2/2001	Gulf of Gabès, Tunisia		M	2		75	1252	1259					
Bradaï *et al.* (2002)	1-2/2001	Gulf of Gabès, Tunisia		F	3	69.5	98	828	4000					the dimensions of the 3rd individual were TL=815, W=1450
Bradaï *et al.* (2002)	1/3/2003	Gulf of Gabès, Tunisia		F	2	94	100		2300					
De Maddalena *et al.* (2002)	26/7/2000	Ganzirri, Mesina Strait	70	M	1		85		1610					
De Maddalena *et al.* (2002)	6/2000	Linosa and Porto Empedocle	200		5	70	80							
De Maddalena *et al.* (2002)	21/11/1989	Catania			1		95		4000					from the Catania fish market

D'Onghia *et al.* (2003); Politou *et al.* (2003); Mytilineou *et al.* (2005)	9/1999, 4/2000, 7/2000, 9/2000	East Ionian Sea, Greece	388-501											first record from the Ionian Sea, caught in low abundances
Schembri *et al.* (2003)		Malta												review of Matese ichthyofauna
Bradaï *et al.* (2006)		Gulf of Gabès Tunisia												
Gristina *et al.* (2006)	autumn of 1997-1998	Strait of Sicily	290-350											mean standardised catch rates for the species per sampling area and year is provided
Capezzuto *et al.* (2010); Maiorano *et al.* (2010)	1985-2008	NW Ionian Sea	322-345											review of fish caught in trawling surveys form 1985 to 2008
Scacco *et al.* (2010)	2000-2002	Portopalo di Capopassero (SE Sicily)		M	8									used for caudal fin shape analyses
Scacco *et al.* (2010)	2000-2002	Portopalo di Capopassero (SE Sicily)		F	6									used for caudal fin shape analyses
Dimech *et al.* (2012)	1/6/2007	Malta	517-671											biomass (kg/km²) is given
Ragonese *et al.* (2013)	1994-2009	Central Mediterranean												the authors describe the species as "rare in Malta and Tunisia, common in the other zones; sold at the market"
El Kamel-Moutalibi *et al.* (2014)	21/5/2014	Eskerkis Bank, Tunisia	150-300	M	1		70		1000					includes morphological measurements
El Kamel-Moutalibi *et al.* (2014)	21/5/2014	Eskerkis Bank, Tunisia	150-300	F	1		79		1280					includes morphological measurements
El Kamel-Moutalibi *et al.* (2014)	1/4/2007	Tunisian waters		M	1		81		3000					
El Kamel-Moutalibi *et al.* (2014)	15/7/2008	Tunisian waters		F	1		110		5000					
Papaconstantinou (2014)		Ionian Sea												review of Greek ichthyofauna
Rafrafi-Nouira *et al.* (2015)	25/9/2014	Cani Rocks, Tunisia	56	F	1		99							includes morphological measurements
Capapé *et al.* (2018)	24/11/2015	Island of Zembra, Tunisia	150	M	2	74	84	1300	1735					includes morphological measurements
Capapé *et al.* (2018)	24/11/2015	Island of Zembra, Tunisia	150	F	2	72	112	1150	2255					includes morphological measurements
Capapé *et al.* (2018)	2/8/2018	off Bizerte, Tunisia	130-140	M	1		72		1130					includes morphological measurements
Capapé *et al.* (2018)	2/8/2018	off Bizerte, Tunisia	130-140	F	1		70		1092					includes morphological measurements
Follesa *et al.* (2019)	2012-2015	Central Mediterranean (Sicily, South Italy, Ionian Sea)	200-800											data from MEDITS expedition (GSAs 16, 19, 20). Frequency of occurrence is given
Adriatic Sea														
Fredj & Maurin (1987)		Adriatic Sea												presence of the species (depths from 0 up to >1000 m)
Jukic-Peladic *et al.* (2001); Ferretti *et al.* (2013)	1948	Adriatic Sea			2									inventory of species caught in scientific surveys

Soldo (2006)		Adriatic Sea												the author states "often caught as bycatch in trawls and by deep bottom longlines, but their current status in the Adriatic is unknown"
Lipej & Dulčić (2010)		Adriatic Sea												checklist of the fishes in the Adriatic
Follesa *et al.* (2019)	2012-2015	South Adriatic	200-800											data from MEDITS expedition (GSA 18). Frequency of occurrence is given
West Mediterranean														
Tortonese (1969)		S. Margherita, Ligurian Sea												a medium-sized specimen from the market of S. Margherita (Eastern Riviera)
Fredj & Maurin (1987)		W Mediterranean												presence of the species (depths from 0 up to >1000 m)
Gil de Sola Simarro (1994)	1991-1992	Alboran Sea	200-500		5									overall weight 21050 g
Lloris *et al.* (1998)	1995	Iberian Mediterranean	423-433		1									data from MEDITS expedition
Baino *et al.* (2001)	1994-1999	Morocco, Spain and France												data from MEDITS expedition (biomass index 0.7 kg/km^2)
Baino *et al.* (2001)	1994-1999	Tyrrhenian, Corsica, Sardinia and Sicily												data from MEDITS expedition (biomass index 3.9 kg/km^2)
Storai (2004)		Livorno		M	1		98							based on musem material
Storai (2004)		Livorno		F	2									based on musem material
Serena & Relini (2006)	1985-2004	Northern Tuscany												data from GRUND surveys
Serena & Relini (2006)	1994-2004	W Mediterranean												data from MEDITS surveys (it includes all Mediterranean, not specifying the area H. perlo was caught)
Dufur *et al.* (2007)		Port Cross and Corsica												presence of the species in an MPA
Mullas *et al.* (2011)	2008-2010	Sardenia	600		3									during experimental trawl surveys (MEDITS and GRUND)
Bonomo *et al.* (2011)	1906-1963	Milazzo, Sicily												catches in tuna traps
Ordines *et al.* (2011)	3/2003, 2/2004	Algeria	300-505		2									only the presence of 2 individuals is being reported
Mendoza *et al.* (2014)	2006-2011	SE Spain, W Mediterranean												presentation of a vulnerability index
Marongiu *et al.* (2017)	1994-2015	Sardenia	273-336		1		80.5							data from MEDITS expedition
Agnetta *et al.* (2019)	spring 2005	Gulfs of Castellammare, Termini Imerese, Sant'Agata and Patti			24									fished to be used for stable isotope analyses. Average lengths are given
Guallart *et al.* (2019b)	26/6/2019	Ibiza channel, Balearic Sea		F	1		64.3							includes morphological measurements
Guallart *et al.* (2019a)	24/2/2018	Balearic Sea	650	F	1		79.6		1590					
references that could not be allocated to a specific Mediterranean Area														
Vassilopoulou *et al.* (2007)		Greek Seas												presented in a list of totally discarded species
Peristeraki & Megalofonou (2007)		Greek Seas												presence of the species in the Greek Seas
Thessalou-Legaki & Legakis (2005)		Greek Seas												presence of the species in the Greek Seas, with notes on the Greek legislation related to the species

Appendix 2: List of records of* Heptranchias perlo *in the Mediterranean, based on secondary references (literature not available to the authors). F=female, M=male, N=number of individuals.
Priloga 2: Seznam zapisov o pojavljanju vrste* Heptranchias perlo *v Sredozemskem morju, ki temeljijo na sekundarnih referencah (literatura, ki ni bila dostopna avtorjem). F=samica, M=samec, N=število osebkov.

main Reference	**secondary Reference**	**date**	**locality**	**Sex**	**N**
East Mediterranean					
Athanasiou & Boulos (1964)	Capapé (1980)		Lebanon		
Demetropoulos & Neocleous (1969)	Hadjichristophorou (2006)		Famagusta Bay and Morphou Bay, Cyprus		
Cihangir *et al.* (2002)	Çoker & Akyol (2014)		Bay of Magusa, East Cyprus		
Erhard (1858)	Papaconstantinou (2014)		Aegean Sea		
Heldreich (1978)	Papaconstantinou (2014)		Aegean Sea		
Carus (1893)	Papaconstantinou (2014)		Aegean Sea		
Bertrand *et al.* (2000)	Papaconstantinou (2014)		Aegean Sea		
BOLD	Guallart *et al.* (2019a,b)	2009	off Cyprus		5
Central Mediterranean					
BOLD	Guallart *et al.* (2019a,b)	2007	Malta	M	2
BOLD	Guallart *et al.* (2019a,b)	2008	NW Ionian Sea	M	1
Adriatic Sea					
Soljan (1963)	Capapé (1980)		N Adriatic (former Yugoslavia)		
West Mediterranean					
Moreau (1881)	Capapé (1980), Guallart *et al.* (2019a)		Nice, Sete		
LoBianco (1909)	Guallart *et al.* (2019a)		off Naples		
Gibert (1913)	Guallart *et al.* (2019a,b)		Catalonia, Spain		
Lozano Rey (1928)	Guallart *et al.* (2019a,b)	1915	Motril, Alboran		1
Dieuzeide *et al.* (1953)	Capapé (1980)		Morocco		
Capapé (1975)	Capapé (1980)		Morocco		
Capapé (1977)	Capapé (1980), Guallart *et al.* (2019a)		Toulon, France		
Barrull & Mate (2002)	Guallart *et al.* (2019a,b)	2000	Alboran		1
Hemida (2005)	Guallart *et al.* (2019a,b)		Algeria		
Bearez *et al.* (2017)	Guallart *et al.* (2019a,b)		Gulf of Lions		
Ramirez (2017)	Guallart *et al.* (2019a)	1995, 2002	Alboran (GSA01)		2
BOLD	Guallart *et al.* (2019a)		Mazzara de Vallo	F	1
BOLD	Guallart *et al.* (2019a)	2009	off Sardinia	F	2
references that could not be allocated to a specific Mediterranean Area					
Doderlein (1881)	Papaconstantinou (2014)		Greek seas		
Apostolidis (1883, 1907)	Papaconstantinou (2014)		Greek seas		
Hoffman & Jordan (1892)	Papaconstantinou (2014)		Greek seas		
Belloc (1948)	Papaconstantinou (2014)		Greek seas		
Tortonese (1956)	Guallart *et al.* (2019a)		Italian waters		
Bini (1960; 1965; 1967)	Papaconstantinou (2014)		Greek seas		
Ondrias (1971)	Capapé (1980), Papaconstantinou (2014)		Greek seas		
Boeseman (1973; 1984)	Papaconstantinou (2014)		Greek seas		
Economidis (1973)	Capapé (1980), Papaconstantinou (2014)		Greek seas		
Fisher *et al.* (1987)	Papaconstantinou (2014)		Greek seas		
diNatale (1998)	Guallart *et al.* (2019a)		Italian waters		
Machias *et al.* (2001)	Papaconstantinou (2014)		Greek seas		
Legakis & Maragou (2009)	Papaconstantinou (2014)		Greek seas		

PREGLED O POJAVLJANJU MORSKEGA PSA SEDMEROŠKRGARJA *HEPTRANCHIAS PERLO* (CHONDRICHTHYES: HEXANCHIDAE) V SREDOZEMLJU: ZGODOVINSKI IN RECENTNI PODATKI

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POVZETEK

Avtorji poročajo o pojavljanju morskega psa sedmeroškrgarja Heptranchias perlo *(Bonnaterre, 1788) v Sredozemskem morju na podlagi celovitega pregleda literature, ki je bil osnova za pripravo podatkovne baze o razširjenosti te vrste. Poleg tega v delu omenjajo biološke podatke o samici te redke vrste na robu ogroženosti, ki je bila ujeta v okviru eksperimentalnega vzorčenja v mirtonskem morju (jugozahodno Egejsko otočje, Grčija). Namen tega prispevka je podati povzetek o razpoložljivih podatkih o tej vrsti v Sredozemskem morju, ki bo služil za prihodnja dopolnjevanja ocen glede ohranitvenega statusa vrste v bazenu.*

Ključne besede: hrustančnice, prehrana, plodnost, sredozemska razširjenost

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A HISTORICAL CATCH OF WHITE SHARK, *CARCHARODON CARCHARIAS* (LAMNIFORMES: LAMNIDAE), IN THE SEA OF MARMARA (TURKEY) FROM THE 1950s

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ABSTRACT

In the late 1950s, a white shark, Carcharodon carcharias *(Linnaeus, 1758), was incidentally captured by tuna handliners off the coast of Burgazada. Currently, 58 white sharks have been reported from Turkish waters, which represents some 7.5 percent of the total Mediterranean records (n=773). The decrease in white shark sightings from the Sea of Marmara over the years is most likely linked to a strong decline of tuna populations in the same region. The present study is one of the many examples of effective use of internet-based records in white shark research.*

Key words: white shark, *Carcharodon carcharias*, Sea of Marmara, historical record, bycatch

CATTURA STORICA DI SQUALO BIANCO, *CARCHARODON CARCHARIAS* (LAMNIFORMES: LAMNIDAE), NEL MAR DI MARMARA (TURCHIA) DAGLI ANNI '50

SINTESI

Alla fine degli anni '50, uno squalo bianco, Carcharodon carcharias *(Linnaeus, 1758), fu accidentalmente catturato da tonniere a mano al largo della costa di Burgazada. Attualmente nelle acque turche sono stati segnalati 58 squali bianchi, che rappresentano circa il 7,5 % delle segnalazioni totali per il Mediterraneo (n = 773). La diminuzione nel numero di avvistamenti di squali bianchi nel Mar di Marmara è molto probabilmente legata a un forte calo delle popolazioni di tonno nella stessa regione. Il presente studio è uno dei tanti esempi di utilizzo efficace dei dati disponibili su Internet nella ricerca sugli squali bianchi.*

Parole chiave: squalo bianco, *Carcharodon carcharias*, Mar di Marmara, segnalazione storica, catture accidentali

INTRODUCTION

Large sharks and their hunters have always been a bankable commodity for the media, a guarantee for attracting the public interest (Francis, 2012). Due to logistical difficulties of studying a marine predator of that size, the white shark, *Carcharodon carcharias* (Linnaeus, 1758) has often been described as elusive (Huveneers *et al.*, 2018). For that reason, as well as the white shark's charismatic nature and dramatic interactions with humans, reports of the species tend to gain significant public attention. *C. carcharias* is an epipelagic shark, inhabiting coastal and offshore waters, from the surface down to a depth of 1300 m (Serena, 2005). While its contemporary Mediterranean distribution range extends over the entire region, the species is currently absent from the Sea of Marmara, where it had been a documented bycatch of bluefin tuna, *Thunnus thynnus* (Linnaeus, 1758), until the last quarter of the 20th century (De Maddalena & Heim, 2012; Kabasakal, 2003). With the advent of social media and the digitization of photographs of historical shark catches, which may be uploaded to the internet, researchers nowadays have more opportunities to access the historical material about events sunken into oblivion. In the present article, the author reports on a historical catch of white shark off the Prince Islands (Sea of Marmara), in the 1950s.

MATERIAL AND METHODS

An extensive research dealing with the identification of historical and contemporary records of *C. carcharias* in Turkish waters has been conducted since 2000, and the present article is part of this ongoing study, the results of which were published in previous years (relevant publications are summarized in Kabasakal, 2019). Species identification follows the criteria proposed by Serena (2005). Photographs of the here presented white shark are preserved in the digital archives of the Ichthyological Research Society. While the historical account of this great white shark is available at the link below, the author conducted online interviews with an elderly islander, Mrs. Maria Pilitsoglou, who witnessed the capture of this specimen, to provide further evidence supporting the provenance of the historical catch: https://m.facebook.com/story.php?story_fbid=130023338618546&id=100048326409241.

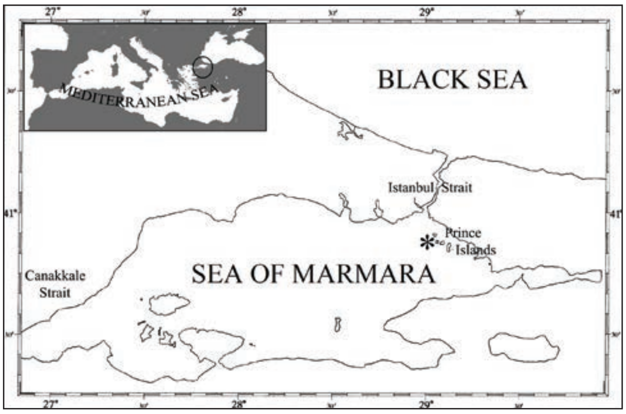

Fig. 1: Map depicting the approximate capture locality (⁎) of the white shark by tuna handliners off Burgazada, in the 1950s.

Sl. 1: Zemljevid obravnavanega območja s približno lokaliteto (⁎), kjer so tunolovci ujeli belega morskega volka pri Burgazadi v petdesetih letih prejšnjega stoletja.

RESULTS AND DISCUSSION

Sometime during the late 1950s, a white shark, *C. carcharias*, was captured by tuna handliners off the coast of Burgazada (Sea of Marmara; Fig. 1). Based on the principal descriptive characters (Serena, 2005), including large triangular teeth, strong and conical snout, (clearly depicted in Fig. 2), the present specimen was identified as *C. carcharias*. The length of the white shark was reportedly 4 m. Two recreational fishermen from Burgazada, Mr. Muvakkar Orhon and Mr. Selimpaşalı Ali, set out to sea to catch bluefin tuna by handline, which was the main method used in bluefin tuna fishery in the Sea of Marmara during the 1950s. In handlining bluefin tuna, a large bonito, *Sarda sarda* (Bloch, 1793), was fixed on a chunky fishing hook. These were mostly hand-made, forged by blacksmiths. The scarcity of large high-quality, ready-to-use fishing hooks to be utilized by bluefin tuna handliners during that period was the main reason why incidentally captured white sharks had to be landed in order for the fishing hook to be removed from the animal's jaws with the least possible damage to it.

After baiting the hook with a bonito, the fishermen lowered the hook and line at a depth of around 30 m and waited for the bluefin tuna to bite. According to their statements, the fishermen were very experienced handliners, having captured over 300 bluefin tunas during the previous years, and several white sharks as well. The white shark that took the bait struggled with the hook and the fishermen for nearly two hours, then perished. After the animal had been landed on the Burgazada coast, one of the islanders, Captain Bebeko, detached one of its teeth; unfortunately, according to the interview with the Captain's daughter, Mrs. Maria Pilitsoglou, this valuable sample was lost. Nevertheless, Mrs. Pilitsoglou provided a clear description of the tooth, which was triangular in shape, with serrated edges, a well-known descriptive character of *C. carcharias*. Her statement is available on the social media at the following link: https://m.facebook.com/story.php?story_fbid=130023338618546&id=100048326409241.

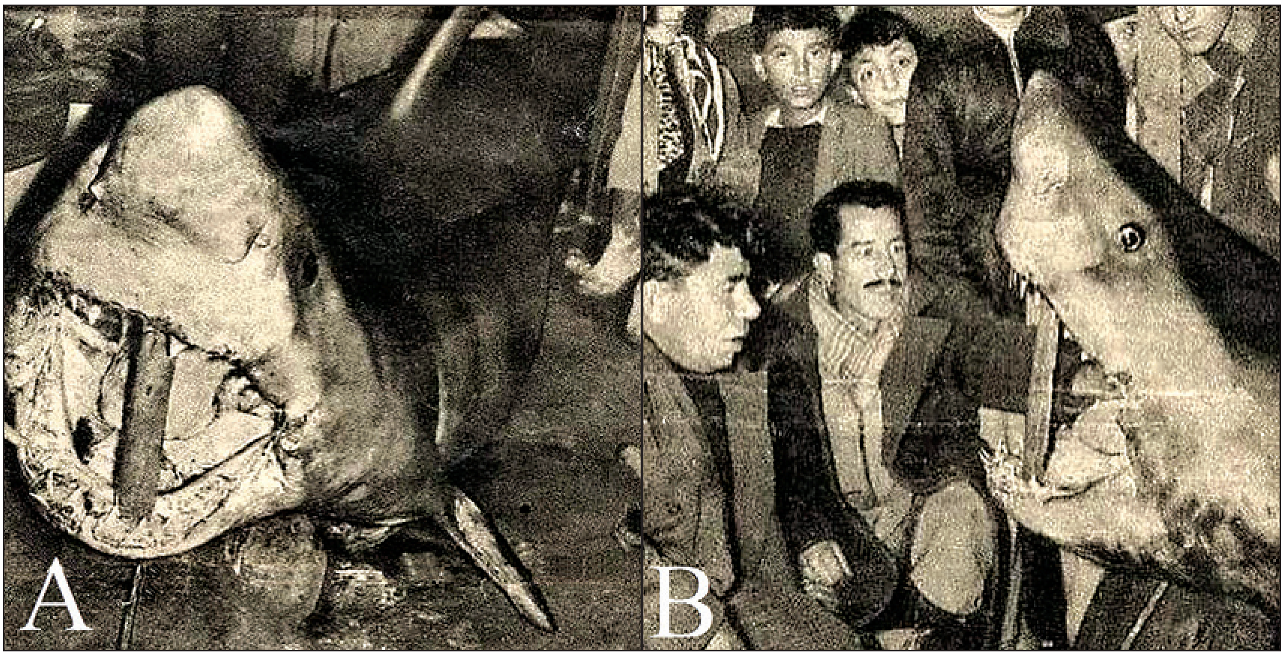

Fig. 2: Front view (A) and lateral view (B) of the captured white shark. Large triangular teeth and a strong and conical snout are clearly visible on both images. (Photo courtesy: Burgazisland Antigoni Burgazada archive).
Sl. 2: Pogled od spredaj (A) in od strani (B) na ulovljenega belega morskega volka. Veliki trikotni zobje in močan ter koničast gobec so dobro vidni na obeh posnetkih (z dovoljenjem arhiva Burgazisland Antigoni Burgazada).

De Maddalena & Heim (2012) and Boldrocchi *et al.* (2017), reported on the records of 596 and 628 white sharks, respectively. In a recent study on the abundance and distribution of the white shark in the Mediterranean Sea, Moro *et al.* (2019) collected 773 records of white shark from several parts of the Mediterranean, dated between 1860 and 2016. Prior to the present study, 57 white sharks had been recorded from Turkish waters (Kabasakal *et al.*, 2018). The addition of the white shark presented herein raises this number to 58, which represents 7.5 percent of all Mediterranean records (Moro *et al.*, 2019). A close relationship between bluefin tuna and white shark occurrence in the Mediterranean Sea has been suggested by many researchers (Boldrocchi *et al.*, 2017; De Maddalena & Heim, 2012; Moro *et al.*, 2019). Indeed, the decrease in white shark sightings in the Sea of Marmara over the years and the strong parallel decline of tuna populations in the same region (Kabasakal, 2016) appears to confirm that. The last sighting of *C. carcharias* in the Sea of Marmara dates back to May 1985, preceding the records of last mass captures of bluefin tuna in Marmaric waters by only a year (Kabasakal, 2003, 2016).

Since the white shark is a critically endangered species in the Mediterranean and in some of its areas a protected species as well (Otero *et al.*, 2019, Serena 2005), the selection of an appropriate and non-destructive sampling for future studies of white sharks is of utmost importance; presently, the screening of the internet and social media seems to be an advantageous method. The expansion of the use of internet and social networks during the last 20 years has likely increased the probability of finding records of white shark captures (Moro *et al.*, 2019), and the present study is one of the many examples of the promising use of internet-based records in ichthyological research.

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ZGODOVINSKI PREGLED ULOVA BELEGA MORSKEGA VOLKA, *CARCHARODON CARCHARIAS* (LAMNIFORMES: LAMNIDAE), V MARMARSKEM MORJU (TURČIJA) IZ PETDESETIH LET

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POVZETEK

V zgodnjih petdesetih prejšnjega stoletja so belega morskega volka, Carcharodon carcharias *(Linnaeus, 1758), naključno ujeli tunolovci ob obali Burgazada. Do sedaj je bilo 58 zapisov o pojavljanju belega morskega volka v turških vodah, kar predstavlja 7,5 % vseh sredozemskih zapisov (n=773). Upadanje v opazovanju belega morskega volka v Marmarskem morju v zadnjih letih je najverjetneje povezano z močnim zdesetkanjem populacij tunov v regiji. Pričujoča raziskava je eden od mnogih primerov učinkovite uporabe spletnih virov pri raziskovanju belega morskega volka.*

Ključne besede: beli morski volk, *Carcharodon carcharias*, Marmarsko morje, zgodovinski zapis, prilov

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THE FIRST RECORD OF KITEFIN SHARK *DALATIAS LICHA* IN ALBANIAN WATERS

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ABSTRACT

The aim of this paper is to present the first documented record of the kitefin shark, Dalatias licha*, in Albanian waters. Although Albania is situated at the confluence of two seas, and has an Adriatic as well as an Ionian coastline, D. licha was not recorded previously as present in Albanian waters, in either its Adriatic or Ionian parts. The kitefin shark individual was captured off the coast of Vlora by a professional fisherman and identified in situ by two researchers.*

Key words: Kitefin shark, *Dalatias licha*, Chondrichthyes, Albanian coast, Adriatic Sea

PRIMO RITROVAMENTO DELLO SQUALO ZIGRINO *DALATIAS LICHA* IN ACQUE ALBANESI

SINTESI

Lo scopo di questo articolo è presentare il primo ritrovamento documentato dello squalo zigrino, Dalatias licha*, nelle acque albanesi. Sebbene l’Albania sia situata alla confluenza di due mari e abbia una costa adriatica e una ionica, D. licha non è stata segnalata in precedenza nelle acque albanesi, né in quelle adriatiche né in quelle ioniche. Lo squalo zigrino è stato catturato al largo della costa di Valona da un pescatore professionista e identificato in situ da due ricercatori.*

Parole chiave: squalo zigrino, *Dalatias licha*, Chondrichthyes, costa albanese, mare Adriatico

INTRODUCTION

The kitefin shark, *Dalatias licha* (Bonnaterre, 1788), is a deep-water, benthic to mesopelagic species, mainly distributed in the western Atlantic, western Indian, and Pacific Oceans (Last & Stevens, 1994). The range of this species in the Mediterranean appears to be confined to the western and central basins of the Mediterranean, where it is considered as common (Baino *et al.,* 2001; Navaro *et al*., 2014), while it is thought as rare in the eastern part of the basin (Ergüden *et al*., 2017). Occurence of the species has been documented several times off the western Mediterranean (Bottaro *et al*., 2005, Capapé *et al*., 2008) and Levantine coasts (Golani, 2005). Papaconstantinou (1988) reported the presence of the kitefin shark in the Aegean Greek waters, while Kabasakal and Kabasakal (2002) indicated the presence of the species in the north-eastern Aegean Sea. However, due to the absence of kitefin shark in the last 20 years' fishing records, Kabasakal & Karhan (2015) concluded that a Marmaric occurrence of *D. licha* is questionable and requires confirmation. Since then, the first record of an adult female specimen of *D. licha* was reported from Iskenderun Bay (Eastern Mediterranean, Turkey) (Erguden *et al.,* 2017). Chatzispyrou *et al.* (2019) reported the first record of *D. licha* in the Laconian Gulf of the Greek Ionian Sea, where the kitefin shark is also considered to be a very rare species.

It is listed among Adriatic species, but considered very rare and confined to the deep waters of the central and south Adriatic (Lipej *et al*., 2004).

The kitefin shark reaches a maximum size of 182 cm total length (TL); males mature at ca. 100 cm TL and females when they reach about 120 cm TL; the size at birth ranges from 30 to 40 cm TL. Reproduction is lecithotrophic viviparous; presumably asynchronous; and litter size is 3–16 pups (average 6–8) (Daley *et al.,* 2002; Ebert *et al*., 2013). This shark can reach a maximum age of 32–36 years, its age at maturity ranges from 15.5 to 21.5 years (Irvine *et al*., 2012), while generation length is estimated at 29 years. A slow growth rate, late sexual maturity, and a long gestation period for its life span make this species vulnerable (Stevens *et al.,* 2000). Little information is available on the biology of this species in the Mediterranean.

Albania, situated at the confluence of two seas, has 380 km of coastline, 284 km of which stretch along the Adriatic Sea in the north, and the remaining 96 km face the Ionian Sea. Since the kitefin shark was not, until now, listed as present in Albanian waters, either in the Adriatic or Ionian area, this is the first documented report on the presence of *D. licha* in Albanian waters.

MATERIAL AND METHODS

On 22 July 2019, a single male individual of *D. licha* was landed by a professional fisherman in the Fishing Center Oriku (Radhime), South Albania. The specimen was caught during bottom trawling, between the north of the Sazani Island and Vjosa Delta, *(*40.580144° N, 19.176254° E*),* at a depth of 300 m, in an area that belongs to the Adriatic Sea (Fig. 1). Identification and morphometric measures of the specimen were performed on site according to guidelines by Compagno (1984). After the measurements were made, the specimen was frozen and kept in the freezer as part of the Fishing Center Orikum collection, in Vlora (Albania) for further investigations.

RESULTS AND DISCUSSION

The specimen displayed the following combination of specific characteristics (Fig. 2): short-and blunt-snout, two almost equal-sized spineless dorsal fins, no anal fin, papillose thick lips, small slender-cusped upper teeth and very large lower teeth with erect triangular serrated cusps and distal blades, the first dorsal fin on back with its origin behind the pectoral rear tips and its base closer to the pectoral base than the pelvis, and caudal fin with the ventral lobe not expanded (Compagno, 1984). The total length (TL) and weight (W) were 106 cm and 3.3 kg, respectively. The specimen caught was an adult male.

The global conservation status of the *D. licha* according to IUCN standards is defined as vulnerable (Finucci *et al*., 2018), the same as in the Mediterranean (Walls & Guallart, 2016). Moreover, in 2010, the European Union Fisheries Council prohibited direct fishing of kitefin shark in the European Community and international waters. In the Mediterranean Sea, the ban on deep-water fishing below 1,000 m of depth may provide the kitefin shark with a limited indirect respite from fishing pressure, although it refers to depths greater than the species' preferred range.

D. licha is captured as bycatch in deep-water longline, bottom trawl, and gillnet fisheries in the western and central Mediterranean basins, and the biomass in this region seems to be very low (Baino *et al*., 2001), with local scientific trawl surveys indicating steady declines. Considering a 15% decline in the period between 1972 and 2004, according to the data by Gruppo Nazionale Demersali (GRUND), and if an exponential decline is assumed, the annual proportional change would be 0.9949. Therefore, the reduction for the time period 1972–2059 (87 years, three generations) is 36%. When projecting this decline into the future

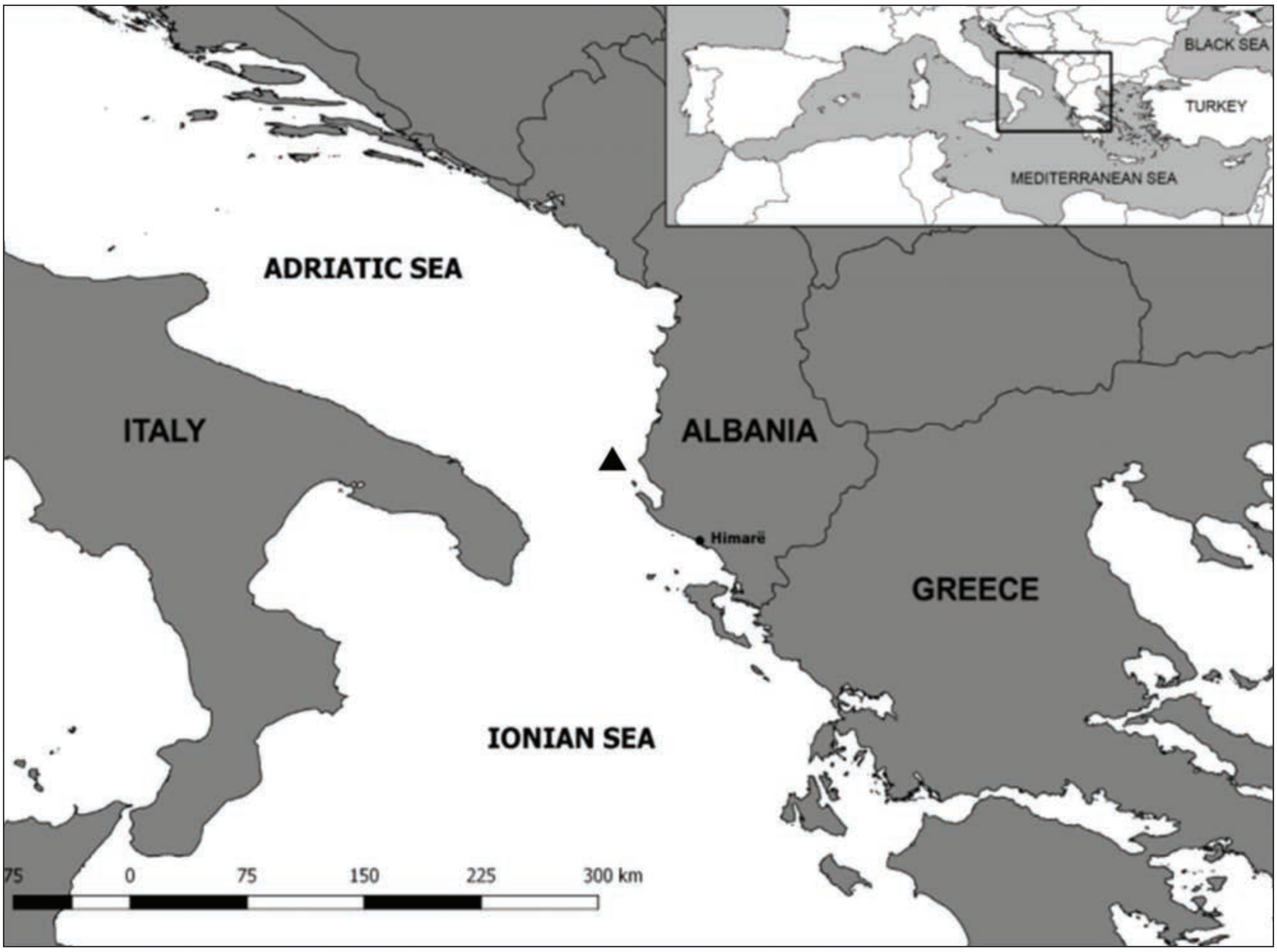

Fig. 1: Capture site off Vlora (triangle) of the** D. licha **specimen.
Sl. 1: Lokacija ulova primerka vrste** D. licha **pri mestu Vlora.

(2015–2102, a three-generation period), a decline of another 36% is also calculated (Walls & Guallart, 2016).

In the Mediterranean, the kitefin shark has been caught incidentally in benthic trawl targeting red shrimp, *Aristeus antennatus* (Risso, 1816), and Norway lobster, *Nephrops norvegicus* (Linnaeus, 1758). This species has likely been previously misidentified as other large deep-water sharks, including Portuguese dogfish, *Centroscymnus coelolepis* Barbosa du Bocage & de Brito Capello, 1864, and leafscale gulper shark, *Centrophorus squamosus* (Bonnaterre, 1788) (ICES 2006). Discard mortality is unknown, but presumed to be high (Rodríguez-Cabello & Sánchez, 2017), and the extent of illegal, unreported, and unregulated (IUU) fishing is unknown (Walls & Guallart, 2016).

During exploratory surveys to collect data on exploited and virgin stocks of the deep-sea red shrimp (DESEAS project), kitefin sharks were caught in all three study areas (the Balearic, western Ionian, and eastern Ionian areas). In the Balearic area abundance decreased with depth, in the western Ionian area the species was found to be more abundant between 1,000 and 1,499 m, while in the eastern Ionian area it was present at shallower depths (Sion *et al*., 2004).

Jardas (1996) supposed that this species only occurs in the Adriatic in the comparatively deep waters of the Jabuka Pit, but is very rare. Later, Bello (1999) reported that *D. licha* is infrequently caught by bottom trawl on southern Adriatic bathyal grounds.

Albania is an EU candidate country and, since there is a general trend to increase the deep-water fishing effort, which is likely to affect the kitefin shark population in the future, we point out the need to investigate the biology and ecology of this species in the Mediterranean (including Albania) in order to determine the conservation strategies for *D. licha* in the Mediterranean Sea.

Fig. 2: *D. licha* ***landed at the Fishing Center Orikum (Radhime), Albania. (a) The whole specimen, (b) head and eyes, (c) head and jaws, (d) tail, and (e) ventral side of the body.***
Sl. 2: Primerek vrste *D. licha* ***v ribiškem središču Orikum (RadhimeI, Albanija. (a) celotni primerek, (b) glava in oči, (c) glava in čeljusti, (d) rep in (e) trebušna stran telesa.***

ACKNOWLEDGEMENTS

We would like to thank Save Our Seas foundation for the financial support of the surveys along the Albanian coasts to collect the data about shark catches.

PRVI ZAPIS O POJAVLJANJU KLINOPLAVUTEGA MORSKEGA PSA *DALATIAS LICHA* V ALBANSKIH VODAH

Nexhip HYSOLAKOJ
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ABSTRACT

Namen tega prispevka je predstaviti prvi dokumentirani primer o pojavljanju klinoplavutega morskega psa, Dalatias licha*, v albanskih vodah. Čeprav meji Albanija tako na Jadransko kot tudi na Jonsko morje, doslej D. licha ni bil potrjen v nobenem. Primerek klinoplavutega morskega psa je ujel ribič ob obali mesta Vlora, že na mestu samem pa sta ga določila raziskovalca.*

Ključne besede: klinoplavuti morski pes, *Dalatias licha*, Chondrichthyes, albanska obala, Jadransko morje

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OCCURRENCE OF A LARGE BIGEYE THRESHER SHARK, *ALOPIAS SUPERCILIOSUS* (LAMNIFORMES: ALOPIIDAE), IN THE NORTHEASTERN LEVANTINE SEA (ISKENDERUN BAY, EASTERN MEDITERRANEAN SEA, TURKEY)

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ABSTRACT

On 9 April 2019, a single female specimen of Alopias superciliosus *Lowe, 1841 was incidentally captured by a commercial purse seiner at an approximate depth of 20 m, off the coast of Çevlik, İskenderun Bay, Turkey. The present specimen is the largest to be captured in northeastern Levantine Sea to date, and one of the largest specimens, approaching the alleged 500 cm maximum TL, caught in the entire Mediterranean Sea. While the congeneric thresher shark,* A. vulpinus*, is now listed as protected species in the Turkish Marine Fisheries Act, a similar conservation status for the protection of* A. superciliosus *is urgently needed.*

Key words: thresher shark, Alopiidae, coast of Cevlik, Levantine Sea, conservation, bycatch

PRESENZA DI SQUALO VOLPE OCCHIONE, *ALOPIAS SUPERCILIOSUS* (LAMNIFORMES: ALOPIIDAE), NEL MAR LEVANTINO NORD-ORIENTALE (BAIA DI ISKENDERUN, MEDITERRANEO ORIENTALE, TURCHIA)

SINTESI

Il 9 aprile 2019, una femmina di squalo volpe occhione, Alopias superciliosus *Lowe, 1841, è stata accidentalmente catturata da una rete a circuizione commerciale, a una profondità di circa 20 m, al largo della costa di Çevlik, nella baia di İskenderun, in Turchia. L'esemplare è il più grande ad essere stato catturato nel Mar Levantino nord-orientale fino ad oggi. Si tratta inoltre di uno degli esemplari più grandi, avvicinandosi al presunto limite massimo di 500 cm, catturato in tutto il mare Mediterraneo. Mentre lo squalo volpe,* A. vulpinus*, è ora considerato specie protetta dalla legge turca sulla pesca marittima, è urgentemente necessario uno stato di conservazione simile per la protezione di* A. superciliosus.

Parole chiave: squalo volpe occhione, Alopiidae, costa di Cevlik, Mar Levantino, conservazione, catture accidentali

INTRODUCTION

The bigeye thresher shark, *Alopias superciliosus* Lowe, 1841, is one of the three species in the family Alopiidae, which is distributed worldwide in all temperate and tropical oceans (Ebert *et al.*, 2013). Despite its occurrence in the epipelagic and mesopelagic zones of open oceans, *A. superciliosus* is a common inhabitant of coastal waters over continental shelves, with seldom occurrence in shallow inshore waters (Froese & Pauly, 2020).

The first record of the bigeye thresher shark in the Mediterranean was reported from Italian waters, during observations in the fishing centres of Mazara del Vallo (Trapani, Sicily) (Cigala-Fulgosi, 1983), and was followed by a few dozen further records from elsewhere within the spcies' distribution range, which extends from the west to the east of the Mediterranean, including the Marmara Sea, which were summarised by Lanteri *et al.* (2017). *A. superciliosus* was recorded for the first time in Turkish waters by Mater (2005) in the Bay of Gökova.

This article reports on the capture of a large female of *A. superciliosus* in the Bay of İskenderun, north-eastern Levantine waters, and presents morphometric measurements of the examined specimen.

MATERIAL AND METHODS

On 9 April 2019, a single female specimen of *A. superciliosus* was incidentally captured by a commercial purse seiner at an approximate depth of 20 m, off the coast of Çevlik, İskenderun Bay, Turkey (location: 35° 57′ 14″ N, 35° 54′ 30″ E; Fig. 1). The specimen was photographed (Figs. 2, 3 and 4), and morphometric measurements (in cm) and weight (in grams) were recorded on site. Morphometric measurements were based on Compagno (2001), and measured to the nearest milimetre. Identification of the examined species follows Compagno (2001) and Serena (2005), and taxonomic nomenclature follows Froese & Pauly (2020).

RESULTS AND DISCUSSION

The total length (TL) of the examined bigeye thresher shark (Figs. 2, 3 and 4) was 472 cm, and its weight 400 kg. The morphometric measurements of the examined female are provided in Table 1, together with morphometric data extracted from several articles on *A. superciliosus*. Based on the following descriptive features that coincided with those proposed in Compagno (2001) and Serena (2005), the

***Fig. 1: Map depicting the approximate site of capture (*) of the examined** A. superciliosus.*
***Sl. 1: Zemljevid obravnavanega območja s približno oznako lokalitete (*), kjer je bil analiziran primerek vrste** A. superciliosus* **ujet.**

Tab. 1: Comparison of selected morphometric measurements of the* A. superciliosus *specimen examined in this study with those of other reported specimens from the Mediterranean Sea. Values provided in parentheses are the percentages that selected morphometric measurement take up of TL. *Since Lanteri et al. (2017) base their record on the collected head and pectoral fins of the examined specimen, the TL value is not provided. W Med: western Mediterranean; NW Med: northwestern Mediterranean; SE Med: southeastern Mediterranean; NE Med: northeastern Mediterranean; N/A: not available.

Tab. 1: Primerjava izbranih morfometričnih meritev na pregledanem primerku vrste* A. superciliosus *v tej raziskavi s podatki, pridobljenimi iz drugih raziskav v Sredozemskem morju. Vrednosti v oklepaju so deleži izbranih morfometričnih meritev glede na celotno dolžino telesa. *Ker so Lanteri in sod. (2017) zbrali le glavo in prsne plavuti pregledanega primerka, dolžina telesa ni navedena. W Med: zahodno Sredozemlje; NW Med: severozahodno Sredozemlje; SE Med: jugovzhodno Sredozemlje; NE Med: severovzhodno Sredozemlje; N/A: ni podatka.

	This study	**Kabasakal *et. al.* (2011)**	**Kabasakal (2017)**	**Ayas *et al.* (2020)**	**Corsini-Foka & Sioulas (2009)**	**Lanteri *et al.* (2017)***	**Farrag (2017)**
Locality	Iskenderun Bay (SE Med. Turkey)	Fethiye Coast (Aegean Sea, Turkey)	Antalya Bay (W Med. Turkey)	Mersin Bay (NE Med. Turkey)	Dodecanese waters (Aegean Sea, Greece)	Ligurian Sea (NW Med. Italy)	Egyptian coast of Med. Sea, Egypt
Sex	Female	Female	Female	Female	Male	Female	N/A
Measurements	Value (cm) (% of TL)	Value (cm) (% of TL)	Value (cm) (% of TL)	Value (cm) (% of TL)	Value (cm) (% of TL)	Value (cm)	Value (cm) (% of TL)
Total Length (TL)	472.0	450.0	342.4	240.0	310.0	N/A	180.0
First dorsal fin length	40.0	41.0 (9.1%)	-	17.9 (7.4%)	27.0 (8.7%)	-	-
First dorsal fin base length	32.0 (6.8%)	32.0 (7.1%)	-	13.6 (5.6%)	21.0 (6.8%)	-	-
Pectoral fin length	83.0 (17.5%)	82.0 (18.2%)	-	51.5 (21.4%)	62 (20.0%)	25.4	35 (19.4%)
Pectoral fin base length	40.0 (8.5%)	30.0 (6.7%)	-	20.1 (8.4%)	21 (6.8%)		-
Ventral fin length	37.0 (7.8%)	39.0 (8.7%)	-	20.6 (8.6%)	26.0 (8.4%)	-	-
Ventral fin base length	30.0 (6.4%)	30.0 (6.7%)	-	15.4 (6.4%)	21.0 (6.8%)	-	-
Distance between dorsal fin origin and ventral fin origin	-	-	-	17.8 (7.4%)	23.0 (7.4%)	-	-
Distance between pectoral fin origin and ventral fin origin	204 (43.2%)	-	-	68.9 (28.7%)	77.0 (24.8%)	-	-
Predorsal length	-	128.0 (28.4%)	-	87.7 (36.5%)	94.0 (30.3%)	-	57.0 (31.6%)
Preventral length	-	165.0 (36.7%)	-	105.3 (43.9%)	118.0 (38.1%)	-	70.0 (38.9%)
Prepectoral length	-	55.0 (12.2%)	38.6 (11.2%)	43.7 (18.2%)	45.0 (14.5%)	-	29.0 (16.1%)
Preanal length	-	-	-	-	-	41.7	89.0 (49.4%)
Precaudal fin length	-	-	240.5 (70.2%)	-	-	-	-
Prebranchial length	-	-	34.6 (10.1%)	-	-	-	-
Preorbital length	-	-	14.7 (4.2%)	-	-	31.6	9.0 (5.0%)
Preoral length	-	-	15.1 (4.4%)	-	-	11.0	-
Interorbital space	-	-	9.4 (2.7%)	-	-	12.3	7.0 (3.9%)
Eye length	-	-	6.9 (2.01%)	-	-	7.4	4.5 (0.95%)
Eye height	-	-	5.1 (1.4%)	-	-	4.7	-
Mouth width	20.0 (4.2%)	-	-	-	-	7.4	-
Pectoral fin anterior margin	-	-	46.4 (13.5%)	-	-	10.4	-
Tail length	240.0 (50.5%)	217.0 (48.2%)	-	103.8 (43.3%)	143.0 (46.1%)	54.4	84.0 (17.8%)

***Fig. 2: Female** A. superciliosus* **(472 cm in TL), captured off the coast of Çevlik, northeastern Levantine Sea (Photo: D. Ergüden archive).**
***Sl. 2: Samica vrste** A. superciliosus* **(472 cm v dolžino telesa), ujeta ob obali Çevlika, severovzhodno Levantsko morje (Foto: D. Ergüden arhiv).**

examined specimen was identified as *A. superciliosus*: cylindrical body, massive before the first dorsal fin; snout moderately long and bulbous; head with deep grooves extending along either sides from behind the eyes to the areas above the gill openings; eyes large and reaching the dorsal surface of head; interorbital space nearly flat; first dorsal midbase closer to the pelvic fin base than to the pectoral fin bases; pectoral fins falcate with broad apices; upper surface of the body brownish to dark grey, growing lighter in colour ventrally.

The story of *A. superciliosus* in the Mediterranean Sea dates to the early 1980s, when Cigala-Fulgosi (1983) recorded the species in the region for the first time. However, the discovery of taxidermied specimens caught in Dodecanese waters (southeastern Aegean Sea) in the 1950s suggests that *A. superciliosus* had been present in the Mediterranean Sea some thirty years earlier than the first published report on its occurrence was made (Corsini-Foka & Sioulas, 2009). Following Cigala-Fulgosi's (1983) report, several captures of bigeye thresher shark were reported from different parts of the Mediterranean Sea. These include Pescara, Italy (Cugini & De Maddalena, 2003), waters around Toulon (Capape, 1977), the Catalan littoral (Barrull *et al.,* 1999), eastern Sardinia (Vacchi & Serena, 2000), and the Ligurian Sea (Lanteri *et al.,* 2017). In the eastern Mediterranean region, sporadic records of *A. superciliosus* were reported from the Turkish Mediterranean and Aegean coasts (Mater, 2005; Kabasakal *et al*., 2011; Gökoğlu *et al*., 2017; Kabasakal, 2017; Ayas *et al*., 2020), as well as from the Sea of Marmara (Kabasakal & Karhan, 2008), Egyptian waters (Farrag, 2017), Israel, off the Ashod coast (Golani, 1996), Dodecanese waters, the SE Aegean Sea (Corsini-Foka & Sioulas, 2008), and from Cyprus waters (Kleitou *et al*., 2017). Lanteri *et al*. (2017) compiled a full list of 40 Mediterranean records of *A. superciliosus* with some data on the captured specimens and relevant references. With the addition of the specimens reported by Kabasakal (2017), Ayas *et al*. (2020), and the one recorded in the present study, the total number of records of *A. superciliosus* from the Mediterranean and Turkey increased to 43 and 15, respectively, with the latter number representing almost 35 % of all records reported in the Mediterranean to date. Although recent data suggest that the distribution of *A. superciliosus* in the Mediterranean is extending from the western part of the region to the Levantine Sea in the east and the Marmara Sea in the northernmost part, this shark species is still considered rare in the Mediterranean (Serena, 2005; Lanteri *et al*., 2017), and the small sample of 43 recorded specimens from the 1950s to date seems to validate this view. An overview of *A. superciliosus* records from Turkish waters is presented in Table 2.

While the maximum total length reported for *A. superciliosus* is 484 cm (Ebert & Stehmann, 2013), Lanteri *et al*. (2017) provide records on specimens that reach 500 cm. The specimen presented in our article is the largest ever caught in the northeastern Levantine Sea to date. It is also one of the largest specimens, approaching the alleged 500 cm maximum TL, that have ever been caught in the entire Mediterranean Sea. According to Ebert and Stehmann (2013), females mature between 332 and 356 cm TL; thus, the present specimen is considered a mature female.

Tab. 2: An overview of the records of* A. superciliosus *from Turkish waters. GN: gill net; SN: shrimp net; PS: purse seine; TN: trammel net; SN: stationary net; BT: bottom trawl; LL: longline; PSLL: pelagic swordfish longline.
Tab. 2: Pregled zapisov o pojavljanju vrste* A. superciliosus *v turških vodah. GN: zabodna mreža; SN: mreža za kozice; PS: zaporna plavarica; TN: trislojna mreža; SN: stoječa mreža; BT: pridnena povlečna mreža; LL: parangal; PSLL: parangal za mečarice.

No	**Authors**	**Date**	**Depth (m)**	**Locality**	**Region**	**Gear**	**Sex**	**Length** (cm, TL)	**Weight** (Kg)
1	Clo *et al.* (2008)	April 2005	-	Marmaris	SE Aegean Sea	GN	-	350	160
2	Mater (2005)	23 May 2005	12	Gökova	SE Aegean Sea	SN	-	350	150
3	Kabasakal & Karhan (2008)	25 February 2007	-	Silivri	Marmara Sea	PS	-	450	-
4	Kabasakal *et al.* (2011)	28 February 2011	110	Fethiye	SE Aegean Sea	TN	♀	430	300
5	Kabasakal *et al.* (2011)	2 July 2011	-	Silivri	Marmara Sea	PS	♀	250	65
6	Lanteri *et al.* (2017)	25 February 2013	-	-	Marmara Sea	-	-	370	250
7	Lanteri *et al.* (2017)	13 March 2013	-	Yeşilköy	Marmara Sea	-	-	200	110
8	Lanteri *et al.* (2017)	15 July 2013	-	Yediburunlar	SE Aegean Sea	-	-	500	95
9	Lanteri *et al.* (2017)	15 April 2015	-	Antalya	Mediterranean Sea	-	-	-	-
10	Kabasakal *et al.* (2011)	21 May 2016	100	Sivrice	NE Aegean Sea	SN	♀	400	-
11-12	Gökoglu *et al.* (2017)	March, April and July 2015	600-700	Antalya	Mediterranean Sea	BT, LL	♀,♂	180-299	15.5-65
13	Kabasakal (2017)	22 December 2016	-	Antalya Bay	Mediterranean Sea	PSLL	♀	342.4	-
14	Ayas *et al.* (2020)	02 January 2020	25	Taşucu	Mediterranean Sea	TN	♀	240	48
15	Present specimen	09 April 2019	20	Keldağ, Çevlik Coast	Mediterranean Sea	PS	♀	472	400

Fig. 3: Front (A) and lateral (B) views of the examined* A. superciliosus *(Photo: D. Ergüden archive).
Sl. 3: Pogled od spredaj (A) in od strani (B) pregledanega primerka vrste* A. superciliosus *(Foto: D. Ergüden arhiv).

Fig. 4: Dentition on the upper and lower jaws of the examined *A. superciliosus* ***(Photo: D. Ergüden archive).***
Sl. 4: Zobovje na spodnji in spodnji čeljustnici pri pregledanem primerku vrste *A. superciliosus* ***(Foto: D. Ergüden arhiv).***

In the Mediterranean Sea, the bigeye thresher shark is considered occasional bycatch affected by interaction with pelagic fishing gear, as well as bottom trawls, longlines and entangling nets (Serena, 2005; Bariche, 2012). The previous IUCN category – "data deficient" - for *A. superciliosus* was recently changed to "endangered" for the Mediterranean Sea, and "vulnerable" worldwide (Otero *et al.,* 2019). *A. superciliosus* is a typical *k-selected* species, with the maximum litter size ranging from 2 to 4 embryos (Bariche, 2012). While the congeneric thresher shark, *A. vulpinus* is now listed as a protected species in the Turkish Marine Fisheries Act (Öztürk, 2018), a similar conservation status for the protection of *A. superciliosus* is urgently needed.

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POJAVLJANJE VELIKE VELIKOOKE MORSKE LISICE, *ALOPIAS SUPERCILIOSUS* (LAMNIFORMES: ALOPIIDAE), V SEVEROVZHODNEM LEVANTSKEM MORJU (ZALIV ISKENDERUN, VZHODNI MEDITERAN, TURČIJA)

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POVZETEK

Devetega aprila 2019 so ujeli samico velikooke morske lisice Alopias superciliosus *Lowe, 1841 v zaporno plavarico, na globini približno 20 m ob Çevliku v zalivu İskenderun Bay, v Turčiji. Gre za doslej največji primerek te vrste v severovzhodnem Levantskem morju in nasploh v Sredozemskem morju, saj je meril okoli 500 cm v dolžino. Njena sorodnica iz istega rodu, navadna morska lisica,* A. vulpinus, *je danes v turškem morskem ribolovnem aktu zavarovana vrsta, zato je nujno čimprej urediti podoben ohranitveni status tudi za vrsto* A. superciliosus.

Ključne besede: morska lisica, Alopiidae, obala pri Cevliku, Levantsko morje, ohranjanje, prilov

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THE OCCURRENCE AND STATUS OF THRESHER SHARK (*ALOPIAS VULPINUS*) IN WATERS OFF SLOVENIA

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ABSTRACT

The authors report data on common thresher sharks, Alopias vulpinus *(Bonnaterre, 1788) caught in Slovenian territorial waters. The sharks were captured largely during summer months, mainly August. Over the past five years three cases of immature sharks were recorded, which additionally confirms the fact that the area of northern Adriatic Sea is a nursery for thresher shark. The authors try to assess the current level of knowledge of thresher sharks based on older and recent landings and sightings of the species in the territorial waters of Slovenia.*

Key words: thresher shark, *Alopias vulpinus*, incidental catches, feeding habits, nursery, northern Adriatic

PRESENZA E STATO DELLO SQUALO VOLPE (*ALOPIAS VULPINUS*) IN ACQUE AL LARGO DELLA SLOVENIA

SINTESI

Gli autori riportano i dati sulle catture dello squalo volpe, Alopias vulpinus *(Bonnaterre, 1788), nelle acque territoriali slovene. Gli squali sono stati catturati soprattutto durante i mesi estivi, principalmente in agosto. Negli ultimi cinque anni sono stati registrati tre casi di squali immaturi, dato che inoltre conferma che l'Adriatico settentrionale è un area di riproduzione dello squalo volpe. Gli autori cercano di valutare l'attuale livello di conoscenza sugli squali volpe in base ai dati degli sbarchi e degli avvistamenti più vecchi e recenti della specie nelle acque territoriali della Slovenia.*

Parole chiave: squalo volpe, *Alopias vulpinus*, catture accidentali, abitudini alimentari, area di riproduzione, Adriatico settentrionale

INTRODUCTION

Thresher sharks (Alopiidae) are powerful large-sized pelagic sharks with an extremely long heterocercal tail. Two of them, the common thresher shark, *Alopias vulpinus* (Bonnaterre, 1788), and the bigeye thresher shark, *Alopias superciliosus* Lowe, 1841, are commonly recorded in the Mediterranean Sea. The common thresher shark is a mesopredator inhabiting temperate and subtropical waters (Compagno, 1984; Barrull & Mate, 2002; Gervelis & Natanson, 2013), widespread in the Atlantic, Pacific, and Indian Oceans, and in the Mediterranean. It is often associated with areas characterized by high biological productivity (Cartamil *et al.*, 2010). Young specimens mainly occur in shallow waters, whereas adults are more common over the continental shelf (Compagno *et al.*, 1989). At least one record of bigeye thresher shark (*A. superciliosus*) has been reported in the southern Adriatic to date (Madiraca *et al.,* 2015).

With regard to the abundance of common thresher shark in the Adriatic Sea in the past, the information is contrasting. Faber (1883), for example, reported that it was "general, but rare", while Brusina (1888) mentioned it was not rare. In more recent reports the common thresher shark is considered a regularly occurring species in the Adriatic Sea (Tortonese, 1956; Bini, 1967; Lipej *et al.,* 2004), especially in its northern part (Notarbartolo di Sciara & Bianchi, 1998; Lipej, 1999). However, recently published evidence seems to suggest that its population in the northern Adriatic Sea (Finotto *et al*., 2016) and other areas (Ferretti *et al.,* 2008) is facing a substantial decline.

Together with some other rare and large-sized sharks, the common thresher shark is among the least studied species in the Mediterranean Sea (Kabasakal & Kabasakal, 2004; Kabasakal, 2007; Dimarchopoulou *et al*., 2017; Mancusi *et al*., 2020, and others). One of the aims of this paper is therefore to present a survey of new and older data on the occurrence of thresher shark in the Slovenian sea and its adjacent areas, and discuss the recent status of this epipelagic mesopredator in the closer and broader Adriatic areas.

MATERIAL AND METHODS

On 10th August 2020 a small-sized thresher shark was captured in bottom trawl 4 Nm off Izola, between Cape Ronek (Izola) and Koper, at approximately 20 m depth on muddy bottom. The specimen was delivered to the fishing port of Izola, where it was measured and weighed. After the specimen was dissected, its stomach was isolated and stored in a deep freezer for a diet analysis. In the laboratory, the full stomach was weighed and its content washed through sieves. Prey specimens were isolated and cautiously measured to the nearest 0.01 mm with a calliper and weighed (wet weight) to the nearest 0.01 g using a Sartorius TE 1502S balance. Two weeks later, on 24th August 2020, another immature specimen was caught 3 Nm out off Izola. Of that, however, we were only able to obtain a photograph and data on the main body dimensions and weight provided by the fisherman who captured it. Both specimens were sold for human consumption.

Nowadays, a valuable source of data is information shared through modern technology tools, such as the internet and the social media, which complete the traditional knowledge of the fishermen (*sensu* Raicevich *et al*., 2010). We tried to collect all data published in the newspapers and on social media sites about thresher sharks in the territorial waters of Slovenia from 1900 to 2020. We also checked the available databases on fish landings of the Bios web (www.biosweb.org) of the Fisheries Research Institute of Slovenia (Bolje *et al.,* 2020).

RESULTS AND DISCUSSION

The two specimens caught in 2020 were identified as *A. vulpinus* on the basis of the following diagnostic characters (Compagno, 1984): head broad with short snout, forehead strongly arched, flanks above pectoral bases marked with a conspicuous white patch extending forwards from the abdominal area, no deep horizontal grooves on either side of the nape (typical of *A. superciliosus*), eyes not reaching the dorsal surface of the head.

Tab. 1: Biometric parameters of the immature specimen caught in the waters off Ronek on 10th August 2020.
Tab. 1: Biometrični parametri mladostnega primerka, ujetega pri rtu Ronek 10. avgusta 2020.

Biometric parameter	mm/kg
Fork length (mm)	1024
Prepectoral length	243
Prebranchial length	199
Preorbital length	43
Predorsal length	484
Prepelvic length	697
Precaudal length	982
Upper caudal lobe	836
Total length	1860
Eye diameter	25
Weight	30 kg

Fig. 1: Adult specimens of thresher shark (*Alopias vulpinus*) caught in Slovenian territorial waters. Legend: a – a 450 cm long specimen caught on 23rd September 1996 (Photo: B. Šuligoj), b – a 430 cm long specimen caught near Lazaret on 31st December 1997 (Photo: B. Šuligoj), c – a 350 cm long specimen caught on 19th August 2010 in the waters off Izola (Photo: L. Lipej), and d – a 370 cm long specimen caught on 25th May 2004 (Photo: L. Lipej).

Sl. 1: Odrasli primerki navadne morske lisice (*Alopias vulpinus*), ujeti v slovenskih teritorijalnih vodah. Legenda: a – 450 cm dolg primerek, ujet 23. septembra 1996 (Foto: B. Šuligoj), b – 430 cm dolg primerek, ujet blizu Lazareta 31. decembra 1997 (Foto: B. Šuligoj), c – 350 cm dolg primerek, ujet 19. avgusta 2010 v vodah blizu Izole (Foto: L. Lipej), in d – 370 cm dolg primerek, ujet 25. maja 2004 (Foto: L. Lipej).

The first specimen was an immature male with a total length of 186 cm, weighing approximately 30 kg (Tab. 1). The second specimen caught was of a similar size and weighed 30 kg. We were unable to determine its sex from the photograph alone.

The analysis of the stomach content showed the presence of three small pelagic fish species, in vast majority (80.7% in terms of numerical abundance N% and 74.9% in terms of biomass B%) pilchard (*Sardina pilchardus*), the rest were anchovy (*Engraulis encrasicolus*) (N% = 15.8 and B% = 22.7) and Atlantic horse mackerel (*Trachurus trachurus*) (N% = 3.5 and B% = 2.3; Tab. 2). Only a few diet studies have been performed to date, but according to the available information the thresher shark preys mainly on small pelagic fish such as anchovies, sardines, mackerels and cephalopods (Young *et al.,* 2015). The thresher shark is often recorded together with large schools of small pelagic fish (Preti *et al.*, 2001), on which it feeds close to the surface, stunning them with its tail-slaps (Aalbers *et al.*, 2010). Finotto *et al.* (2016) stated that the presence of thresher shark in the northern Adriatic Sea is positively correlated with the abundance of the species' preferred prey in the area, the European sardine.

Tab. 2: The stomach content of the immature thresher shark specimen caught on 10th August 2020. Legend: N – number of specimens of a particular prey species, B – biomass of all weighed specimens of a particular species, N% and B% relative abundance and biomass, respectively.

Tab. 2: Vsebina želodca mladostnega primerka morske lisice, ujetega 10. avgusta 2020. Legenda: N – število primerkov posamezne vrste plena, B – biomasa primerkov posamezne vrste plena, N% in B% relativna abundanca in relativna biomasa plena.

Species	**N**	**N%**	**B**	**B%**
Trachurus trachurus	2.0	3.5	8.1	2.3
Sardina pilchardus	46.0	80.7	258.3	74.9
Engraulis encrasicholus	9.0	15.8	78.3	22.7
sum	**57**	**100**	**344.7**	**100**

In the summer months of 2020, adult common thresher sharks were also sighted in the adjacent Italian waters of the Gulf of Trieste. In July 2020 a 400 cm long shark was caught and filmed near Trieste and subsequently released (Anonymous, 2020). In the very same period (19th July 2020) another specimen of common thresher shark, estimated at approximately 300 cm fork length, was captured and subsequently released in the waters of the Quarnaro archipelago in Croatia (Tomljanović, 2020).

Checking the published data in newspapers, web sites and the social media 10 reports were found regarding thresher sharks in Slovenian waters in the past thirty years. If we also take into account the two immatures from 2020, we have 12 records of common thresher sharks in total (Tab. 3). The great majority of the reported sharks were adults, measuring from 350 cm to 500 cm in total length (Fig. 1). Most of the recorded thresher sharks were captured or sighted during the months of August and September, which corresponds well with seasonality recorded by Finotto *et al.* (2016) for the Italian part of the northern Adriatic Sea. Generally, much larger thresher sharks would be reported from Slovenian waters. Apart from the common thresher sharks recorded in August 2020, only one specimen, captured on 18th August 2015, was small, reaching 150 cm in total length.

During the last five years the Statistical Office of the Republic of Slovenia reported on landings of thresher sharks every year except 2016. The biomass reported in 2015 was 6.5 kg, which fits well with the small-sized specimen mentioned above. According to the length *vs* age relationship examined in age and growth studies by many authors (Cailliet *et al.,* 1983; Mendizabal & Oryza, 1995; Smith *et al.*, 2008; Gervelis & Natanson, 2013) the specimens with a fork length of approximately 100 cm could be considered as 1 to 2 years old and the one shorter than 100 cm as less than one year old. Pups at birth measure approximately 60 to 70 cm in fork length (Cartamil *et al.* 2010). According to the von Bertalanffy growth model, the estimated size at birth of common thresher shark is between 114 and 156 cm total length (Bigelow & Schroeder, 1948; Compagno, 1984; Moreno *et al.*, 1989). Thus, the specimen caught in August 2015 could be regarded as a neonate thresher shark (Fig. 2).

The Gulf of Trieste and the northern Adriatic Sea may act as a nursery area for certain elasmobranch species, as was previously already pointed out by several researchers (*e.g.* Notarbartolo di Sciara & Bianchi, 1998; Jardas *et al.*, 2008; Fortuna *et al.,* 2010). A nursery area is an environment where juvenile sharks and other elasmobranchs are supported by available food and reduced predation (Cartamil *et al.,* 2010). The area is productive, diversified in terms of habitat, and rather shallow (less than 30 m of depth). We have collected many neonates and immature elasmobranchs in the Gulf of Trieste that were captured as bycatch. Neonate specimens of sandbar shark (*Carcharhinus plumbeus* (Lipej *et al.,* 2000, 2008)), smoothhound (*Mustelus mustelus*), punctulated smoothhound (*Mustelus punctulatus*), pelagic stingray (*Pteroplatytrygon violacea*), starry skate (*Raja asterias*), marbled electric ray (*Torpedo marmorata*) and others were recorded in Slovenian coastal sea (*unpublished data*). Many blue sharks (*Prionace glauca*) less than 80 cm in total length have been caught as bycatch in the area. As for the adjacent regions, Fortuna *et al.* (2010) reported 13 common thresher sharks that were caught in the period between July 2006 and December 2008, 10 in the Veneto region and 3 in the Emilia Romagna region.

Many authors point out the fact that nowadays large sharks seem to be restricted to the eastern and southern Mediterranean Sea (Sperone *et al.,* 2012). Barausse *et al.* (2014) considered the common thresher shark and other large-sized shark meso-

Fig. 2: Immature specimens of thresher shark (*Alopias vulpinus*) caught in Slovenian territorial waters. Legend: a – immature specimen caught on 18th August 2015 (Photo: S. Radin), b – immature specimen caught on 10th August 2020 (Photo: J. Francé), and c – immature specimen caught on 24th August 2020 (Photo: I. Virant).

Sl. 2: Mladostni primerki navadne morske lisice (*Alopias vulpinus*), ujeti v slovenskih teritorialnih vodah. Legenda: a – mladostni primerek, ujet 18. avgusta 2015 (Foto: S. Radin), b – mladostni primerek, ujet 10. avgusta 2020 (Foto: J. Francé), in c – mladostni primerek, ujet 24. avgusta 2020 (Foto: I. Virant).

predators to have been largely depleted even before 1945 in the western part of the northern Adriatic Sea due to intensive exploitation. The study on the occurrence of thresher shark in the northern Adriatic Sea based on landings data (Finotto *et al.*, 2016) suggests the main cause of the decline of common thresher sharks to be their mortality in commercial target and bycatch fisheries. In addition, the majority of the specimens caught were juveniles (app. 90 %) and many of them weighed less than 10 kg (Finotto *et al.,* 2016). According to Moreno *et al.* (1989) this size is close to their size at birth. Hattour & Nakamura (2004) reported that small-scale fishery in Tunisian waters was targeting neonate specimens of thresher shark. Finotto *et al.* (2016) considered food availability to be a strong driver of the presence of *A. vulpinus* in the northern Adriatic Sea.

The data on thresher shark in Slovenian marine waters, provided from different sources, show that the species is still present at least in summer months; however, there is a substantial lack of knowledge regarding basic data. Although the available data are mostly related to adult thresher sharks, they also include records of immature specimens and, in one case, a neonate. The rapid decline of common thresher shark during the last 75 years in the northern Adriatic Sea as reported by Finotto *et al.* (2016) is calling for urgent conservation measures. The common thresher shark is, like the majority of sharks and other elasmobranchs, a typical K-selected species, characterised by a slow population growth and long generation time. The species is nowadays listed on the IUCN Red List of Threatened Species as "vulnerable" to global extinction (Goldman *et al.*, 2007). The national Red List of marine fishes of Croatia (Jardas *et al.*, 2008) also defines the status of common thresher shark as "vulnerable". In Italy, A. vulpinus has markedly decreased in abundance and is considered "critically endangered" (Rondinini *et al.*, 2013). In the Act on Protected Animal Species of Slovenia, the common thresher shark is not mentioned.

To date, no attempts have been made in the northern Adriatic Sea to prepare some conservation measures to reduce the fishing mortality. An immediate release of the still living captured shark specimens should become a practice. Since many arguments point out the importance of the northern Adriatic Sea as a nursery area for thresher shark and many other elasmobranch species, the countries sharing the northern Adriatic should adopt suitable legal acts and efficient conservation instruments for their protection. One of the first promising measures regarding thresher shark conservation at a national level would be a complete ban on its fishing in Slovenian waters. As this species is only caught as bycatch and captures are rare and as such not

Tab. 3: Documented evidence of the occurrence of thresher shark in Slovenian waters during the past 25 years.
Tab. 3: Dokumentirani primeri pojavljanja morske lisice v slovenskih vodah v zadnjih petindvajsetih letih.

n	date	locus	record	sex	TL (cm)	Weight (kg)	Photo/Source
1	20 Aug 1995	Slovenian marine waters	Caught	?	400	194	Dulčić & Lipej, 2002
2	22 Aug 1995	Bay of Piran	Sighted	?	400	?	Newspaper Delo
3	15 Sep 1995	Cape Ronek (near Izola)	Caught	?	500	300	Dulčić & Lipej, 2002
4	24 Sep 1996	Fiesa	Caught	?	450	300	Fig 1/a; Dulčić & Lipej, 2002
5	31 Dec 1997	Lazaret	Caught	?	430	230	Fig. 1/b; Dulčić & Lipej, 2002
6	25 Aug 2001	Bay of Piran, Slovenian waters	Caught	?	430	270	Dulčić & Lipej, 2002
7	2 Jan 1998	Lazaret (Koper)	Caught	?	430	200	Newspaper Delo
8	26 May 2004	Bay of Piran	Caught	?	370	200	Fig 1/d; Newspaper Delo
9	19 Aug 2010	Gulf of Trieste, off Izola	Caught	?	350	155	Fig 1/c; Newspaper Delo
10	18 Aug 2015	3 Nm, Slovenian waters	Caught	?	150	6.5	Fig 2/a; Biosweb, M. Radin
11	10 Aug 2020	Cape Ronek (Izola)	Caught	M	186	30	Fig 2/b; This work
12	24 Aug 2020	3 Nm off Izola	Caught	M	187	30	Fig 2/c; This work

financially important, a management strategy based on the release of the still living specimens should be developed.

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POJAVLJANJE IN STATUS NAVADNIH MORSKIH LISIC (*ALOPIAS VULPINUS*) V VODAH SLOVENIJE

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POVZETEK

Avtorji poročajo o pojavljanju navadne morske lisice (Alopias vulpinus) *na podlagi ribiških ulovov v slovenskih teritorijalnih vodah. Morske lisice so bile ulovljene praviloma v poletnih mesecih, predvsem avgusta. V zadnjem petletju so se v ribiške mreže zapletli trije mladostni primerki, ki še dodatno potrjujejo dejstvo, da je Severni Jadran razmnoževalno okolje navadne morske lisice. Avtorji nadalje poskušajo oceniti poznavanje stanja navadnih morskih lisic v slovenskem morju na podlagi razpoložljivih recentnih in starejših podatkov.*

Ključne besede: morska lisica, naključni ulov, prehranjevalne navade, jaslice, Severni Jadran

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FIRST RECORD OF A YOUNG-OF-THE-YEAR *CARCHARODON CARCHARIAS* IN THE STRAIT OF THE DARDANELLES

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ABSTRACT

On 8 June 2020, a young-of-the-year (YOY) white shark, Carcharodon carcharias *(Linnaeus, 1758), measuring 155 cm total length, was incidentally gillnetted off the Kumkale coast, at the southern end of the Dardanelles. The captures of this and other specimens highlight the potential importance of the northeastern Aegean Sea as a nursery grounds for the species.*

Key words: white shark, nursery ground, young-of-the-year, Aegean Sea

PRIMA SEGNALAZIONE DI UN ESEMPLARE DI ETÀ INFERIORE A UN ANNO DI *CARCHARODON CARCHARIAS* NELLO STRETTO DEI DARDANELLI

SINTESI

L'8 giugno 2020, uno squalo bianco di età inferiore a un anno, Carcharodon carcharias *(Linnaeus, 1758), che misurava 155 cm di lunghezza totale, è stato accidentalmente catturato con reti da posta al largo della costa di Kumkale, all'estremità meridionale dei Dardanelli. Le catture di questo e altri esemplari evidenziano l'importanza potenziale del mar Egeo nord-orientale come area di riproduzione per la specie.*

Parole chiave: squalo bianco, area di riproduzione, giovane dell'anno, mar Egeo

INTRODUCTION

Limited information is available on the reproductive biology of the white shark, *Carcharodon carcharias* (Linnaeus, 1758) (Lamniformes: Lamnidae), because of its elusive character and long-distance movements across its global distribution ranges (Huveneers *et al.*, 2018). Due to its large size, high media profile, dramatic interactions with humans, and charismatic nature, the large white shark has long attracted remarkable public attention; however, encounters or captures of young-of-the-year (YOY) and juvenile white sharks also provide valuable data for researchers, as they may inform on the locations of parturition and nursery grounds.

Whilst *C. carcharias* is listed as globally vulnerable (Rigby *et al.*, 2019), it is categorised as critically endangered in the Mediterranean Sea (Soldo *et al.*, 2016; Otero *et al.*, 2019), highlighting that an improved knowledge of the species is required in this area. Due to the occurrence of YOY specimens, De Maddalena & Heim (2012) and, more recently,

Fig. 1: Present YOY white shark, incidentally captured off Kumkale coast, in the southern Dardanelles. (A) dorsolateral view, (B) ventral view, (C) close-up of the mouth and dentition highlighting triangular teeth, and (D) caudal view showing keels and anal fin. (Photo: E. Bayrı).
Sl. 1: Primerek prvoletnega mladiča, ki je bil naključno ujet ob obali Kumkale v južnem delu dardanelske ožine. (A) dorzolateralni pogled, (B) pogled s trebušne strani, (C) bližinski posnetek ust in trikotnega zobovja in (D) pogled na repni del z očitnimi gredlji in podrepno plavutjo. (Foto: E. Bayri = skopirati iz angleškega)

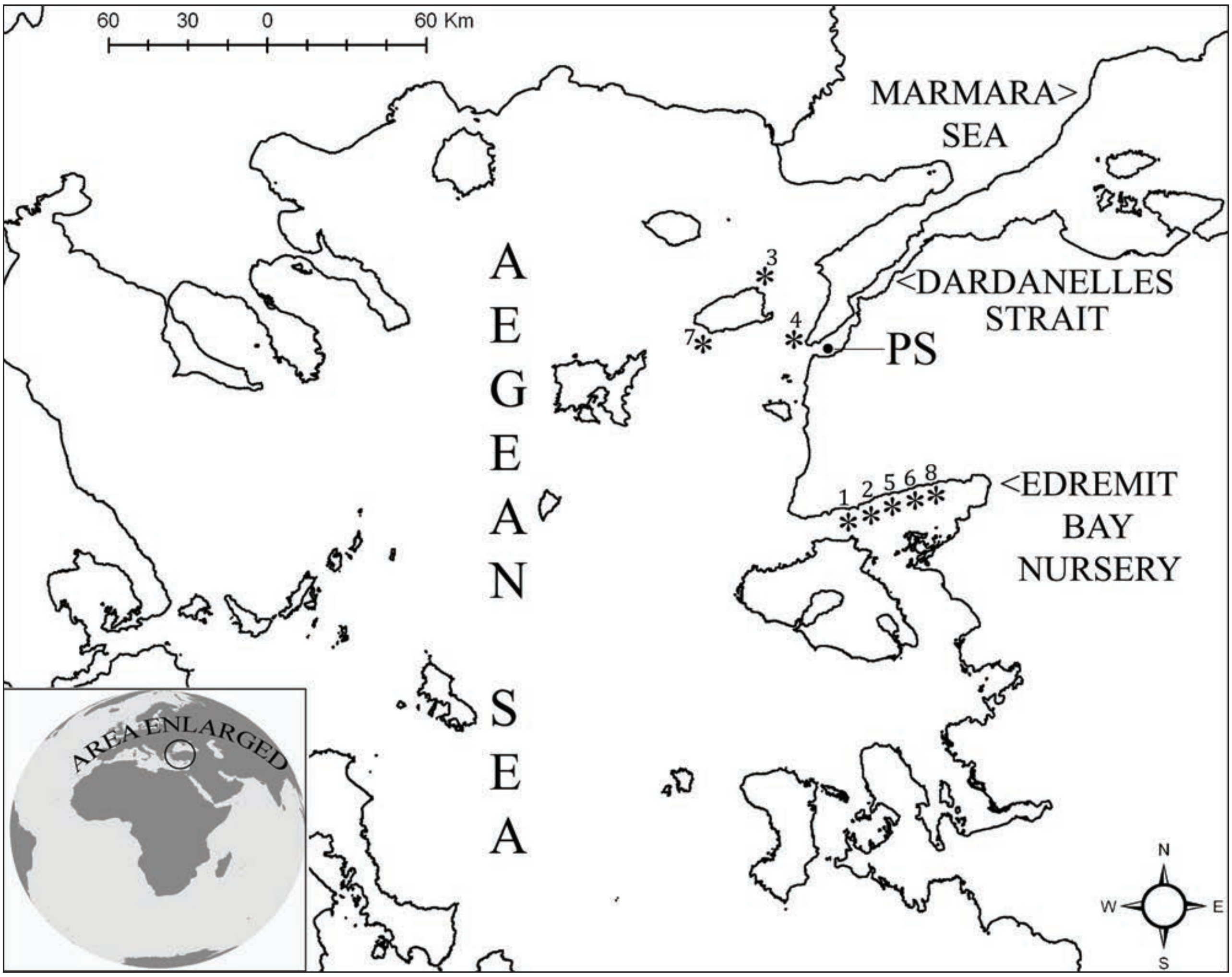

Fig. 2: Map depicting the approximate capture localities of previous specimens (⁎) and of the present (PS) white shark YOY. The numbers are the same as in the 'No.' column of Table 2.
Sl. 2: Zemljevid obravnavanega območja z označenimi približnimi lokacijami predhodnih primerkov (⁎) in obravnavanega prvoletnega primerka (PS). Številke so identične tistim iz Tabele 2.

Boldrocchi *et al*. (2017) emphasized that the Sicilian Channel could serve as a nursery ground for white shark in the central Mediterranean Sea. The incidental captures of two new-born white sharks between late spring and mid-summer 2008 in the waters of Edremit Bay (Turkey) (Kabasakal & Gedikoğlu, 2008), and the subsequent occurrences of further YOY and juveniles in the same area (Kabasakal *et al*., 2018), suggest that the northeastern Aegean Sea could also serve as a nursery ground for *C. carcharias* in the Mediterranean.

Given that *C. carcharias* is considered critically endangered in the Mediterranean (Soldo *et al*., 2016; Otero *et al*., 2019), the examination and reporting of any incidentally captured specimens can provide important data, which are generally only collected on an opportunistic basis (Jessup, 2003). In the present article, the authors report on the first record of a YOY white shark from the southern entrance to the Dardanelles (the strait connecting the Aegean Sea to the Sea of Marmara), and provide morphometric measurements as well.

MATERIAL AND METHODS

The present specimen of *C. carcharias* was incidentally caught in gill net on 8 June 2020. Morphometric measurements, following Compagno (2001), were recorded, and photographs were taken on site by the second author. Total length and other measurements were performed by means of a tape measure, with the specimen laid on the flat ground laterally and the caudal fin placed in natural position (Compagno, 2001). Species identification followed

Compagno (2001) and Ebert & Stehmann (2013). The YOY and juvenile white sharks were identified using the following length categories (Boldrocchi *et al.*, 2017): YOY ≦1.75 m total length (TL), and juveniles >1.75-3.0 m TL.

RESULTS AND DISCUSSION

The present specimen of a YOY white shark (Fig. 1) was incidentally captured in a gill net off the coast of Kumkale, at the southern entrance to the Dardanelles (Fig. 2). The following descriptive characters, which were in agreement with the descriptions by Compagno (2001) and Ebert & Stehmann (2013), were observed on the examined fresh specimen, allowing the authors to identify it as *C. carcharias*: stout, spindle-shaped body with conical snout (Fig. 1a, b, c); mouth broadly rounded, large triangular teeth with serrated edges (Fig. 1b, c); origin of the first dorsal fin above the pectoral inner margin (Fig. 1a); strong keels on the caudal peduncle (Fig. 1c). Unlike in adult specimens, the apex of the first dorsal fin in the YOY specimen was more rounded (Fig. 1a), coinciding with the morphology of the smallest free-living white sharks (Santana-Morales *et al.*, 2020). The dorsal colouration was dark grey, the ventral surface white, the tips of the pectoral fins with black blotches (ventrally), and the anal fin white (Fig. 1a, c, d). No umbilical scar was observed on the belly of the examined specimen. The morphometric measurements of the examined specimen are given in Table 1.

The occurrence of new-born and YOY white sharks in the coastal waters of the northeastern Aegean Sea was documented over ten years ago (Kabasakal & Gedikoğlu, 2008), with the account providing detailed descriptions and morphometrics for new-born *C. carcharias* from Edremit Bay. Further new-born, YOY and juvenile white sharks have since been incidentally captured in this area (see Table 2 for capture details and biological information).

While all of these previous YOY specimens from the Aegean Sea were reported from outside the Dardanelles (Fig. 2), the present specimen was incidentally captured at the southern entrance to this strait that leads to the Sea of Marmara. This raises the question of whether the present YOY white shark was born in the northeastern Aegean or whether it is indicative of a link to the Sea of Marmara. Although white shark historically occurred in the Sea of Marmara (Kabasakal, 2003; Boldrocchi *et al.*, 2017), *C. carcharias* is thought to have disappeared from that area following the local depletion of bluefin tuna *Thunnus thynnus* (Linnaeus, 1758), with the last confirmed record dating from 1985 (Kabasakal, 2016). Interestingly, Boldrocchi *et al.* (2017) noted that juvenile *C. carcharias* had not been recorded from

Tab. 1: Morphometric measurements of the present young-of-the-year white shark, *C. carcharias.* ***The abbreviations in parentheses follow those given by Compagno (2001).***
Tab. 1: Morfometrične meritve prvoletnega mladiča belega morskega volka, *C. carcharias.* ***Okrajšave v oklepaju so povzete po Compagno (2001).***

Morphometric measurement	**Value (cm)**	**% of TL**
Total length (TL)	155	-
Fork length (FL)	133	86
Precaudal length (PCL)	121.5	78
Presecond dorsal fin length (PCL)	101.5	65
Head length (HDL)	37	24
Prebranchial length (PG1)	28	18
Interdorsal space (IDS)	34	22
Dorsal-caudal fin space (DCS)	17	11
Prespiracular length (PSP)	14	9
Preorbital length (POB)	10	6
Prepectoral fin length (PP1)	36	23
Prepelvic fin length (PP2)	80	52
Snout-ventral length (SVL)	86	55
Preanal fin length (PAL)	105	68
Ventral-caudal fin length (VCL)	46	30
Pelvic fin-anal fin space (PAS)	17	11
Anal fin-caudal fin space (ACS)	15	10
Pelvic fin-caudal fin space (PCA)	29	19
Pectoral fin-pelvic fin space (PPS)	37	24
Prenarial length (PRN)	5.8	4
Preoral length (POR)	10	6
Eye length (EYL)	2	1
Eye height (EYH)	2	1
First gill slit height (GS1)	6	4
Intergill length (ING)	12	8
Fifth gill slit height (GS5)	12	8
Pectoral fin radial length (PIR)	19	12
Pectoral fin anterior margin (PIA)	30	19
Pectoral fin length (P1L)	7	5
Pectoral fin inner margin (P1I)	24	15
Pectoral fin posterior margin (P1P)	21	14
Pectoral fin height (P1H)	26	17

Tab. 2: Capture data and relevant references of the young-of-the-year and juvenile white sharks, *C. carcharias*, ***caught in the previous years and of the YOY examined in the present study, in chronological order. The numbers in the 'No.' column match those marked by an asterisks (*) in Figure 2. PS: present specimen.***

Tab. 2: Datumi ulova in pomembni viri prvoletnih in juvenilnih primerkov belega morskega volka, *C. carcharias*, ***ujetih v preteklih letih, upoštevaje tudi prvoletni primerek iz pričujoče raziskave, nanizani po kronološkem redosledu. Številke v prvem stolpcu se navezujejo na primerke, označene z zvezdico (*) v sliki 2. PS: pričujoči primerek.***

No	Date	Locality	TL (cm)	W (kg)	Gear	References
1	1 July 2008	Altınoluk	125,5	-	Gill-net	Kabasakal and Gedikoğlu (2008)
2	4 July 2008	Altınoluk	145	-	Gill-net	Kabasakal and Gedikoğlu (2008)
3	21 February 2009	Gökçeada	180	47.5	Bottom-trawl	Kabasakal *et al.* (2009)
4	15 April 2009	Çanakkale	300	102	Purse-seine	Kabasakal *et al.* (2009)
5	6 July 2011	Altınoluk	85		Trammel-net	Kabasakal (2014)
6	2 January 2016	Altınoluk	175	-	Trammel-net	Kabasakal *et al.* (2018)
7	January 2017	Gökçeada	180	-	Trammel-net	(H. Kabasakal, pers. obs.)
8	April 2017	Altınoluk	160	-	Gill-net	(H. Kabasakal, pers. obs.)
PS	8 June 2020	Kumkale	155	-	Gill-net	Unpublished data

the Sea of Marmara either. Consequently, whilst the present record of a YOY white shark in the southern Dardanelles further supports the possibility of a nursery ground for the species in the northeastern Mediterranean, it may also be a sign that the species is beginning to recolonise its former habitat in the vicinity of the Sea of Marmara.

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PRVI ZAPIS O POJAVLJANJU PRVOLETNEGA BELEGA MORSKEGA VOLKA (*CARCHARODON CARCHARIAS)* V DARDANELSKI OŽINI

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POVZETEK

Osmega junija 2020 je bil blizu obale Kumkale na južnem koncu dardanelske ožine naključno ujet v zabodno mrežo prvoletni mladič (YOY) belega morskega volka, Carcharodon carcharias *(Linnaeus, 1758), ki je meril 155 cm v dolžino. Ulov tega in drugih primerkov te vrste potrjuje, da predstavlja severovzhodno Egejsko morje jaslice za to vrsto.*

Ključne besede: beli morski volk, jaslice, prvioletni mladič, Egejsko morje.

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REPORT ON A GREAT WHITE SHARK *CARCHARODON CARCHARIAS* OBSERVED OFF LAMPEDUSA, ITALY

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ABSTRACT

A female great white shark (Carcharodon carcharias) *estimated at 500 cm was observed on 23 May 2020 near Lampedusa, in the Pelagie Islands, Italy. This record is of special relevance given the importance of the Strait of Sicily as a parturition ground and nursery area for this species, which is classified as critically endangered in the Mediterranean Sea by the International Union for Conservation of Nature (IUCN).*

Key words: great white shark, *Carcharodon carcharias*, Lampedusa, Italy, Mediterranean Sea

SEGNALAZIONE DI UNO SQUALO BIANCO *CARCHARODON CARCHARIAS* OSSERVATO AL LARGO DI LAMPEDUSA, ITALIA

SINTESI

Una femmina di squalo bianco (Carcharodon carcharias) *di lunghezza stimata pari a 500 cm, è stata osservata il 23 maggio 2020 presso Lampedusa, nelle Isole Pelagie, Italia. Tale caso è di particolare interesse a causa dell'importanza del Canale di Sicilia quale area di parto e di nursery per la specie che è classificata come in pericolo critico di estinzione nel mar Mediterraneo dall'Unione Internazionale per la Conservazione della Natura (IUCN).*

Parole chiave: squalo bianco, *Carcharodon carcharias*, Lampedusa, Italia, Mediterraneo

INTRODUCTION

Since 1996, the Italian Great White Shark Data Bank (Banca Dati Italiana Squalo Bianco) has collected a substantial amount of information regarding historical and recent records on the great white shark, *Carcharodon carcharias* (Linnaeus, 1758), from the Mediterranean Sea. This data include information on size, distribution, habitat, behaviour, reproduction, diet, fishery, and attacks on humans (De Maddalena, 2000a, 2000b, 2002, 2006; Celona *et al.*, 2001, 2006; De Maddalena & Heim, 2012; De Maddalena & Zuffa, 2009; De Maddalena *et al.*, 2001, 2003; Galaz & De Maddalena, 2004). An accurate recording of new observations of great white sharks in the Mediterranean area is a fundamental part of this ongoing research programme. Data on the presence of the species in the Mediterranean Sea have also been reported in recent years by Boldrocchi *et al*. (2017), Kabasakal (2014, 2016), Kabasakal & Gedikoğlu (2008), Kabasakal *et al.* (2018).

In the present article, we report the record of a large great white shark spotted in May 2020 by sport fishermen in the Pelagie Islands, in Italian Mediterranean waters.

MATERIAL AND METHODS

On the morning of 23 May 2020, three sport fishermen, Salvatore Sicurello and two friends, were aboard an 8 m long boat in the waters of Lampedusa Island, the Pelagie archipelago, Italy, in the Central Mediterranean Sea (Fig. 1). The anglers were fishing with *bolentino*, using strips of European flying squid, *Todarodes sagittatus* (Lamarck, 1798), as bait, without chum, and they caught some red porgies, *Pagrus pagrus* (Linnaeus, 1758). At 10:04 a.m., with a 5-6 kn wind and a calm sea, the dorsal fin of a shark was observed in 60-70 m deep blue waters, 10 nm south of the Lampedusa harbour. The shark was observed by the anglers for approximately 3 minutes. They were the only boat in the area at that moment. The shark showed no particular interest in the boat and, after swimming nearby, left the area. After the encounter, the three sport fishermen resumed fishing but moved to another site.

A short, 1:30 minute low-resolution video, filmed by Mr. Sicurello from the boat, was uploaded on a Facebook group, and brought public attention to this case. The video was later published by several Italian media (Stampa TV, 2020).

A higher resolution version of the video was provided by Mr. Sicurello to the authors, and was fundamental for identification purposes. A data collection form was sent by the authors to Mr. Sicurello, in order to collect detailed information on the observation.

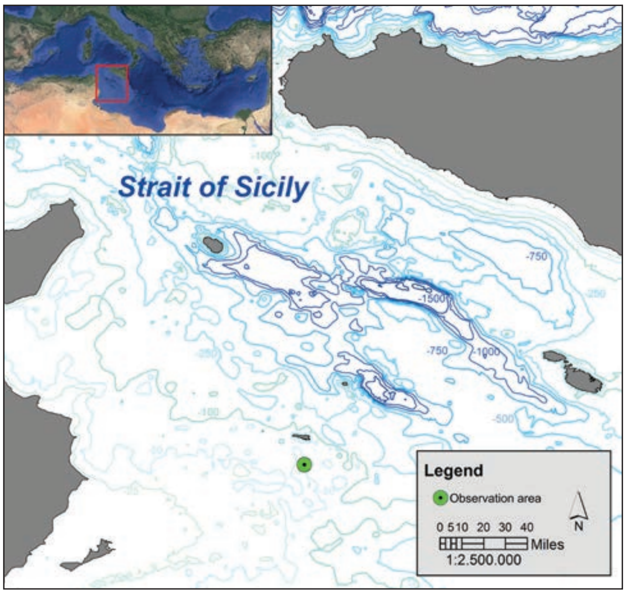

Fig. 1: Map showing the exact location where the female great white shark, *Carcharodon carcharias* ***(Linnaeus, 1758), estimated at 500 cm TL, was observed on 23 May 2020 (map created with ArcGis).***
Sl. 1: Zemljevid obravnavanega območja (v ArcGis) z označbo lokalitete, kjer je bila 23. maja 2020 opažena približno 500 cm dolga samica belega morskega volka *(Carcharodon carcharias* ***(Linnaeus, 1758)).***

RESULTS AND DISCUSSION

Some evident morphological features of the animal, including brownish grey coloration, markedly spindle-shaped body, massive trunk, wide head, pointed conical snout, large and pointed dorsal fin with irregular posterior margin, long and wide pectoral fins, wide caudal keels, long gill slits, lunate caudal fin, presence of black spot at the pectoral fin insertion, white marks on pectoral fin, free rear tip, pelvic fins and caudal fin lower lobe (Fig. 2), allowed the authors to make an immediate identification of the shark as a great white shark, *Carcharodon carcharias* (Linnaeus, 1758).

Other typical features of the species, such as the large triangular serrated teeth and the black apex of the pectoral fin's ventral surface, could not be observed due to the fact that the video was filmed from the surface, and the shark never exposed the ventral surfaces to the observer. However, based on the observable features listed above we identified the species as *C. carcharias*.

The higher resolution version allowed a close observation of the pelvic area, including a glimpse of the pelvic fin's free rear tip, which revealed the absence of claspers. We could therefore conclude that the observed shark was a female.

Fig. 2: The female great white shark, *Carcharodon carcharias* ***(Linnaeus, 1758), estimated at 500 cm TL, observed near Lampedusa, the Pelagie Islands, Italy, on 23 May 2020 (stills from a video by Salvatore Sicurello).***

Sl. 2: Približno 500 cm dolga samica belega morskega volka *(Carcharodon carcharias* ***(Linnaeus, 1758)), opažena 23. maja 2020 blizu Lampeduse (Isole Pelagie, Italija) (slika dobljena iz videoposnetka, ki ga je posnel Salvatore Sicurello).***

The size of the shark was estimated by Mr. Sicurello at 500 cm total length (TL), based on the size of the 8-metre boat.

The encounter took place in the Strait of Sicily, between Italy and Tunisia, a well-known parturition ground and nursery area for newborn and juvenile white sharks (Cigala-Fulgosi, 1990; De Maddalena & Heim, 2012). Since female white sharks attain sexual maturity between 400 and 500 cm TL, and both mating and parturition tend to occur in spring and summer (Compagno, 2001; Francis, 1996), we can assume that the female shark observed near Lampedusa was sexually mature, and speculate that perhaps its presence in the area may be related to mating or parturition. No mating scar is observable in the video, but this may be due to the relatively low resolution of the images, and should not eliminate the possibility of sexual maturity and potential sexual activity.

Great white sharks have long sexual maturation times, low fecundity, long gestation periods, and produce small numbers of young, which makes them highly vulnerable to over-exploitation (De Maddalena & Heim, 2012). Limited evidence indicates that great white sharks have few nursery areas, therefore even minimal fishing pressure in one of these pupping areas where pregnant females and newborns are concentrated, like the Strait of Sicily, can have devastating results. Great white sharks were, without a doubt, at one time much more abundant in the Mediterranean than they are presently, which could be the result of overfishing either the shark or its preys. A decrease of 45.88% in the number of great white shark records in the Mediterranean has been reported from the 1989-1998 decade to the 1999-2008 decade (De Maddalena & Heim, 2012). The observation of a potentially mature female in an important parturition ground presented herein is therefore a positive sign of the species' continuous vitality in the area. We also underline the importance of citizen science, public engagement, and social networks for the detection and observation of species of interest, including ecological observation of scientific relevance (Tiralongo *et al.*, 2019a, 2019b).

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ZAPIS O POJAVLJANJU BELEGA MORSKEGA VOLKA *CARCHARODON CARCHARIAS* PRI LAMPEDUSI, ITALIJA

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POVZETEK

Triindvajsetega marca 2020 so avtorji opazovali približno pet metrov dolgo samico belega morskega volka (Carcharodon carcharias) *blizu Lampeduse (Isole Pelagie, Italija). Ta zapis je še posebej pomemben, saj je Sicilski preliv razmnoževalno območje te vrste, ki je opredeljena kot kritično ogrožena v Sredozemskem morju po merilih Mednarodne zveze za ohranjanje narave (IUCN).*

Ključne besede: beli morski volk, *Carcharodon carcharias*, Lampedusa, Italija, Sredozemsko morje

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A LEUCISTIC WHITE SHARK, *CARCHARODON CARCHARIAS* (LAMNIFORMES: LAMNIDAE), FROM THE NORTHERN AEGEAN SEA, TURKEY

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ABSTRACT

On 14 June 2020, a leucistic white shark, Carcharodon carcharias *(Linnaeus, 1758), was sighted by two recreational fishermen in the waters of Saros Bay, off the coast of Enez. The eyes of the individual were dark pigmented. The apex of the sighted white shark was narrowly rounded and a broad unpigmented white area was seen extending from the base of the first dorsal fin to the belly. A whitish patch, covering a large part of the apex of the first dorsal fin was also present. As no case of leucism in white sharks has ever been registered before, this sighting represents the first report of leucism in white sharks.*

Key words: white shark, leucism, abnormality, pattern, Aegean Sea

SQUALO BIANCO LEUCISTICO, *CARCHARODON CARCHARIAS* (LAMNIFORMES: LAMNIDAE), NEL MAR EGEO SETTENTRIONALE, TURCHIA

SINTESI

Il 14 giugno 2020, uno squalo bianco leucistico, Carcharodon carcharias *(Linnaeus, 1758), è stato avvistato da due pescatori ricreativi nelle acque della baia di Saros, al largo della costa di Enez. Gli occhi dell'esemplare erano pigmentati di scuro. L'apice dello squalo bianco avvistato era strettamente arrotondato e si vedeva un'ampia area bianca non pigmentata che si estendeva dalla base della prima pinna dorsale al ventre. Era presente anche una macchia biancastra, che ricopriva gran parte dell'apice della prima pinna dorsale. Poiché nessun caso di leucismo negli squali bianchi è mai stato registrato prima, questo avvistamento rappresenta il primo rapporto di leucismo negli squali bianchi.*

Parole chiave: squalo bianco, leucismo, anomalia, modello, mar Egeo

INTRODUCTION

Leucism, a genetic disorder reported in mammals, reptiles, amphibians, teleosteans, and, since recently, in elasmobranchs, is associated with abnormal skin pigmentation (Bruckner & Coward, 2018). This term is suggested as a more apt description of previously reported colour aberrations in elasmobranchs (Clark, *2002)*. True albinos lack all dark body pigments and are devoid of eye coloration; leucism differs from true albinism in that it is characterized by a diminished or no body coloration, and darkly pigmented eyes (Clark, 2002; Veena *et al*., 2011). Although, Smale & Heemstra (1997; cited in Clark, 2002) reported true albinism in *Carcharodon carcharias* (Linnaeus, 1758), no case of leucism in white sharks has been reported previously. In the present article, the author reports on the first record of leucism in *C. carcharias*, based on a video footage recorded off the coast of Enez, in the northern Aegean Sea, Turkey.

MATERIAL AND METHODS

The sighting of a leucistic white shark, *C. carcharias,* was recorded by a boatman, Mr. Yunus Saç, and the video shot was posted on the websites of several local or national news portals, such as the 15 June 2020 issues of the internet news portals Hudut (Hudut, 2020), Milliyet (Milliyet, 2020) and Haber7 (Haber7, 2020). The web addresses of the surveyed news portals, in which the video footage and relevant the information on the present sighting of the leucistic white shark were made available, are given as electronic supplementary material in the references. The definition of leucism is based on Clark (2002). Species identification and taxonomic nomenclature follow Ebert and Stehmann (2013) and Otero *et al*. (2019). The captured images of the sighting are kept in the archive of the author and available on request for further inspection.

RESULTS AND DISCUSSION

On 14 June 2020, a leucistic white shark (Fig. 1), *C. carcharias,* was sighted by recreational fishermen, Mr. Yunus Saç and Mr. Aslan Cihan, while they were fishing in the waters of Saros Bay, off the coast of Enez (Fig. 2). According to the testimony of the fishermen, the water depth where the leucistic white shark occurred was 15 m, and the approximate locality of occurrence was nearly 2 km offshore. The length of the shark estimated to be 2 m; based on the length categories proposed by Boldrocchi *et al*. (2017; >1.75-3.0 m TL juvenile) it can thus be considered juvenile. A stout spindle-shaped body with a conical snout, a large erect first dorsal fin and minute second dorsal fin; strong keels on caudal peduncle; and large gill-slits revealed that the specimen was a white shark. The observed descriptive characters are parallel with the field marks given by Ebert and Stehmann (2013) and Otero *et al*. (2019). Since the available images show the white shark only from above and it was not possible to observe the pelvic region of the specimen, its sex remains unknown. The eyes of the shark were dark pigmented. The apex of the sighted white shark was narrowly rounded and a broad unpigmented white area was seen extending from the base of the first dorsal fin to the belly (Fig. 1). A whitish patch, covering a large part of the apex of the first dorsal fin was also present (Fig. 1).

In the De Maddalena and Heim book (2012), the authors present a very detailed description of the coloration of *C. carcharias*: "The dorsal coloration ranges from deep blue to lead grey to brownish gray to almost black along the back and is a little lighter along the sides. The coloration abruptly changes to snow white on the undersides, with no color pattern. An irregular boundary separates the dorsal dark coloration from the ventral white coloration (...) The dark dorsal coloration partially extends to the pelvic region by forming irregular patches. Newborn white sharks have a coloration that is very similar to that of the adults." The unpigmented white area of the observed individual is in contrast with the description by De Maddalena and Heim (2012). Since one of the main distinctions between leucism and true albinism is the red or pinkish coloration of the eyes in albinos, and dark pigmented eyes in leucistic animals (Clark, 2002; van Grouw, 2006), the sighted specimen was considered as a 'leucistic' white shark, since it exhibited dark pigmented eyes (Fig. 1b). Despite a single case of albinism reported in *C. carcharias* (Smale & Heemstra, 1997; cited in Clark, 2002), no confirmed case of albinism in white sharks has been reported in the Mediterranean (De Maddalena & Heim, 2012). Furthermore, no case of leucism in white sharks has been reported, either. Thus, the present sighting is the first case of leucism in white sharks reported to date. So far, only 5 cases of leucism in elasmobranchs have been reported, of which only one was originally reported as albinism (see Clarke, 2002, for relevant references and species). According to Gervais *et al.* (2016), atypical pigmentation in animals has been related to genetic alterations in melanin production, inbreeding within isolated populations, environmental stress associated with areas of high human activity, and exposure to elevated temperatures. Since Mediterranean white sharks are considered as belonging to an isolated 'sink' population with little or no contemporary immigration from the closer Atlantic (Gubili *et al*., 2010), the sighting of the present leucistic white shark can provide further evidence highlighting the genetic vulnerability of *C. carcharias* in the Mediterranean Sea.

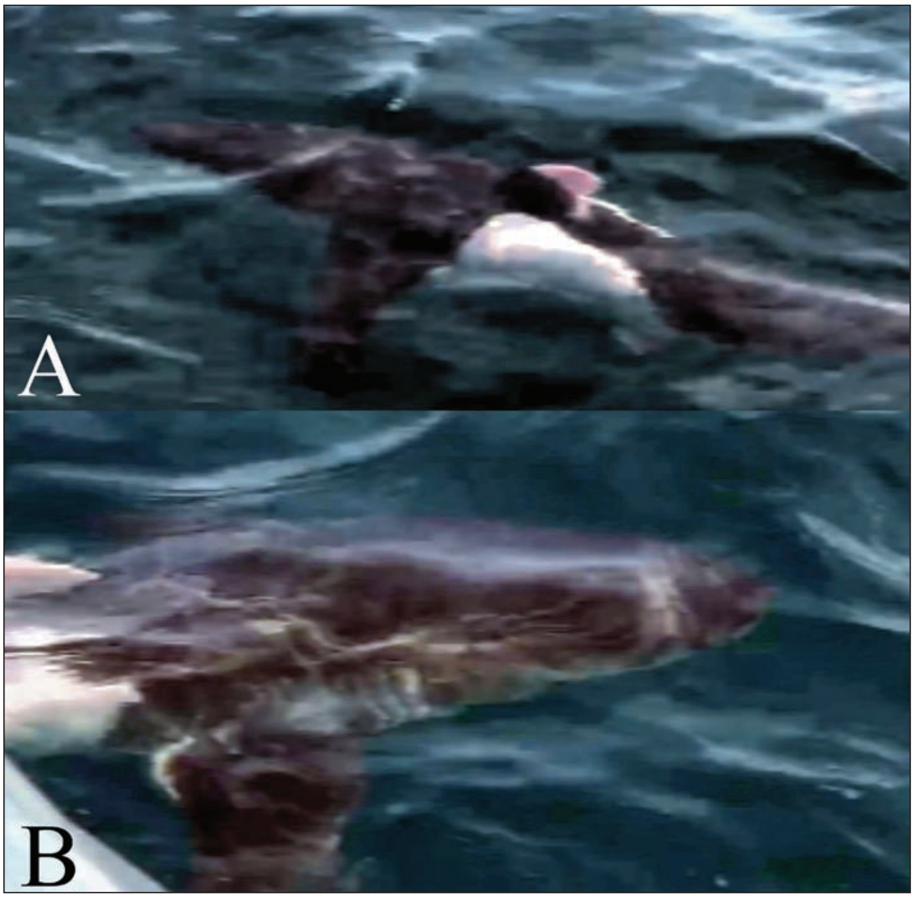

Fig. 1: Images captured from the video footage of the leucistic white shark (ca. 2 m of TL) sighted in the waters of Saros Bay, Turkey; lateral view (A) and head view (B) of the specimen (Photo: H. Kabasakal archive).
Sl. 1: Fotografija iz video posnetka o beličnem primerku belega morskega volka (pribl. 2 m telesne dolžine), opaženega v turških vodah zaliva Saros; bočna stran (A) in sprednji del (B) primerka (Foto: arhiv H. Kabasakala).

Fig. 2: Approximate sighting locality (*) of the leucistic white shark in the northern Aegean Sea, Turkey.
Sl. 2: Približna lokacija lokalitete, kjer je bil opažen belični beli morski volk v severnem Egejskem morju, Turčija.

ACKNOWLEDGEMENTS

The author thanks to following persons: Dr. Alessandro De Maddalena, curator of the Mediterranean Great White Shark Data Bank, for confirming the identification of the present white shark; Dr. Arda Tonay, for providing some essential literature on leucism; and Mr. İsmail Cem Odabaşı, for video capture of the images depicted in Figure 1. Special thank goes to my wife, Özgür, and my son, Derin, for their endless love and patience.

BELIČNI PRIMEREK BELEGA MORSKEGA VOLKA, *CARCHARODON CARCHARIAS* (LAMNIFORMES: LAMNIDAE), IZ SEVERNEGA EGEJSKEGA MORJA, TURČIJA

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POVZETEK

Štirinajstega junija 2020 sta rekreativna ribiča opazovala belični primerek belega morskega volka, Carcharodon carcharias *(Linnaeus, 1758) v vodah zaliva Saros ob obali Eneza. Oči so bile temno pigmentirane. Apeks belega morskega volka je bil ozko zaokrožen, viden pa je bil bel, nepigmentiran predel, ki se je raztezal od korena prve hrbtne plavuti do trebuha. Poleg tega je belkasta lisa pokrivala večji del vrha prve hrbtne plavuti. Ker doslej ni bilo zabeleženih primerov beličnosti pri belem morskem volku, predstavlja to opazovanje prvi zapis o tem pojavu.*

Ključne besede: beli morski volk, beličnost, anomalije, vzorec, Egejsko morje

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LEUCISTIC PIEBALD STRIPED PANRAY, *ZANOBATUS SCHOENLEINII* (CHONDRICHTHYES: ZANOBATIDAE), FROM THE COAST OF SENEGAL (EASTERN TROPICAL ATLANTIC)

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ABSTRACT

In the present paper, a case of leucism/piebaldism is reported in a striped panray Zanobatus schoenleinii *(Müller & Henle, 1841) captured at a low depth off the coast of Senegal (eastern tropical Atlantic). This is the second case recorded to date for this species. The specimen was sub-adult male with developed but flexible claspers, which measured 495 mm total length and 279 mm disc width, and weighed 751 g. Comments on albinism in fishes are provided in this paper, especially those reported in batoid species.*

Key words: morphology, colour, pigmentation, morphometric measurements, batoid species

ESEMPLARE LEUCISTICO DI *ZANOBATUS SCHOENLEINII* (CHONDRICHTHYES: ZANOBATIDAE) AL LARGO DELLA COSTA DEL SENEGAL (ATLANTICO TROPICALE ORIENTALE)

SINTESI

L'articolo riporta un caso di leucismo/piebaldismo in un esemplare di Zanobatus schoenleinii *(Müller & Henle, 1841), catturato in acque poco profonde al largo della costa del Senegal (Atlantico tropicale orientale). Si tratta del secondo caso di questo tipo registrato fino ad oggi per tale specie. L'esemplare era un maschio sub-adulto, con pterigopodi sviluppati ma flessibili, di lunghezza totale pari a 495 mm, larghezza del disco di 279 mm e 751 g di peso. Gli autori discutono i casi di albinismo nei pesci, in particolare quelli riportati per le specie batoidi.*

Parole chiave: morfologia, colore, pigmentazione, misure morfometriche, specie batoidi

INTRODUCTION

The striped panray, *Zanobatus schoenleiniii* (Müller & Henle, 1841), is an endemic species known from the eastern tropical Atlantic, where it only occurs in the area between southern Morocco (Lloris & Rucabado 1998), Mauritania (Maurin & Bonnet, 1970), Senegal (Diatta *et al.*, 2013), Guinea-Bissau (Sanches, 1991), and the Gulf of Guinea (Blache *et al.*, 1970).

Zanobatus schoenleinii is both commonly and abundantly captured in handicraft fishery throughout the coast of Senegal (Cadenat,1951; Séret & Opic, 1990; Capapé *et al.*, 1995). The species inhabits shallow coastal waters not exceeding 50 m of depth (Capapé *et al.*, 1995). In the wake of a

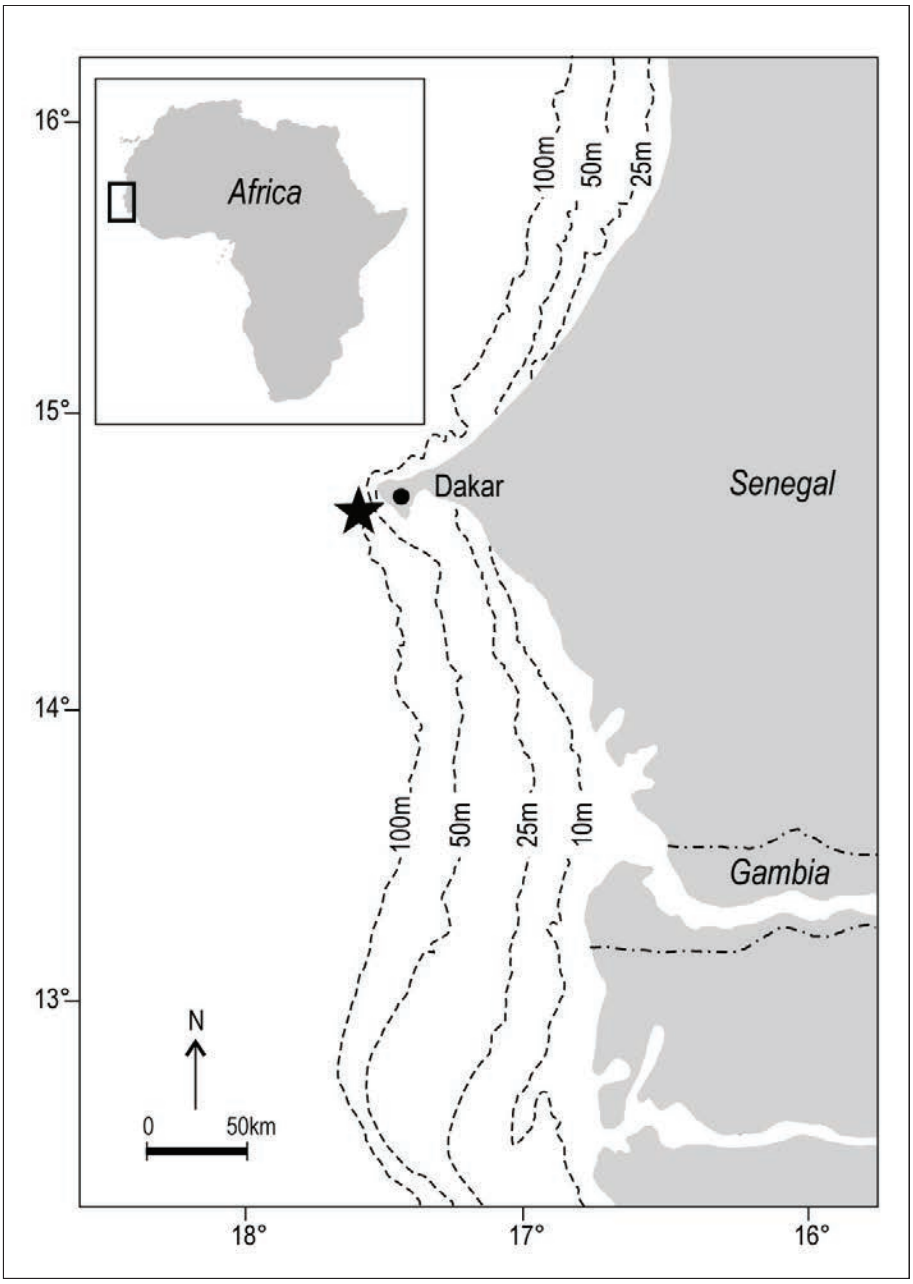

Fig. 1: Map of the Senegalese coast indicating the capture site of the leucistic specimen of** Zanobatus schoenleinii **(black star).

Sl. 1: Zemljevid senegalske obale z označeno lokaliteto, kjer je bil ujet belični primerek vrste** Zanobatus schoenleinii **(črna zvezdica).

collaboration with experienced fishermen, several *Z. schoenleinii* were collected in shallow coastal waters surrounding the touristic area of Dakar. All collected specimens were delivered to the laboratory for thorough examination, including the abnormal specimens described and commented in the present paper.

MATERIAL AND METHODS

A total of 105 specimens were captured on 25 May 2019 using trammel nets at a depth between 5 and 10 m on soft bottom, off Ouakam, a handicraft fishery site located 5 km north Dakar, in Cape Verde Peninsula, Senegal, at 14° 43′ 26″ N and 17° 29′ 21″ W (Fig. 1). Of these specimens, 104 were normal and one specimen abnormal, displaying non-pigmented areas on the dorsal surface.

All specimens were measured to the nearest millimetre and weighed to the nearest gram. The normal specimens ranged between 253 mm and 580 mm in total length (TL), 154 and 340 mm in disc width (DW), and weighed between 104 and 1433 g in total body weight (TBW). However, a sub-sample including 51 normal specimens and the single abnormal specimen was used in order to obtain a more visible view, allowing to clearly distinguish this abnormal specimen from the normal specimens. The subgroup ranged between 250 and 300 mm DW and weighed between 561 and 1346 g TBW.

Morphometric measurements recorded on one of the normal specimens and the abnormal specimens are presented in Table 1, following Diatta *et al.* (2013). Both specimens were fixed in 10% buffered formaldehyde, preserved in 75 % ethanol and deposited in the Ichthyological Collection of the Institut Supérieur d'Aquaculture et de Pêche of Bizerte (Tunisia), receiving catalogue numbers, ISPAB-Zan-sch-01 for the normal specimen and ISPAB-Zan-sch-02 for the abnormal specimen.

The relation between DW and TBW was used as a complement following Froese *et al.* (2011), including all specimens, normal and abnormal, to show if this latter would have been able to develop in the wild like normal specimens. This relation, TBW = $a\text{DW}^b$, was converted into its linear regression, expressed in decimal logarithmic coordinates, and correlations were assessed by least-squares regression as: log TBW = log a + b logDW. Significance of constant b differences was assessed according 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 logistic model STAT VIEW 5.0.

RESULTS AND DISCUSSION

All normal specimens were identified as *Zanobatus schoenleinii* following the combination of main

Fig. 2: Normal specimen of* Zanobatus schoenleinii *(Ref. ISPAB- Zan-sch-01), from the coast of Senegal. Dorsal surface, scale bar = 100 mm.

Sl. 2: Normalni primerek vrste* Zanobatus schoenleinii *(Ref. ISPAB- Zan-sch-01) iz senegalske obale. Hrbtna stran, merilo = 100 mm.

morphological characters: disc sub-circular, wider than long; snout blunt, angle nearly 120° in front; nostrils narrow, anterior valves connected across the internarial space; mouth straight; teeth small; spiracles large without folds; dorsal and caudal fins small and rounded; covered by a rigid skin, unlike and minute scales, a medial row of thorns in disk and tail, and three rows arranged in an arc of circle on each shoulder; back brown with dark cross bands with white spots in between near the pectoral edges (Tab. 1; Fig. 2). Such description is in total agreement with Garman (1913), Cadenat (1951), Blache *et al*. (1970), and Séret & Opic (1990).

The abnormal specimen was a sub-adult male of *Zanobatus schoenleinii*, with developed but flexible claspers, measuring 495 mm TL, 279 mm DW and 751 g TBW (Tab. 1; Fig. 3). The central part of the disc was brown with dark spots externally larger and abundant on the central part of the disc, conversely, dark cross bands were totally lacking. An area surrounding eyes and spiracles was clear and whitish. The edges of both pectorals were largely clear, both dorsal fins and caudal fin whitish, belly entirely beige. The eye colour was black, which confirmed that the specimen was simultaneously leucistic and piebald and not a true albino (*sensu* Quigley *et al.* (2019). It is the second case reported for *Z. schoenleinii*, a similar specimen was previously collected from the coast of Senegal (Diatta *et al*., 2013).

Quigley *et al.* (2019) noted that albinism is a disorder controlled by different genes in which the pigment melanin is absent or non-functional. Additionally, leucism is a partial lack of pigmentation of the skin controlled by a single recessive allele (Jones *et al*., 2016). The term partial albinism or pseudo-albinism was previously used, but is now considered obsolete (Van Grouw, 2006). Lipej *et al.* (2011) showed that large albino specimens of marbled torpedo *Torpedo marmorata* Risso, 1810 could also be captured in the wild and that, consequently, total or partial albinism does not compromise life and development. Similar patterns were also reported for the striped panray (Diatta *et al*., 2013). The relationship log DW *versus* log TBW is log TBW = -6.97 + 4.07 * log DW; r = 0.94, n = 52. It appears a positive allometry but the leucistic piebald specimen which clearly displays a TBW lower than this of the other specimens (Fig. 4). Following the opinion of Quigley *et al.* (2019), such pattern suggests that this abnormal specimen did not develop like other normal specimens in the wild due to being

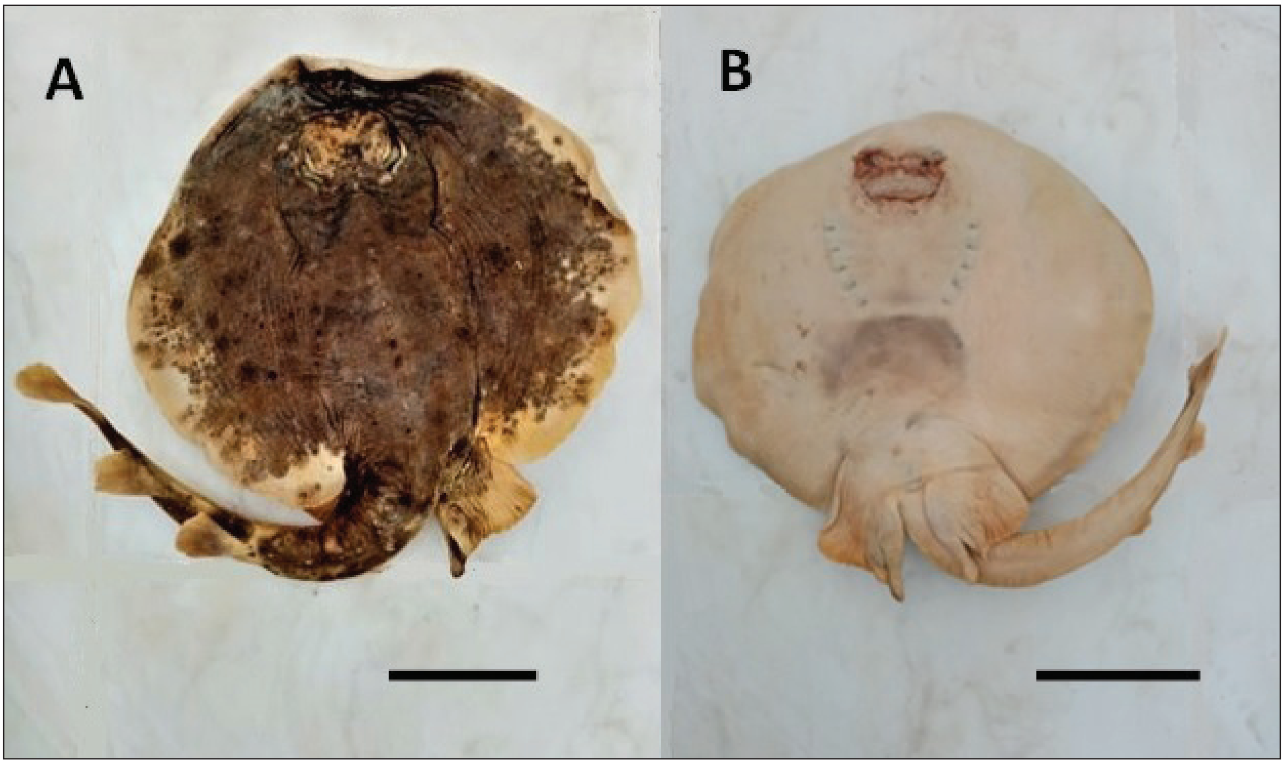

Fig. 3: Leucistic piebald specimen of* Zanobatus schoenleinii *(Ref. ISPAB- Zan-sch-01) from the coast of Senegal. A. Dorsal surface, scale bar = 80 mm. B. Ventral surface, scale bar = 100 mm.
Sl. 3: Belični piebaldistični primerek vrste* Zanobatus schoenleinii *(Ref. ISPAB- Zan-sch-01) iz senegalske obale. A. Hrbtna stran, merilo = 80 mm. B. Trebušna stran, merilo = 100 mm.

Tab. 1: The morphometric measurements (in mm and as % DW) and total body weight recorded in the leucistic piebald specimen of *Zanobatus schoenleinii* ***(ISPAB-Zan-sch-02) and compared to a normal specimen (ISPAB-Zan-sch-01), both from the coast of Senegal.***

Tab. 1: Morfometrične meritve (v mm in kot % DW) in celotna telesna masa pri beličnemu piebaldističnemu primerku vrste *Zanobatus schoenleinii* ***(ISPAB-Zan-sch-02) v primerjavi z normalnim primerkom (ISPAB-Zan-sch-01). Oba sta bila ujeta ob senegalski obali.***

References	**ISPAB-Zan-sch-01**		**ISPAB-Zan-sch-02**	
Measurements	**MM**	**% DW**	**MM**	**% DW**
Total length	559	194.8	495	177.4
Disc length	313	94.8	255	91.4
Disc width	330	100.0	279	100.0
Disc depth	44	13.3	34	12.2
Eyeball length	17	5.2	18	6.5
Pre-orbital length	70	21.2	59	21.2
Inter-orbital length	26	7.9	28	10.0
Spiracle diameter	23	6.7	19	6.8
Interspiracular width	33	10.0	30	10.8
Space between eye and spiracle	13	3.9	11	3.9
Pre-oral length	72	21.2	60	21.5
Mouth width	43	13.0	43	15,4
First gill-slit	8	2.5	9	3.2
Fifth gill-slit	7	2.4	7	2.5
Width between first gill-slit	82	24.8	69	24.7
Width between fifth gill-slit	51	15.5	43	15.4
Snout tip to eye	81	24.3	68	24.4
Snout tip to mouth	81	24.3	68	24.4
Snout tip to first gill-slit	106	32.1	102	36.6
Snout tip to fifth gill-slit	150	45.5	132	47.3
Snout tip to vent	270	81.8	225	80.7
Pectoral fin anterior margin	205	71.4	185	66.3
Pectoral fin posterior margin	184	62.1	143	51.3
Pelvic fin anterior margin	50	15.2	48	17.2
Pelvic fin posterior margin	77	23.3	55	19.7
Second dorsal inneredge	10	3.0	11	3.9
Interdorsal distance	30	9.1	32	11.5
Second dorsal to caudal birth	28	8.6	35	12.5
Total body weight	**1507**		**751**	

maladapted. But it could also explain why of the 633 batoid species known to date worldwide, only 22 cases of albinism, leucism and piebaldsim had been reported (Quigley *et al.*, 2018), 23 including the present specimen.

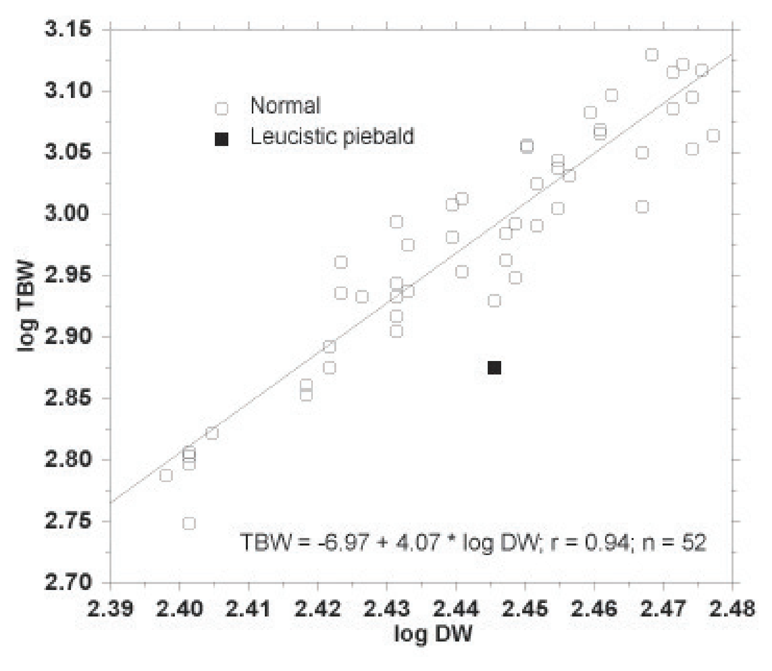

Fig. 4: Total body mass (TBM) versus disc width (DW) relationship expressed in logarithmic co-ordinates for normal and leucistic piebald specimens of* Zanobatus schoenleinii *collected from the coast of Senegal.
Sl. 4: Odnos med celotno telesno maso (TBM) in širino diska (DW), izražen v logaritmični skali pri normalnih in leucističnih piebaldističnih primerkih vrste* Zanobatus schoenleinii*, ujetih ob senegalski obali.

Talent (1973) noted that lack of pigmentation could be considered as disadvantage for sharks and rays, calling the attention of possible predators to their presence in the wild. Generally, abnormal specimens are considered of lower value than normal specimens among fishermen and are sometimes discarded at sea; this could also explain their scarcity in fish landings. Unfavourable environmental conditions, such as large exposure to pollutants, could also play a role in the lack of pigmentation, especially in species living a benthic zones, such as *Zanobatus schoenleinii*. Such phenomenon was particularly observed in batoids, which generally inhabit sandy-muddy bottoms (Ribeiro-Prado *et al.*, 2008; Diatta *et al.*, 2013). The fact that albinos, leucistic and piebald specimens are more sensitive to pollutants than normal specimens remains a valid hypothesis, which should, however, be validated by further studies. Since Diop *et al.* (2012) and Bonnin *et al.* (2016) report that the coast of Senegal**,** especially around the touristic area of Dakar, has been, for decades, increasingly exposed to pollutants in the wild and their impact on the local biodiversity cannot be totally ruled out, the presently studied case could be a good instance of that.

BELIČNI PRIMEREK VRSTE *ZANOBATUS SCHOENLEINII* (CHONDRICHTHYES: ZANOBATIDAE) IZ SENEGALSKE OBALE (VZHODNI TROPSKI ATLANTIK)

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ABSTRACT

V pričujočem prispevku avtorji poročajo o primeru beličnosti/piebaldizma pri vrsti skata Zanobatus schoenleinii *(Müller & Henle, 1841), ujetega v plitvini ob obali Senegala (tropski vzhodni Atlantik). Gre za drugi primer pojava te anomalije pri tej vrsti. Primerek je bil subadultni samec, ki je meril 495 mm v dolžino, 279 mm v premeru diska in tehtal 751 g, ter imel razvita, a še vedno prožna klasperja. Avtorji nadalje razpravljajo o primerih albinizma, še posebej tistih pri skatih.*

Ključne besede: morfologija, barva, pigmentacija, morfometrične meritve, skati

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GONADAL DEVELOPMENT OF BOGUES, *BOOPS BOOPS* (LINNAEUS, 1758), FROM ORAN BAY (TELEOSTEI, SPARIDAE)

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ABSTRACT

Our study aims to investigate the reproductive cycle of Boops boops *caught in Oran Bay. The samples were received monthly from commercial catches of coastal trawlers operating in this area from January 2016 to December 2017. The overall sex ratio was in favor of females and the length frequency distribution according to sex revealed that females were predominant beyond 14 cm of total length, presuming the beginning of the sexual inversion already described for this Sparidae species. The spawning period was established based on the follow-up of the gonado-somatic index, and appeared to last from February to late June with a peak in the March-April period. Our findings can contribute to a better understanding of the reproductive cycle of this species and help adopt measures toward a more adequate stock management of the most abundant sparid that is landed daily in many Mediterranean and Algerian fisheries.*

Key words: *Boops boops*, reproductive cycle, spawning season, size at first maturity, Oran, Algeria

SVILUPPO GONADALE DELLA BOGA, *BOOPS BOOPS* (LINNAEUS, 1758) NELLA BAIA DI ORANO (TELEOSTEI, SPARIDAE)

SINTESI

Lo studio si propone di indagare il ciclo riproduttivo degli esemplari di Boops boops *catturati nella baia di Orano. I campioni mensili provenivano dalle catture commerciali dei pescherecci costieri operanti in quest'area, da gennaio 2016 a dicembre 2017. Il rapporto tra i sessi è risultato a favore delle femmine e la distribuzione della frequenza della lunghezza in base al sesso ha rivelato che le femmine erano predominanti oltre i 14 cm di lunghezza totale, presumendo l'inizio dell'inversione sessuale già descritta per questa specie di sparidi. Il periodo di riproduzione è stato stabilito sulla base del follow-up dell'indice gonado-somatico e sembra durare da febbraio a fine giugno, con un picco nel periodo marzo-aprile. Tali risultati possono contribuire a una migliore comprensione del ciclo riproduttivo di questa specie e aiutare ad adottare misure per una gestione più adeguata dello stock dello sparide più abbondante, che viene sbarcato quotidianamente in molte zone di pesca del Mediterraneo e dell'Algeria.*

Parole chiave: *Boops boops*, ciclo riproduttivo, stagione di deposizione delle uova, taglia alla prima maturità, Orano, Algeria

INTRODUCTION

The bogue is a widespread species in the eastern Atlantic, found from Norway to Angola, including the Canary, Cape Verde, and Sao Tome-Principe Islands. It is common between the Bay of Biscay and Gibraltar, and in the Mediterranean and Black Seas (Bauchot & Hureau, 1986). This sparid can be found in the shelf or coastal pelagic zone on various bottoms (sand, mud, rocks and seaweeds). Gregarious and ascending to the surface mainly at night, the species is omnivorous, feeding mainly on crustaceans, as well as planktonophagous (Frimodt, 1995).

In Algeria, the Sparidae family is of high commercial importance, with the bogue representing ~ 20 % of all demersal fish landed and 45 % of all sparid catches (D.P.R.H, 2016). *B. boops* is a demersal and semi-pelagic species typifying the daily landed fish in Oran Bay. It moves in aggregations, ascending to the surface mainly at night (Campillo,1992); in Oran Bay it is fished at depths ranging between 100 and 250 m (*pers. obs.*) and captured by line gear, with bottom trawls and purse seines.

There is some published data on the biology of this species, focusing mainly on the weight-length relationship (Gonçalves *et al.,* 1997; Moutopoulos & Stergiou *et al.,* 2002; Özaydin & Taskavak, 2006; Kara & Bayhan, 2008; Karachle & Stergiou, 2008; Crec'hriou *et al.,* 2013; Özvarol, 2014; Crec'hriou *et al.,* 2015), fishing gear selectivity (Ayaz *et al.,* 2009; Cengiz *et al.,* 2013; Kumova *et al.,* 2015; Eryaşar, 2017; Ilkyaz *et al.,* 2017), feeding habits (Sánchez-Velasco & Norbis, 1997; El-Maremie & El-Mor, 2015), and biology and population dynamics (Anato & Ktari, 1983; Alegria Hernandez, 1989; Gordo, 1996; Allam, 2003; Khemiri *et al.,* 2005; Manaşirli *et al.,* 2006; Monteiro *et al.,* 2006; El-Okda, 2008; Kara & Bayhan, 2008).

Several biological studies on its reproductive cycle have also been conducted (Frau, 1966; Gordo 1995,1996; Cano Fortuna & Lizaso, 1996; El-Agamy *et al.,* 2004; Monteiro *et al.,* 2006; Kasalica *et al.,* 2011; Bottari *et al.,* 2014; Layachi *et al.,* 2015; Taylan & Bayhan, 2015; Mobilia *et al.,* 2016; Dobroslavić *et al.,* 2017), but in relation to Algerian waters, the works are limited to Derbal & Kara, 2008 on feeding habits; Boubaiou, 2014 (morphometrics); Benina, 2015; Kherraz *et al.,* 2016 (population dynamics), Ider *et al.,* 2017 (otolithometry), and only works of Chali-Chabane (1988) in Algiers Bay, and Bensahla-Talet *et al.* (1990) and Kherraz (2011) in Oran Bay dealt with the reproductive cycle of this species. Therefore, the present study aims to estimate more precisely the reproduction parameters of this species to help comparative studies in the Mediterranean and propose measures to allow a renewal of the resources and improved management.

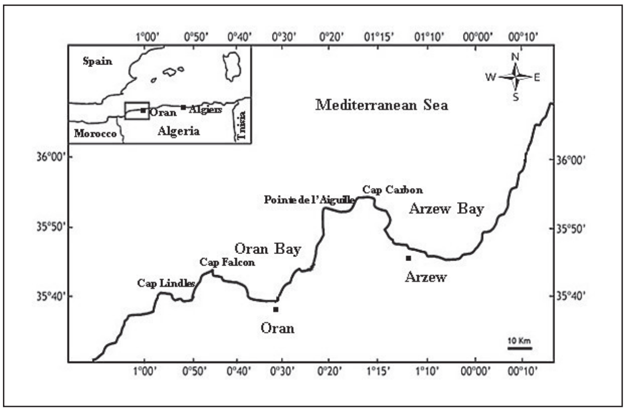

Fig. 1: Map of the study area (Oran Bay).
Sl. 1: Zemljevid obravnavanega območja (Oranski zaliv).

MATERIAL AND METHODS

Specimens of *B. boops* (n=7153; 3317 in 2016, and 3836 in 2017) were caught by trawlers operating in Oran Bay, located in northwestern Algerian coast (western Mediterranean Sea), between Pointe de l'Aiguille and Cape Falcon (35.95 °N-0.65 °E) (Fig. 1) at depths ranging between 100 and 250 m between January 2016 and December 2017. Samples were randomly collected from daily landed fish at the Oran fishery.

At the laboratory, total length (TL), measured to the nearest millimeter with an ichthyometer (± 1 mm), total weight (TW), and gonad weight (GW), using a digital precision balance (± 0.01 g), were recorded for each individual.

Sex ratio

The sex ratio was calculated monthly throughout the study period according to individual sizes (1 cm class interval) and seasons using the formula below, while sexually indeterminate and immature individuals were not taken into account:

$$SR = \frac{nF}{nM+nF} \times 100$$

where:
nF = number of females,
nM = number of males.

To detect statistically significant deviations from the expected 1:1 ratio, the chi-square (χ^2, $P < 0.05$) test was used (Sokal & Rohlf, 1987).

Spawning period

For the description of the sexual cycle of *B. boops* several approaches were used:

Tab. 1: Sexual maturity scale (macro- and microscopic) of the Sparidae modified and used in this study to classify** B. boops **gonads, with a focus on female gonads (Bensahla-Talet** et al.**, 2017).
Tab. 1: Spolna zrelost (makro- in mikroskopska) predstavnikov iz družine Sparidae, prirejena za potrebe te študije za opredelitev gonad vrste** B. boops**, s posebnim poudarkom na samičjih gonadah (Bensahla-Talet** et al.**, 2017).

	Level name	Macroscopic	Microscopic
I	**Immature**	Very small and translucent ovaries. Very small testes; no signs of development.	Oocytes are small arranged on ovigerous lamellae. The nucleus is relatively clear.
II	**Resting**	Ovaries in recovering condition; Testes in recovering condition.	Oocytes are small spherical (about 60 µm), no vitellus is found in their cytoplasm. The nucleus is relatively dense and large with a NPR at its maximum attaining 0.6.
III	**Vitellogenesis (Maturing)**	Larger ovaries and eggs visible. Larger testes, not running.	Vitellogensis initiate characterized by massive entry of small vitelline and lipidic vesicles. Zona radiata begin to thicken and appearance of granulosa formed of single cell layer.
IV	**Ripening and Spawning**	Large transparent eggs that are released under moderate pressure. Sperm released by a light press on the abdomen.	Oocytes attainted their maximal size (~500 µm). The nucleus migrates to the animal pole. The follicle includes a thick zona radiata. The cytoplasm is overload with vitellus and lipid vesicles conferring to the egg a hyaline aspect.
V	**Post spawning**	Ovaries shrunken with few residual eggs, much slime and often redish. Testes small, slack testes and often redish; resting condition.	Many atretic follicles are encountered corresponding to oocytes that have not attained their maturation or mature ones that were not emitted and which will degenerate. The cytoplasm is disorganized and cells undergo pycnosis.

1 - The maturation scale was established following the Holden & Raitt (1974) macroscopic scale, while microscopic description was based on the Aboussouan & Lahaye (1979) scale with a slight modification to fit *B. boops* gonad development (Tab. 1). Both are based on the macroscopic aspect, relative dimensions and microscopic characteristics of the gonads (I: immature, II: resting, III: ripe, IV: ripe and running, V: spent).

2 - Between 10 and 30 specimens of *B. boops* were selected each month for histological examination of the sexual organs, which were placed in Bouin's fixative solution for 48 h, dehydration was carried out by increasing concentrations of acetone/toluene, then fragments were embedded in paraffin wax. Gonads were sectioned with a microtome into 5-6 µm sections and stained with hematoxylin-eosin.

3 - Monthly evolution of the gonado-somatic (GSI) index was calculated as follows:

$$\mathrm{GSI} = \frac{\mathrm{GW}}{\mathrm{TW}} \times 100$$

where:
GSI = gonado-somatic index,
GW = gonad weight (g),
TW = total weight (g).

The nucleoplasmic ratio is considered to be closely related to the mitotic cellular cycle and to the functional phase of cells. It is also a good indicator of dynamic changes in cells (Bensahla-Talet *et al.*, 2017). The nucleoplasmic ratio (NPR) is expressed mathematically as:

$$\mathrm{NPR} = \frac{\mathbf{Nd}}{\mathbf{Cd - Nd}}$$

where:
Nd = nucleus diameter,
Cd = total cell diameter.

Size at first sexual maturity

Size at first sexual maturity (L_m) was defined as the size class at which 50 % of the individuals are mature. Specimens were grouped into 1 cm size classes, and the proportion of mature and immature individuals was recorded. The total length at which 50 % of the specimens were mature was estimated by a logistic non-linear least-squares regression (King, 1995):

$$P = 1 / [1 + e^{-a(L - L_m)}]$$

where:
P = percentage of mature individuals,
a = slope of the curve or rate of increase in maturity,
L_m = length at 50 % maturity,
L = 1 cm length class.

RESULTS

In total, 3317 specimens of *B. boops* were collected in 2016, 1319 of which were males (39.76 %)

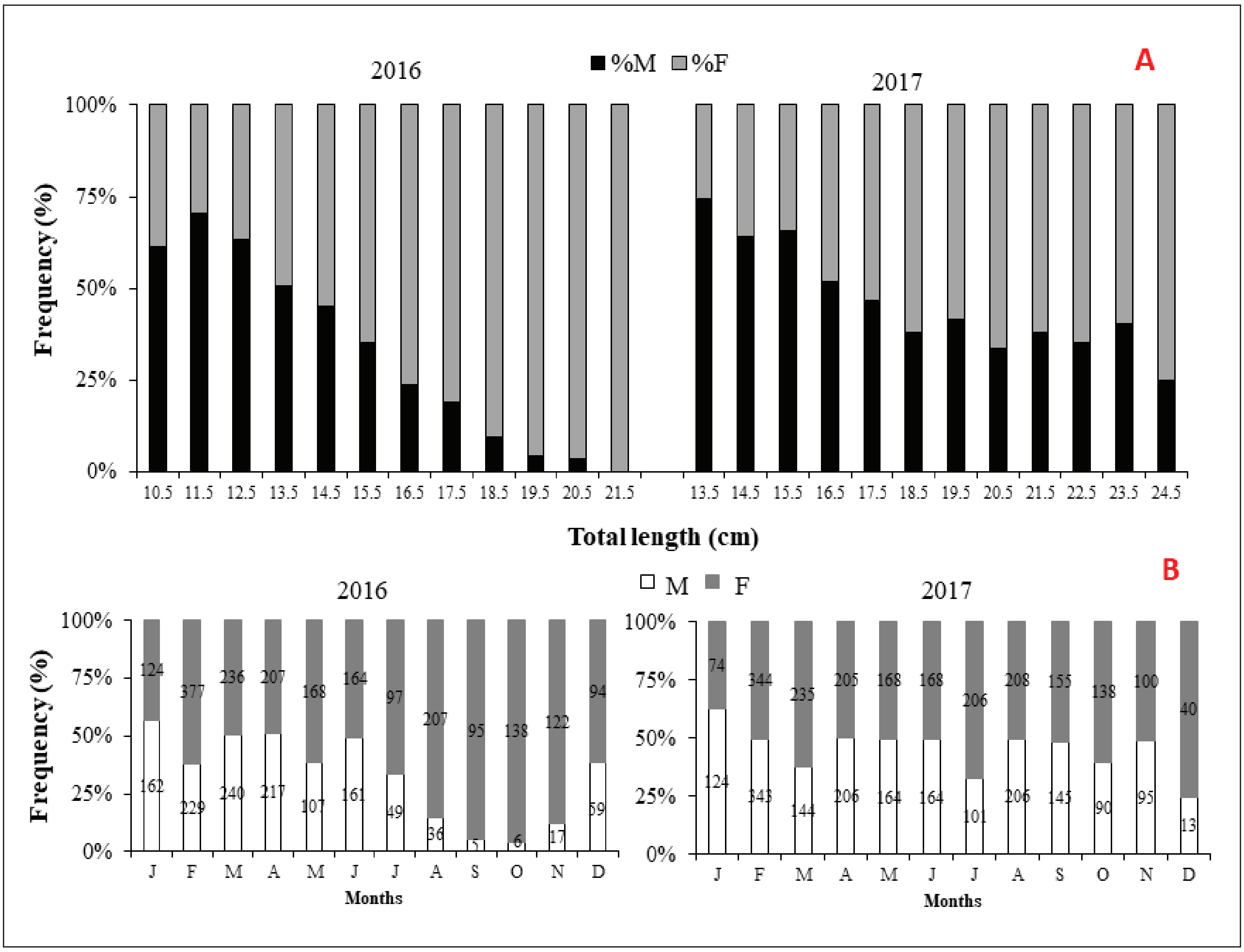

Fig. 2: A. Length frequency distribution of males and females of *B. boops* ***caught in Oran Bay. B. Monthly length frequency distribution of males and females of*** *B. boops* ***caught in Oran Bay.***
Sl. 2: A. Frekvenčna porazdelitev velikosti samcev in samic bukve *(B. boops)****, ujete v Oranskem zalivu. B. Frekvenčna porazdelitev velikosti samcev in samic bukve*** *(B. boops)* ***po različnih mesecih, ujetih v Oranskem zalivu.***

and 1998 were females (60.23 %), while in 2017, 3836 specimens were collected, 1798 males (46.87 %) and 2038 females (53.12 %). The length frequency distribution of the entire population is shown in Fig. 2a, b; the male length range was between 10 and 22.9 cm, the female between 12 and 24.9 cm.

The overall female-male ratio was in favor of females (F:M 1:1.51 in 2016 and F:M 1:1.13 in 2017) and was significantly different from the 1:1 ratio ($\chi2=138.99$ and $\chi2 = 15.02$ respectively > $\chi^2_{t\ 1,0.05 = 3.84}$). Sex ratios between males and females by size class were also significantly different from the 1:1 ratio ($\chi^2_{observed} > \chi^2_{t\ 1,\ 0,05 = 3.84}$) for most size classes, the difference was significant beyond the 14 cm length class in 2016, while in 2017, this difference was distinguished beyond the 17 cm of total length, where females predominated. Males predominated in smaller size classes and females in larger ones (Fig. 2).

Maturity stages

Females with ripe gonads (stage III) and those with ripe and running gonads (stage IV) were observed (Fig. 3) in early winter and were dominant in the March-July period, thus highlighting the spawning period of *B. boops* in Oran Bay. Spent fish (stage V) were recorded from June to November with a maximum in August, while the remaining period of the year gonads in stage II were dominant, marking the sexual rest period of this Sparidae species.

Nucleoplasmic ratio (NPR)

The variation of the nucleoplasmic ratio according to maturity stages is presented in Fig. 3b, reflecting the changes that affect the oocytes. It appears that high values of this ratio are encountered in early oogenesis

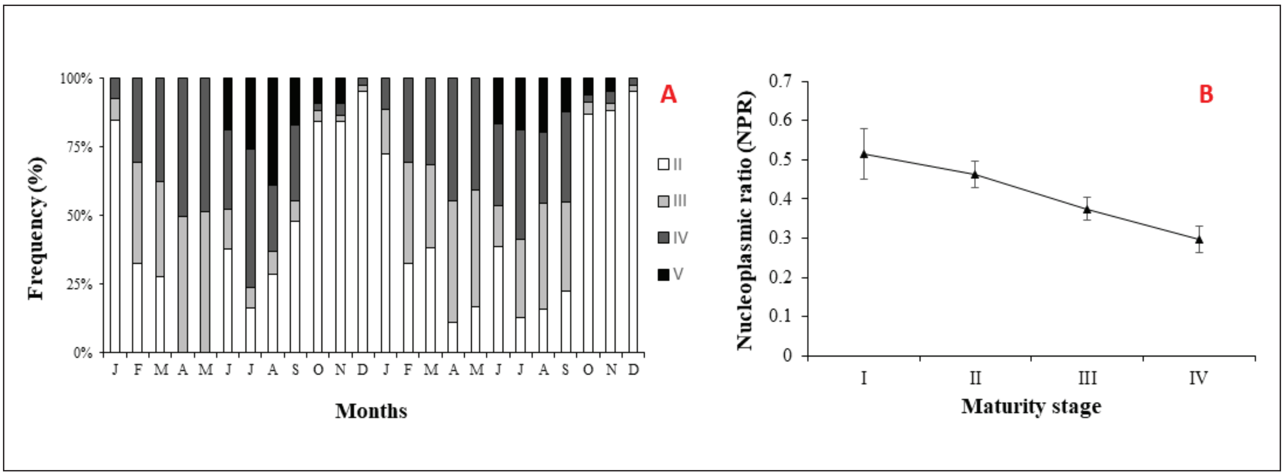

Fig. 3: A. Maturity stages of* B. boops *females caught in Oran Bay (II: resting, III: maturing, IV: ripe and running, V: spent). B. Variation of the nucleoplasmic ratio (NPR) in relation to maturity stages of* B. boops *females.
***Sl. 3: A. Zrelostni stadiji samic bukev* (B. boops) *ujetih v Oranskem zalivu (II: počivajoči stadiji, III: dozorevajoči, IV: zreli, V: dokončani). B. Variacije v nukleoplazmičnem deležu (NPR) v odnosu na zrelostne stadije samic bukve* (B. boops).**

stages, attaining 0.51, and as the oocyte develops, this ratio tends to decrease, attaining its lowest value of 0.29 in stage IV, when the oocytes are ready to be emitted.

Microscopic analysis

As with the majority of teleost fish and especially sparids, the microscopic analysis of the gonads allowed us to describe the following stages in *B. boops*:

Ovaries

Immature period

The oogonia representing the reserve batch are small round cells with a clear nucleus (Fig. 4a), varying in size between 36 and 169 µm, and the NPR is at its maximum value of 0.51.

Resting period

At this stage (Fig. 4b) the oocytes are spherical (169-260 µm), some of them have already began their first cellular division and the cells are arranged as ovarian lamellae with a homogenous and transparent cytoplasm, having numerous nucleoli mixed to a large nucleus containing dense chromatin, the NPR is at 0.46.

Maturing period

Previtellogenesis

Oogonia undergo progressive increase in size reaching 205-390 µm (Fig. 4c, d) with an average NPR of 0.37. The maturation period is mainly characterized by:

A- A clear central nucleus containing some supernumerary nucleoli distributed at the periphery.

B- Thousands of cortical alveoli appearing to mark the beginning of the endogenous lipidic vitellogenesis.

C- The granulosa and zona radiata becoming visible.

The vitellogenesis period (pre-spawning)

A rapid increase in the size of the oocytes is observed at this stage (416 µm), resulting from an intense entry of the protein yolk, also the vitelline globules are rounded and colored red with a mean diameter of 9.5 µm marking the exogenous vitellogenesis (Fig. 4e, f).

Lipid (colorless) inclusions move massively around the nucleus (Fig. 4g, h) forming a central vacuole. The central cytoplasmic zone is filled and repels the cytoplasm at the periphery. The NPR decreases to 0.38.

The oocyte membrane is enveloped by a protective thick membrane, zona radiata, measuring 10.16 µm. The whole is enveloped by the granulosa, formed by one layer of ovarian cells, and the fibrous theca (Fig. 4i).

Ripening and spawning period

The nucleus moves to the animal pole to initiate the first meiotic division (Fig. 4j). Egg release is imminent, cytoplasmic structures merge and give the mature egg a translucent appearance, hence the name hyaline oocyte (Fig. 4k, l); their diameter is max 500 µm (390-542 µm) with an average NPR of 0.29.

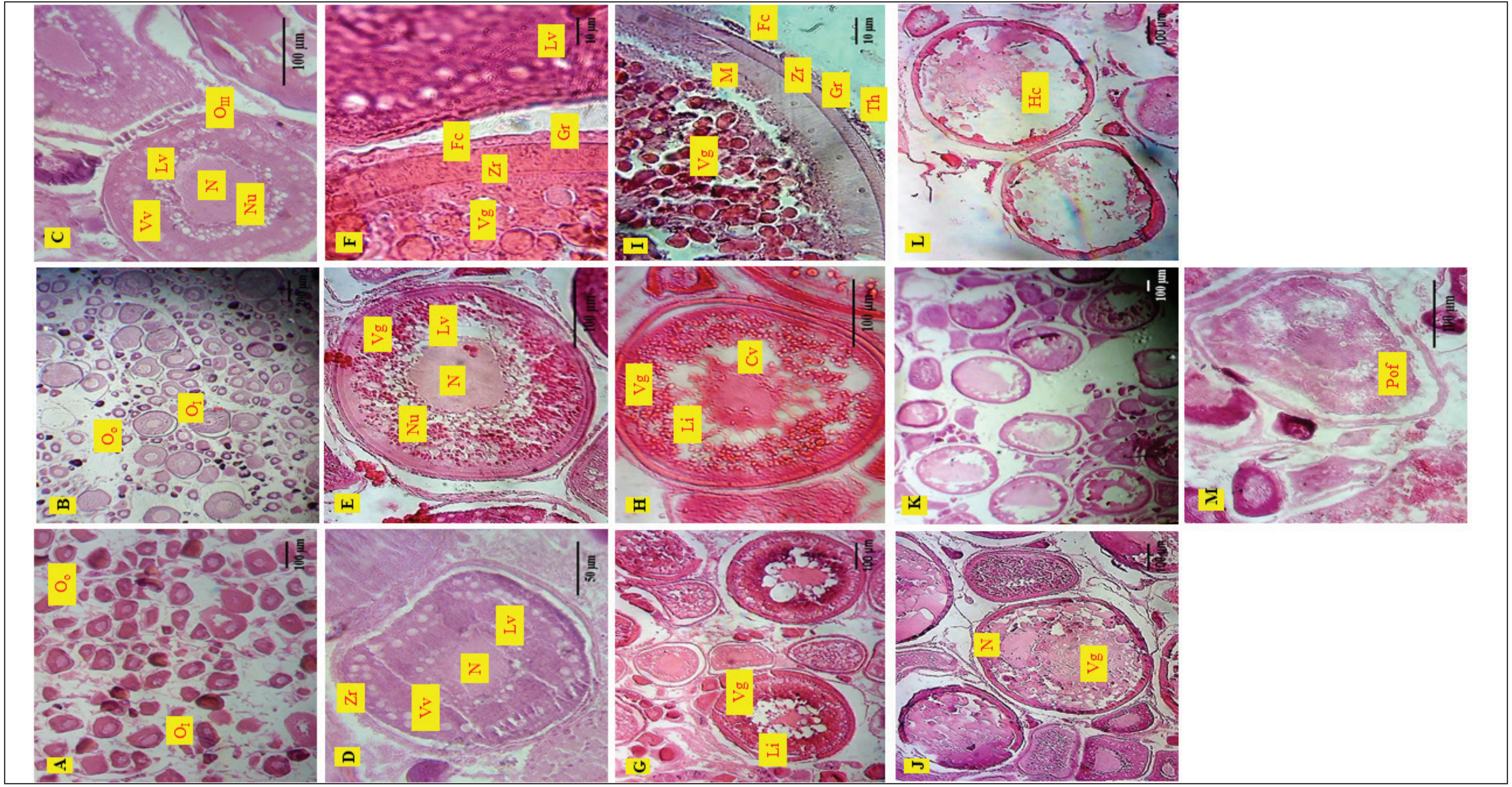

Fig. 4: Ovarian histological slides of B. boops female gonads (a-m) stained by hematoxylin-eosin: (a) general view of an immature ovary × 100; (b) resting ovary with: advanced peri nucleolar oocytes (OII), a large nucleus and homogenous cytoplasm × 40; (c) previtellogenic ovogonia (OIII) presenting a large nucleus surrounded by several lipoprotein vesicles × 250; (d) previtellogenic oogonia (OIII) × 400; (e) early maturing large oocytes with large translucent vitelline vesicles and a thin zona radiata (OIII) × 250; (f) OIII with a thick zona radiata and apparition of granulosa × 1000; (g) hydrated large oocytes (mature) OIV with numerous vitelline globules and important lipid inclusions forming a central vacuole × 100; (h) hydrated large oocytes (mature) × 250; (i) mature oocyte with a thick zona radiata, granulosa and fibrous theca × 1000; (j) hyaline oocyte with nucleus in the animal pole × 100; (k) general view of ovary in spawning phase x 40; (l) hyaline oocyte ready to be released ×100; (m) post-ovulatory follicle × 250. Fc: follicular cells; Gr: granulosa; Hc: hyaline cytoplasm; Li: lipid inclusion; Lv: lipid vesicle; M: oocyte membrane; N: nucleus; Nu: nucleoli; O: oocyte; Oo: oogonia; Vg: vitelline globules; Zr: zona radiata of chorion; Pof: post-ovulatory follicle; Th: theca; Vv: vitelline vesicule; Zr: zona radiata.

Sl. 4: Histološki rezi ovarija samic bukve (B. boops) (a-m), obarvani z hematoksilinom-eozinom: (a) pogled na nezrel ovarij × 100; (b) počivajoči ovarij z: razvitimi perinuklearnimi oocitami (OII), veliko jedro in homogeno citoplazmo × 40; (c) previteligenska ovogonia (OIII) z velikim jedrom, obdan s številnimi lipoproteinski vezikli × 250; (d) previteligenska ovogonia (OIII) × 400; (e) zgodnje dozorevajoče velike oocite z velikimi prozornimi vitelinskimi vezikli in tanko "zona radiata"(OIII) × 250; (f) OIII z debelo "zona radiata" in pojavom "granulosa" × 1000; (g) hidratirane velike oocite (zrele) OIV s številnimi vitelinskimi globuli in pomembni lipidni vključki, ki tvorijo centralno vakuolo × 100; (h) hidratirane velike oocite (zrele) × 250; (i) zrele oocite z debelima "zona radiata" in "granulosa" ter fibrozna teka × 1000; (j) hialina oocita z jedrom v animalnem polu × 100; (k) pogled na ovarij v fazi drstenja x 40; (l) hialina oocita tik pred sprostitvijo ×100; (m) post-ovulatorni folikel × 250. Fc: folikularne celice; Gr: granulosa; Hc: hialina citoplazma; Li: lipidni vključek; Lv: lipidni vezikel; M: membrane oocite; N: jedro; Nu: nukleoli; O: oocita; Oo: oogonija; Vg: vitelinski globuli; Zr: zona radiata pri horionu; Pof: post-ovulatorni folikel; Th: teka; Vv: vitelinski vezikel; Zr: zona radiata.

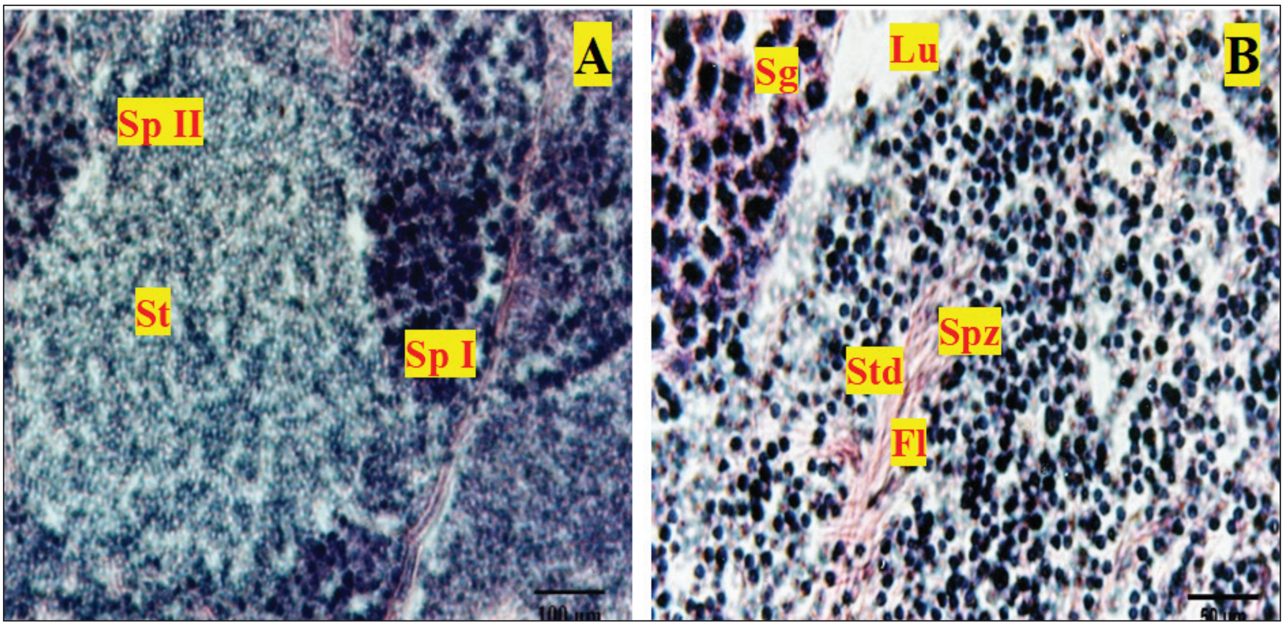

Fig. 5: Spermatogenetic stages; (a) seminiferous tubule with isogenic cysts at different stages of maturation × 100; (b): mature testicle showing seminiferous tubules with lumen full of spermatozoa with their flagella × 1000. Fl: flagella; Lu: central lumen; Sp I: spermatocyte I; Sp II: spermatocyte II; Spz: spermatozoa; Std: spermatids; St: seminiferous tubule.

Sl. 5: Stadiji spermatogeneze; (a) seminiferni tubuli z izogenimi cistami pri različnih zrelostnih stadijih × 100; (b): zreli testikli z vidnimi seminifornimi tubuli z lumnom, napolnjeni s semenčicami z bički × 1000. Fl: bički; Lu: centralni lumen; Sp I: spermatocita I; Sp II: spermatocita II; Spz: spermatozoj; Std: spermatide; St: seminiferni tubul.

Post spawning

In the ovary, a fraction of unemitted mature oocytes enter atresia marking the end of the spawning season; the nucleus enters pycnosis and the yolk disintegrates into a compact cluster; the cytoplasm becomes disorganized; remaining in the ovary is only the reserve oogonia that will be used during the next spawning season (Fig. 4m). At the end of the spawning period, the fish enters the resting phase and the ovary reverts to its initial appearance, which can be recognized by the presence of ovigerous lamellae (Fig. 4a, b).

Testes

With regard to the spermatogenesis in male gonads, the testes studied were mature at the same time as the ovaries. The testicles are formed of a multitude of oval ampoules separated by a connective tissue (Fig. 5). Seminiferous tubules are composed of isogenic cysts at different stages of maturation (Fig. 5a, b). At maturity, spermatids are transformed to spermatozoids, which move into the central lumen and from there into deferent ducts to be released via the genital opening.

Hermaphrodite gonads

B. boops exhibits a protogynous hermaphroditism already described (D'Ancona, 1949; Reinboth, 1962; Frau,1966; Girardin, 1981; Gordo, 1992; Massaro, 2012). During our sampling period, 90 individuals were hermaphrodites presenting the two sexes in the same gonad, the ovotestis. The histological analysis of ovotestis (Fig. 6) allowed us to examine germinal tissues for males and females, which co-exist (Fig. 6a, b, c). The female part is functional and represented by ovogonous cells and some oocytes I (O_I) arranged in ovigerous lamellae. The male part is not yet active and is made up of spermatogonia arranged in isogenic cysts at the beginning of spermatogenesis.

Sexual cycle and spawning period

To determine the reproductive period of *B. boops*, the gonado-somatic index (GSI) was used, which was calculated from samples taken monthly. The GSI value began to rise from January and remained high until May, with a peak in April (3.75 in 2016, and 3.66 in 2017). The GSI then decreased from June and remained low until November, confirming the sexual rest period (Fig. 7), which is in accordance with our macroscopic observation on maturity stages of *B. boops*.

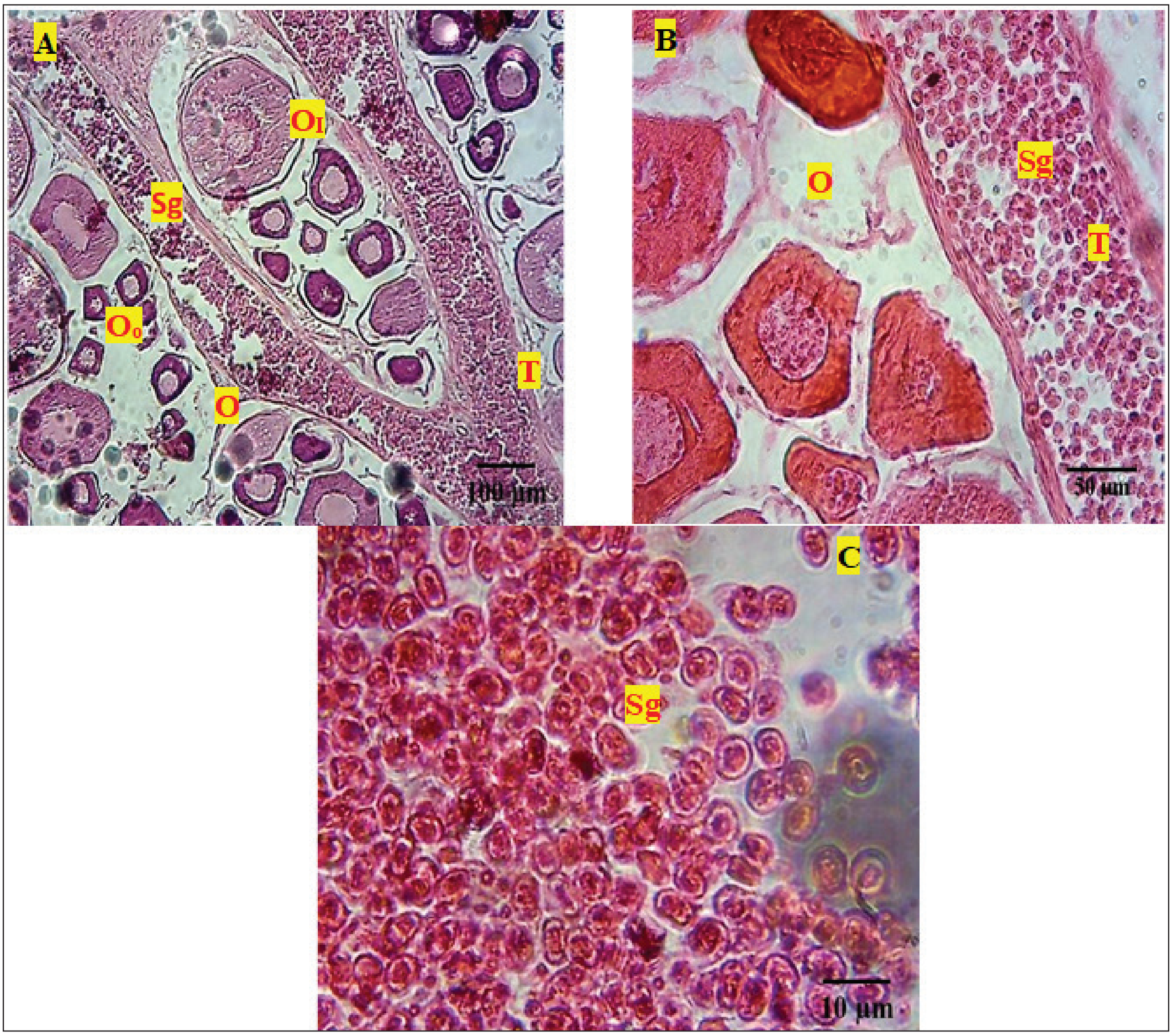

Fig. 6: Section of hermaphrodite gonad of* B. boops*; (a) section of ovotestis × 100; (b) section of hermaphrodite gonad showing a functioning female part and early development of a male part × 250; (c) spermatogonia × 1000. O: ovary; OI: oocyte I; Oo: oogonia; Sg: spermatogonia; T: testis.

Sl. 6: Sekcija hermafroditske gonade pri bukvi (*B. boops*); (a) sekcija ovotestisa × 100; (b) sekcija hermafroditske gonade, ki kaže funkcionalni del samice in zgodnji razvoj moškega dela × 250; (c) spermatogonija × 1000. O: ovarij; OI: oocita I; Oo: oogonija; Sg: spermatogonija; T: testis.

Size at first sexual maturity

An analysis of shares of mature specimens (Fig. 8) showed that in Oran Bay, 50 % of *B. boops* females were mature at 14 cm of total length.

DISCUSSION

In Oran Bay, the overall female-male ratio was found in favor of females, an observation already made by Lamrini, 1998; Monteiro *et al.*, 2006; Kherraz, 2011; Kasalika *et al.*, 2012; and Dobroslavić *et al.*, 2017, while Bottari *et al.*, 2014 found this ratio equally distributed in the southern Tyrrhenian Sea.

The predominance of males in smaller length classes and females in larger classes is probably due to protogynic hermaphroditism already described for this species by D'Ancona, 1949; Reinboth, 1962; Frau, 1966; Gordo, 1995; Cano Fortuna & Sánchez Lizaso, 1996; Lamrini, 1998; Bottari *et al.*, 2014. Specimens are first female and became progressively male, which is characterized by the development of

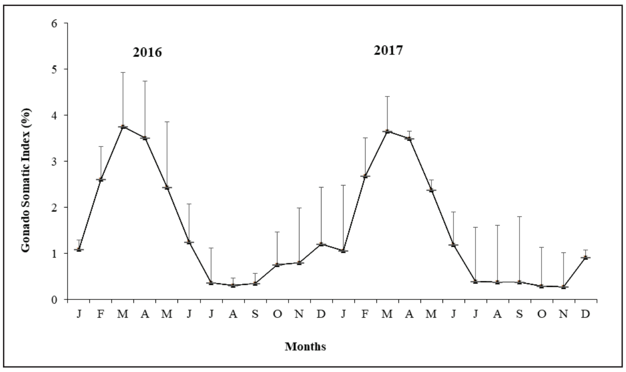

Fig. 7: Monthly changes in the gonado-somatic index of *B. boops* ***females caught in Oran Bay.***
Sl. 7: Mesečne spremembe v gonadosomatičnem indeksu pri samicah bukve *(B. boops)****, ujete v Oranskem zalivu.***

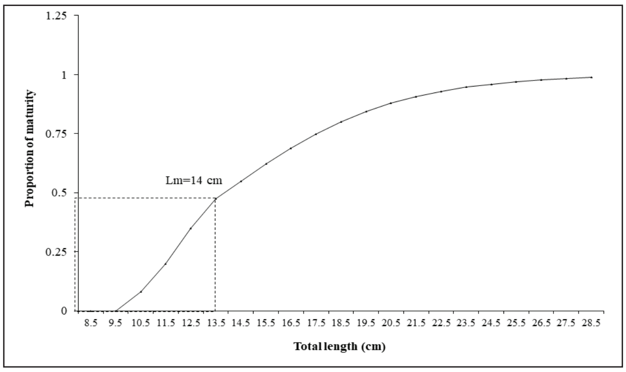

Fig. 8: Sexual maturity for females of *B. boops* ***caught in Oran Bay.***
Sl. 8: Spolna zrelost pri samicah bukve *(B. boops)****, ujete v Oranskem zalivu.***

female organs or maturation of their products before the appearance of the corresponding male product.

Evolution of the sex ratio in relation to length classes led us to establish that sexual inversion for this sparid occurs between 13 and 17 cm of total length, which is in accordance with observations made by other authors who studied the same species (Lamrini, 1998) (16 cm).

Investigation of the reproduction period of *B. boops* following a longitudinal evolution showed that (Tab. 2), generally, this species has one long spawning season that extends from January to July. Our findings in western Algerian coasts showed that the spawning period of this Sparidae species extends from January to July, peaking in spring period, which was already reported for this same bay by Bensahla-Talet *et al*. (1990), and Kherraz (2011), and for the Gulf of Annaba by Derbal & Kara (2008).

In central Algerian waters, this period seems to be shortened to 3 or 4 months, as reported for Algiers Bay (Chali-Chabane, 1988) and Bousmail Bay (Dieuzeide *et al*., 1955; Benina, 2015). The same finding was previously observed in the Gulf of Lion (Girardin, 1981), the Thyrrhenian Sea (Bottari *et al.,* 2014), in the Gulf of Tunis (Anato & Ktari, 1983), in Egyptian waters (Hassan, 1990), and in the Lebanese coasts (Mouneimne, 1978). The differences in the spawning period duration could be due to the inflow of Atlantic water through the Strait of Gibraltar, namely, regional differences in the time and duration of the spawning act of species in the Mediterranean basin can be related to biotic and abiotic factors, such as climate, hydro dynamism, temperatures, salinity, and food availability (Wootton, 1979; Pajuelo and Lorenzo, 2000; Mouine *et al.,* 2007; Tsikliras *et al.,* 2010). Gonçalves & Erzini, 2000, stated that the reproduction period is correspondingly much longer when environmental conditions are favorable. The upwellings and related zooplankton abundance can also affect many species reproduction (Parrish *et al*., 1981).

With regard to the length at first sexual maturity (Tab. 2) in Algerian waters, Derbal *et al*. (2007) found females to be mature at 13.5 cm; in Algiers Bay this length was reported at 13.5 cm (Chali-Chabane, 1988) and 14.6 cm (Benina, 2015), in Oran Bay between 12 and 14 cm, like in some other studies in the Mediterranean. Gordo (1995) and Monteiro *et al*., (2006) reported that length to be between 13 and 15.22 cm in Portuguese waters, while in Spanish waters Cano Fortuna & Sanchez Lizaso (1996) found it equal to 10.2 cm. In Italian coasts, Bottari *et al*. (2014) recorded it at 13.8 cm. In the Adriatic (Kasalica *et al*., 2011) this size was reported to be 11.5 cm TL. In Tunisian waters, the first sexual maturity was reached, by most of the population, at sizes between 14 and 18 cm. In Egyptian and Lebanese waters, this maturity was attained at 13 cm.

Most studies found this length to be comprised between 12 and 14 cm in the Mediterranean, except Bounhiol & Pron (1916) and Kherraz (2011), while in Atlantic waters the bogue seems to reach maturity later, at 17 cm (Lamrini, 1998; Monteiro *et al*., 2006; Massaro, 2012), probably due to environmental conditions, which differ from one habitat to another.

Environmental factors, such as temperature, salinity and food (Gonçalves & Erzini, 2000; Moutopoulos & Stergiou, 2002; Karakulak *et al*., 2006; Bottari *et al.,* 2014) are at the origin of the difference in size at first sexual maturity and in the spawning period between individuals of the same species from different geographic locations.

Mortier (1992), Taupier-Letage & Millot (1998), Salas *et al*. (2001) consider the Algerian current as the most energetic in the Mediterranean basin, conferring to Algerian waters their relative richness.

Tab. 2: Spawning season of* B. boops *in different areas.
Tab. 2: Obdobje drstenja pri bukvi (*B. boops*) v različnih predelih.

Region		J	F	M	A	M	J	J	A	S	O	N	D	Lm50%	Author
Portugal	Algarve		■	■	■	■								13-15	Gordo, 1995
	Peniche			■	■	■	■								
	Algarve		■	■	■	■								15.22	Monteiro *et al.*, 2006
Morocco	Gibraltar strait				■	■	■	■						15.40	Lamrini, 1998
	Beni Ensar Port		■	■	■	■	■	■	■					13.30	Layachi *et al.*, 2015
Spain	Port of Castellon				■	■								-	Zuniga, 1967
	Western Mediterranean			■	■	■								10.20	Cano Fortuna & Sanchez Lizaso, 1996
	Canary island	■	■	■	■	■								17.90	Massaro, 2012
France	Gulf of lion			■	■	■	■							10-20	Girardin, 1981
Algeria	Algerian coasts				■	■								17.20	Bounhiol & Pron, 1916
	Annaba Bay	■	■	■	■	■								13.50	Derbal *et al.*, 2007
	Algiers Bay			■	■	■	■							13.50	Chali-chabane, 1988
	Bousmail Bay		■	■	■									14.60	Benina, 2015
				■	■	■	■							-	Dieuzeide *et al.*, 1955
	Oran Bay	■	■	■	■	■	■	■						17.10	Kherraz, 2011
				■	■	■	■							11.70	Bensahla-Talet *et al.*, 1990
			■	■	■	■								13.30	Aoudjit, 2001
		■	■	■	■	■	■	■						14.00	Present study
Italy	Gulf of Naples			■	■	■								-	Lo Bianco, 1909
	Tyrrhenian Sea				■	■								-	Bini, 1968
			■	■	■									13.80	Bottari *et al.*, 2014
Tunisia	Gulf of Tunis			■	■	■	■							14-18	Anato & Ktari, 1983
Croatia	Adriatic Sea	■	■	■	■	■								-	Dobroslavić *et al.*, 2017
Montenegro		■	■	■	■	■								11.50	Kasalica *et al.*, 2011
Greece	Central Mediterranean		■	■	■	■								-	Vidalis, 1950
Egypt	Alexandria Bay		■	■	■									-	Hassan, 1990
		■	■	■	■	■								13.00	El Agamy *et al.*, 2004
Lebanon	Libanian coasts		■	■	■									13.00	Mouneimne, 1978

Important upwellings, which enhance the development of plankton, the first link of the aquatic food web, are generated by the entrance of Atlantic waters via the Strait of Gibraltar.

The MLS (Minimum Landing Size) set for *B. boops* at 15 cm of TL according to Algerian legislation (Executive Decree no. 2004-86 of 26 Muharram 1425, corresponding to 18 March 2004) (J.O.R.A.D.P, 2004), seems to be inadequate, given that it is too close to the length at first sexual maturity, as has been established during our study (14 cm). It would be recommendable to increase this length and set it at 18 cm, thus giving the opportunity to young females to contribute to and ensure the renewal of the resource.

CONCLUSIONS

The results obtained in the present study shed light on the reproductive biology of *B. boops* in the western Algerian coast. The bogue is of commercial importance to local and national fisheries. The ban on trawl fishery from 1 May to the 1 August as per Algerian legislation (Executive Decree no. 03-481a of 4 Rabi' al-Awwal 1425, corresponding to 24 April 2004), aiming to protect the renewal of the resources, is from our viewpoint insufficient to insure the set objective. We suggest an increase of the minimum landing size and the establishment of two closed fishing seasons per year to allow the renewal of multiple spawning species in Oran Bay and protect juvenile and adult spawners from overfishing.

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RAZVOJ GONAD PRI BUKVI, *BOOPS BOOPS* (LINNAEUS, 1758), IZ ORANSKEGA ZALIVA (TELEOSTEI, SPARIDAE)

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POVZETEK

Avtorji poročajo o reproduktivnem ciklu primerkov bukve Boops boops*, ujetih v Oranskem zalivu. Vzorce so z obravnavanega območja enkrat mesečno dostavili ribiči od januarja 2016 do decembra 2017. Spolni delež je bil v korist samic. Frekvenčna porazdelitev dolžine je pokazala, da so samice prevladovale pri dolžinah, večjih od 14 cm celotne dolžine, kar verjetno odraža začetek spolne inverzije, sicer že opisane pri tej vrsti špara. Obdobje drstenja, ki je bilo določeno na podlagi gonadosomatičnega indeksa, je bilo od februarja do poznega junija z vrhom v marcu in aprilu. Izsledki avtorjev prispevajo k boljšemu poznavanju razmnoževalnega cikla te vrste in bodo pomagali k pripravi ukrepov za primernejše upravljanje s staležem najbolj pogoste vrste špara, ki ga dnevno ribiči ulovijo v mnogih Sredozemskih državah in Alžiriji.*

Ključne besede: *Boops boops*, razmnoževalni cikel, sezone drstenja, velikost pri zrelosti, Oran, Alžirija

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NEW DISTRIBUTIONAL RECORDS OF *GOBIUS BUCCHICHI* (PISCES, GOBIIDAE) FROM THE MEDITERRANEAN SEA AND *IN SITU* COMPARISONS WITH *GOBIUS INCOGNITUS*

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ABSTRACT

We report for the first time the presence of Gobius bucchichi *from the coastal waters of three Mediterranean countries, namely Italy, Slovenia and Greece, thus increasing the knowledge on the distribution of this species in the Mediterranean Sea. We provide high quality in situ photos of the species, highlighting the main differences between similar species as a useful tool for in situ identification, which can be used for monitoring purposes. Habitat preferences, abundance and behaviour of* G. bucchichi *and similar species are also described. Comparisons with similar species, ecological notes, and the current distribution of* G. bucchichi *in the Mediterranean Sea are discussed.*

Key words: identification key, Mediterranean gobies, new records, Adriatic Sea, Aegean Sea, underwater photography

NUOVE SEGNALAZIONI DI *GOBIUS BUCCHICHI* (PISCES, GOBIIDAE) NEL MAR MEDITERRANEO E CONFRONTI *IN SITU* CON *GOBIUS INCOGNITUS*

SINTESI

Riportiamo per la prima volta la presenza di Gobius bucchichi *nelle acque costiere di tre nazioni mediterranee, ovvero Italia, Slovenia e Grecia, apportando nuove conoscenze sulla distribuzione di questa specie nel Mediterraneo. Forniamo anche foto della specie in ambiente di elevata qualità, evidenziando le principali differenze con le specie simili, fornendo quindi uno strumento utile per l'identificazione in situ della specie che può essere usato a fini di monitoraggio. Le preferenze di habitat, l'abbondanza e il comportamento di* G. bucchichi *e delle specie simili sono anch'essi descritti. Confronti con le specie simili, note ecologiche e l'attuale distribuzione di* G. bucchichi *nel Mediterraneo vengono discussi.*

Parole chiave: chiavi di identificazione, gobidi mediterranei, nuove segnalazioni, Adriatico, Egeo, fotografia subacquea

INTRODUCTION

Members of the family Gobiidae Cuvier, 1816, with more than 1900 valid species (Fricke *et al*., 2019), make up one of the largest fish families in the world (Nelson *et al*., 2016). The same is true for the Mediterranean Sea, where Gobiidae, with over 70 species, are the most speciose fish family (Patzner, 2019). However, despite the numerical dominance and ecological relevance of the family, data about ecology and distribution are, for most of the species, scarce and dated (Patzner, 1999; Kovačić *et al*., 2012; Ordines *et al*., 2019). Only in relatively recent times have there been studies considering some ecological aspects and only in certain species (Herler & Patzner, 2005; Kovačić & Pijevac, 2008; Kovačić *et al*., 2012; Tiralongo *et al*., 2020).

Most of the recently described gobies from the Mediterranean Sea are morphologically distinct species (Miller, 1992; Ahnelt & Patzner, 1995; Kovačić & Miller, 2000; Schliewen *et al*., 2019), and their late recognition is probably only due to their cryptobenthic nature and small size, or to their deeper habitat, like in the cases of *Buenia massutii* Kovačić, Ordines & Schliewen, 2017, *Gobius kolombatovici* Kovačić & Miller, 2000, *Lebetus patzneri* Schliewen, Kovačić & Ordines, 2019, and *Speleogobius llorisi* Kovačić, Ordines & Schliewen, 2016 (Kovačić & Miller, 2000; Tiralongo & Pagano, 2015; Kovačić *et al*., 2016; Kovačić *et al*., 2017; Schliewen *et al*., 2019). Hence, their identification *in situ* is relatively simple, yet limited to those species which can be directly observed by divers in the infralittoral (or upper circalittoral). However, *Gobius bucchichi* Steindachner, 1870, a shallow water species, was considered a widespread Mediterranean species until the recent discovery of *Gobius incognitus* Kovačić & Šanda, 2016, a very similar species, yet distinct in morphological, meristic and molecular traits (Kovačić & Šanda, 2016). According to this latter study, the current distribution of *G. bucchichi* appears to be restricted to the eastern Adriatic Sea (Croatia and Montenegro) and northern Ionian Sea (Albania), while *G. incognitus* is widely distributed in the Mediterranean Sea, having been reported from the western to the eastern part of the basin. In consideration of these new data, most, if not all, of the previous literature on *G. bucchichi* concerns *G. incognitus*, although new biological and ecological studies are needed to obtain data clearly attributable to either of the two species (Tiralongo *et al*., 2020).

With this paper we aim to increase the knowledge about the distribution of *G. bucchichi*, reporting first records from three countries and discussing the species distribution in the Mediterranean Sea. We also provide some ecological notes and underline the most important characters for the species identification *in situ*, highlighting above all the main differences with the very similar *G. incognitus*.

MATERIAL AND METHODS

Data were collected in summer during the period 2017–2019 in snorkeling surveys (with a duration of about 1.5 hour per survey) performed within the bathymetric range of 0–4 m at different locations of the Mediterranean Sea (Fig. 1): Piran (Slovenia; Adriatic Sea; 45.51725 N, 13.56823 E) in August 2017, Muggia (Italy, Adriatic Sea; 45.60577 N, 13.72073 E) in August 2018, and Kondyli beach (Greece; Aegean Sea; 37.53090 N, 22.93402 E) in July 2019. In each area we collected data about the abundance of *G. bucchichi*, the depth range in which the species was present and more abundant, and the habitat and contemporary presence of *G. incognitus* and any other similar species. Identification was based on the diagnostic characters that are visible *in situ* and on photographs (Kovačić & Svensen 2018). *Gobius bucchichi*, *G. incognitus* and *Gobius fallax* Sarato, 1889 differ from all other Mediterranean gobies in a lively coloration of the body and head, which is generally light, *i.e*., basically white with yellowish, greenish or greyish tones, and displaying longitudinal rows of darker dots. The identification characters for distinguishing *G. bucchichi* from *G. fallax in situ* and on photographs

Fig. 1: Updated distribution of Gobius bucchichi**; black circles indicate published records; red circles indicate new distributional records from Italy (Adriatic Sea), Slovenia (Adriatic Sea), and Greece (Aegean Sea).**
Sl. 1: Dopolnjena razširjenost vrste *Gobius bucchichi****; črni krogci označujejo objavljene zapise o pojavljanju; rdeči krogci označujejo nove podatke o razširjenosti v Italiji (Jadransko morje), Sloveniji (Jadransko morje), in Grčiji (Egejsko morje).***

Tab. 1: Main differences between** Gobius bucchichi **and** Gobius incognitus **useful for in situ identification. See Fig. 1 for photographic comparisons.

Tab. 1: Glavne razlike med vrstama** Gobius bucchichi **in** Gobius incognitus**, uporabne za razlikovanje na mestu samem. Glej Sl. 1 za fotografsko primerjavo.

	Gobius bucchichi **Steindachner, 1870**	***Gobius incognitus*** **Kovačić & Šanda, 2016**
Dots on cheeks	Usually only two longitudinal rows of dots, with a large dot-free area at the center. In some cases, very close small dots can be present in the central and anterior part of the cheeks. The lower row start behind the corner of the mouth, with two horizontally elongated dots.	Three longitudinal rows of dots, with the central one close to the lower one, parallel to each other. The dots of the central row are very variable in number and are often irregular in shape. The lower row start with a dot on the corner of the mouth.
Dots of the midlateral line	Marked, well aligned and distinct.	Often fused to form larger dark blotches separated by spaces.
Background body color	Uniform, pale yellowish.	Light greenish-grey, often with alternate slightly light and dark areas on the dorsal surface.

are presented in the Results and Discussion section as original contributions. The diagnostic characters for *in situ* distinguishing between *G. bucchichi* and *G. incognitus* are original contributions presented in Table 1. At every reported locality specimens of both species were photographed to record their presence in high quality photos that preserve all the main valid and useful qualities for distinguishing the two species *in situ* (Tab. 1).

RESULTS AND DISCUSSION

In Piran (Slovenia), the mixed sea bottom was characterized by the presence of silt and large boulders (diameter > 1 m). In this area, *G. bucchichi* was quite rare: in a total of 4 surveys with a duration of about 1.5 hours each, only 1–3 medium-sized specimens per survey were observed, at a depth of about 3 m. During the surveys, no specimens of *G. incognitus* were encountered, instead, a massive presence of another similar species, *Gobius fallax* Sarato, 1889, was observed. All the specimens of this latter species were large.

In Muggia (Italy), the nature of the sea bottom was similar to that of Piran. In this area, about 10 specimens per survey of *G. bucchichi* were observed. Most of them were of large size and observed at a depth of 2–4 m. Again, no specimens of *G. incognitus* were observed, while *G. fallax* was quite abundant.

At Kondyli beach (Greece), the mixed bottom was composed of coarse sand and boulders. In this area, some 15 medium-sized specimens per survey of *G. bucchichi* were observed, at a depth of 1–1.5 m (Fig. 2A). Contrarily to the other two locations investigated, we recorded the presence of *G. incognitus*. The size range of the specimens of *G. incognitus* observed was from 4 to 8 cm in total length (TL). While *G. bucchichi* was aggregated in groups of several individuals, the specimens of *G. incognitus* exhibited a more scattered distribution.

In all the locations, the specimens of *G. bucchichi* were observed in sheltered environments, such as small bays, rather than in more exposed surrounding areas with increased wave action. Furthermore, *G. bucchichi*, unlike *G. incognitus*, was never observed associated with *Anemonia viridis* (Forsskål, 1775). On the other hand, this association is common for *G. incognitus*: when it feels threatened it seeks protection among the tentacles of the sea anemone (Tiralongo *et al.*, 2020).

Gobius bucchichi and *G. incognitus* are similar to *G. fallax* (Fig. 2E). However, *G. bucchichi* is distinguished from *G. fallax* by several traits: 1. *G. fallax* presents a stouter body; 2. with the exception of the larger dots along the midlateral line, similar in the two species, the longitudinal lines of brown dots are aligned and well-defined in *G. fallax* (very numerous and tighter in the dorsal area), looking more as interrupted lines or rows of dashes than rows of dots. In *G. bucchichi*, these longitudinal lines are composed of fewer and less aligned brown dots; 3. In *G. fallax*, the dots on the cheeks are not so well-defined as in *G. bucchichi*; 4. *Gobius fallax* displays a "neutral buoyancy" or hyperbenthic position, sometimes staying suspended 10–30 cm above the sea floor or having only a few contact points when resting on the bottom; contrariwise, *G. bucchichi* (and *G. incognitus*) always rests on the bottom. In Table 1, we report all the main differences between *G. bucchichi* and *G. incognitus* useful for *in situ* identification (see Fig. 2A–D for photographic comparisons).

This work reports for the first time the presence of *G. bucchichi* from three new Mediterranean areas: Italy (Adriatic Sea), Slovenia (Adriatic Sea), and Greece (Aegean Sea). Hence, the species shows a wider distribution than previously reported and restricted to the eastern Adriatic Sea and the Albanian Ionian Sea. However, compared to the similar species *G. incognitus* and in agreement with Kovačić & Šanda (2016), the distribution of *G. bucchichi* appears to be significantly more

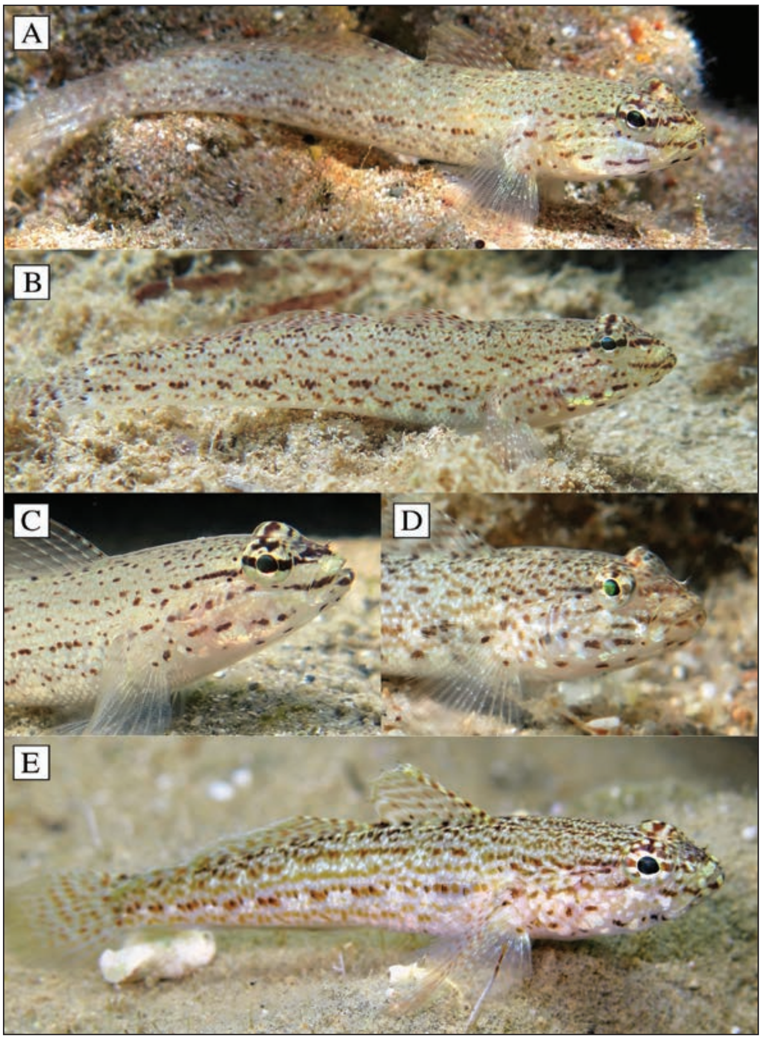

Fig. 2: *Gobius bucchichi*, **specimen from Greece, 15 July 2019 (A);** *Gobius incognitus*, **specimen from Greece, 10 September 2018 (B); detail of the head of** *G. bucchichi*, **specimen from Italy, 24 August 2018 (C); detail of the head of** *G. incognitus*, **specimen from Italy, 22 June 2016 (D);** *Gobius fallax*, **specimen from Croatia, 29 May 2013 (E).**

Sl. 2: *Gobius bucchichi*, **primerek iz Grčije, 15. julij 2019 (A);** *Gobius incognitus*, **primerek iz Grčije, 10. september 2018 (B); detajl glave pri vrsti** *G. bucchichi*, **primerek iz Italije, 24. avgust 2018 (C); detajl glave pri vrsti** *G. incognitus*, **primerek iz Italije, 22. junij 2016 (D);** *Gobius fallax*, **primerek iz Hrvaške, 29. maj 2013 (E).**

limited. Indeed, we failed to detect the presence of *G. bucchichi* in many other locations throughout the Italian seas (with the exception of the northernmost part of the Adriatic) and in Greek waters (Cephalonia, Methoni, Elafonissos, Sithonia, Andros, Paros, Antiparos, Shinoussa, Milos, Kimolos and the Pagasetic Gulf), where we recorded the presence of *G. incognitus* only. We also analysed our photos taken before 2016 in other Greek locations, namely Limnos, Karpathos, Crete, Skiathos, Naxos, Koufonisia, and Donoussa, and the only photographed species was again *G. incognitus*.

Although the differences between the two species (*G. bucchichi* vs. *G. incognitus*) are not very pronounced, an accurate *in situ* examination in most cases allows a reliable identification. Based on the recent discovery of *G. incognitus* (Kovačić & Šanda, 2016), further targeted studies in other Mediterranean areas are necessary in order to expand our knowledge about the true distribution of *G. bucchichi* in the Mediterranean Sea (but also in the Marmara and Black Seas), and about the ecological factors affecting its distribution. *Gobius bucchichi* seems to prefer more sheltered habitats than *G. incognitus*, such as small bays. Furthermore, the former species shows a more gregarious behaviour than the latter one. The current distribution of *G. bucchichi* still appears to be confined to the north of the central-eastern part of the Mediterranean Sea, where the species is usually sympatric with *G. incognitus*. *Gobius incognitus*, on the other hand, appears to be a ubiquitous Mediterranean species.

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NOVI PODATKI O RAZŠIRJENOSTI VRSTE GLAVAČA *GOBIUS BUCCHICHI* (PISCES, GOBIIDAE) IZ SREDOZEMSKEGA MORJA IN *IN SITU* PRIMERJAVE Z VRSTO *GOBIUS INCOGNITUS*

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POVZETEK

Avtorja poročata o prvem pojavljanju vrste glavača Gobius bucchichi *v obalnih vodah treh sredozemskih držav, Italije, Slovenije in Grčije in na ta način prispevata k poznavanju razširjenosti te vrste v Sredozemskem morju. V prispevku objavljata visokokakovostne fotografije, posnete na mestu samem in podajata glavne razlike med podobnimi vrstami, kar je uporabno orodje za identifikacijo na mestu samem in uporabno za namene monitoringa. Opisujeta habitatne preference, abundanco in vedenje vrste* G. bucchichi *in sorodnih vrst. Nadalje razpravljata o primerjavi vrste s sorodnimi vrstami, ekološke beležke in razširjenost vrste v Sredozemskem morju.*

Ključne vrste: ključ za določanje, sredozemski glavači, novi zapisi o pojavljanju, Jadransko morje, Egejsko morje, podvodna fotografija

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OCCURRENCE OF *SCARUS GHOBBAN* (SCARIDAE) AT THE BORDER OF THE AEGEAN SEA (KAŞ, TURKEY)

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ABSTRACT

A single specimen of Scarus ghobban *was caught on 5 May 2020 by a trammel net in the shallows off Cape Uluburun, southeast of Kaş, at a depth of 35 m. This ichthyological note is the second north-westernmost report of* S. ghobban *in the Levantine Sea since its recording at Kastellorizo, an island located close to Cape Uluburun. Only twelve records of* S. ghobban *since 2001 suggest that this species is still rare in the Mediterranean.*

Key words: Scaridae, north-westernmost record, Cape Uluburun, Mediterranean Sea

PRESENZA DI *SCARUS GHOBBAN* (SCARIDAE) AL CONFINE DEL MAR EGEO (KAŞ, TURCHIA)

SINTESI

Un esemplare di Scarus ghobban *è stato catturato il 5 maggio 2020 da un tramaglio nelle secche al largo di Capo Uluburun, a sud-est di Kaş, ad una profondità di 35 m. Questa nota ittiologica rappresenta il secondo avvistamento di* S. ghobban *più a nord-ovest nel Mar Levantino dalla sua segnalazione a Kastellorizo, un'isola situata vicino a Capo Uluburun. Dal 2001 sono stati riportati solo dodici avvistamenti di* S. ghobban*, il che suggerisce che questa specie sia ancora rara nel Mediterraneo.*

Parole chiave: Scaridae, record a nord-ovest, Capo Uluburun, Mediterraneo

INTRODUCTION

The Scaridae family (parrotfishes) consists of 83 species. Two of them are also present in the Mediterranean, one being a Lessepsian migrant (Golani *et al.*, 2006). *Scarus ghobban* Forsskål, 1775 entered the Mediterranean from the Red Sea via the Suez Canal (Golani *et al.*, 2006). Initially, only a few specimens were reported off Israeli and Lebanese coasts (Golani *et al.*, 2006). The species is widely distributed over the Indo-Pacific region (Golani *et al.*, 2006), including the Persian Gulf, the Red Sea and Algoa Bay, South Africa, southern Japan, and other regions, such as the New South Wales, Gulf of California, Ecuador, and Eastern Mediterranean (Froese & Pauly, 2019).

Since the first record of *S. ghobban* in the Mediterranean Sea in 2001, from the Shiqmona coast, Israel (Goren &Aronov, 2002), the fish has expanded its range from Beirut, Lebanon (Bariche & Saad, 2008), to Kastellorizo Island, which is close to the location of the present study (Apostolopoulos & Karachle, 2016). The successive records are shown in Figure 1. This ichthyological note presents the second north-westernmost record of *S. ghobban* in the Levantine Sea.

Fig. 1: Successive records of *Scarus ghobban* **from the Mediterranean Sea: (1) 20 Oct. 2001, Shiqmona, Israel (Goren & Aranov, 2002), (2) 20 Sept. 2004, Shiqmona, Israel (Golani & Levy, 2005), (3) 9 Nov. 2004, Beirut, Lebanon (Bariche & Saad, 2008), (4) 7 Feb. 2010, Zygi, Cyprus (Ioannou et al., 2010), (5) 20 July 2013, Iskele City, Northern Cyprus (Filiz & Sevingel, 2014), (6) 6 Aug. 2013, Keldag coast, Iskenderun Bay (Turan et al., 2014), (7) Sept. 2014, Kastellorizo Island, Greece (Apostolopoulos & Karachle, 2016), (8) July 2012 - Aug. 2016, Tartus, Syria (Soliman et al., 2018), (9) 20 Dec. 2015, Yeşilovacık Bay, Mersin (Yaglıoglu & Ayas, 2016), (10) 24 Dec. 2016, Gazipaşa, Antalya (Ergüden et al., 2018), (11) 22 Dec. 2018, Mina Hasheesh Beach, Egypt (Al Mabruk et al., 2020), (12) 5 May 2020, present study.**

Sl. 1: Zapisi o pojavljanju vrste *Scarus ghobban* **v Sredozemskem morju: (1) 20. okt. 2001, Shiqmona, Izrael (Goren & Aranov, 2002), (2) 20. sept. 2004, Shiqmona, Izrael (Golani & Levy, 2005), (3) 9. nov. 2004, Bejrut, Libanon (Bariche & Saad, 2008), (4) 7. feb. 2010, Zygi, Ciper (Ioannou et al., 2010), (5) 20. jul. 2013, Iskele City, severni Ciper (Filiz & Sevingel, 2014), (6) 6. avg. 2013, obala Keldag, Zaliv Iskenderun (Turan et al., 2014), (7) sept. 2014, otok Kastellorizo, Grčija (Apostolopoulos & Karachle, 2016), (8) julij 2012 - avg. 2016, Tartus, Sirija (Soliman et al., 2018), (9) 20. dec. 2015, zaliv Yeşilovacık, Mersin (Yaglıoglu & Ayas, 2016), (10) 24. dec. 2016, Gazipaşa, Antalya (Ergüden et al., 2018), (11) 22. dec. 2018, plaža Mina Hasheesh, Egipt (Al Mabruk et al., 2020), (12) 5. maj 2020, pričujoče delo.**

Fig. 2:** Scarus ghobban**, captured off Cape Uluburun, Kaş, Turkey (Scale bar: 50 mm).
Sl. 2:** Scarus ghobban**, ujet pri rtu Uluburun, Kaş, Turčija (Merilo: 50 mm).

MATERIAL AND METHODS

On 5 May 2020, one specimen of *Scarus ghobban* was caught by a trammel net in the shallows off Cape Uluburun, Kaş (lat. 36°08.130 N, long. 29°40.394 E, Fig. 1), on the south-western coast of Turkey, at a depth of 35 m. The sample (Fig. 2), fixed in a 6% formaldehyde solution, has been preserved in the fish collection of the Fisheries Faculty, Ege University (ESFM-PIS/2020-01).

Tab. 1: Morphometric measurements as percentages of total length and meristic counts recorded in the** Scarus ghobban **captured off Cape Uluburun, Kaş, Turkey.
Tab. 1: Morfometrične meritve, izražene kot delež celotne dolžine telesa, in meristična štetja pri primerku vrste** Scarus ghobban**, ujetem pri rtu Uluburun, Kaş, Turčija.

Measurements	**Size (mm)**	**Proportion (TL%)**
Total length (TL)	501	
Standard length (SL)	412	82.2
Pre-dorsal fin length	138	27.5
Pre-anal fin length	248	49.5
Pre-pectoral fin length	115	22.9
Interorbitary length	48	9.6
Head length	130	25.9
Eye diameter	15	3.0
Preorbitary length	47	9.4
Meristic counts		
Dorsal fin rays	IX-9	
Anal fin rays	III+9	
Ventral fin rays	I+5	
Pectoral fin rays	15	
Weight (g)	1830	

RESULTS AND DISCUSSION

The morphological description, colour, morphometric measurements with percentages of total length and meristic counts, as presented in Table 1, are in agreement with Golani *et al*. (2006), Froese & Pauly (2019), Ergüden *et al*. (2018). Two distinctive features of *S. ghobban* are its teeth, in both jaws fused to form dental plates with a median suture, and three rows of scales on the cheek.

Scarus ghobban inhabits rocky habitats in shallow waters and feeds on the algae it scrapes off rocks and corals (Golani *et al*., 2006; Froese & Pauly, 2019). *S. ghobban* is usually found in shallow waters at depths of 1-100 m (see Ergüden *et al*., 2018 and references therein) along the eastern Mediterranean. In this study, the specimen was captured in the shallows off Cape Uluburun. It is not known yet how *S. ghobban* crosses Cyprus, but ships could be a possible vector. Finally, it seems that *S. ghobban* is still rare in the Mediterranean, as only twelve intermittent records in various sites in the eastern Mediterranean have been reported since 2001. Seeing that this Lessepsian fish has settled only 100 km away from the Aegean Sea, we expect it will shortly occur in that area as well.

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POJAVLJANJE MODROPROGASTE MORSKE PAPIGE (SCARIDAE) NA MEJI EGEJSKEGA MORJA (KAŞ, TURKEY)

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POVZETEK

Primerek modroprogaste papige, Scarus ghobban*, je bil ujet 5. maja 2020 v trislojno mrežo v plitvinah rta Uluburun, jugovzhodno od Kaşa, na globini 35 m. Ta ihtiološki zapis je po pojavu te vrste pri otoku Kastellorizo blizu rta Uluburun, drugi najbolj severozahodni zapis o pojavu vrste* S. ghobban *v Levantskem morju. Doslej je bilo zabeleženih 12 zapisov o pojavljanju te vrste v Sredozemskem morju, kar kaže na to, da je vrsta še vedno redka.*

Ključne besede: Scaridae, skrajni severozahodni zapis, Rt Uluburun, Sredozemsko morje

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ABUDEFDUF CF. *SAXATILIS* IN THE SARONIKOS GULF, GREECE: UNAIDED INTRODUCTION OR HUMAN AIDED TRANSFER?

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ABSTRACT

One specimen of the sergeant-major fish Abudefduf *sp., provisionally named* Abudefduf *cf.* saxatilis *(Linnaeus, 1758) was observed for the first time in the Saronikos Gulf, Greece in summer 2020. Its distinctive characteristics and potential mode of introduction in the Gulf, whether unaided or man induced transfer, are discussed.*

Key words: *Abudefduf* sp., new record, Saronikos Gulf, crypto-expanding species, citizen science

ABUDEFDUF CF. *SAXATILIS* NEL GOLFO DI SARONICO IN GRECIA: INTRODUZIONE ACCIDENTALE O INTENZIONALE DA PARTE DELL'UOMO?

SINTESI

Un pesce appartenente al genere Abudefduf*, provvisoriamente identificato come* Abudefduf *cf.* saxatilis *(Linnaeus, 1758) è stato osservato per la prima volta nel Golfo di Saronico, in Grecia, nell'estate del 2020. Nell'articolo vengono discusse le caratteristiche distintive dell'esemplare e la potenziale via di introduzione nel Golfo, sia accidentale che intenzionale da parte dell'uomo.*

Parole chiave: *Abudefduf* sp., nuova segnalazione, Golfo di Saronico, specie in cripto-espansione, citizen science

INTRODUCTION

The Saronikos Gulf is a hot spot for alien species in Greek waters (Zenetos *et al*., 2018) with many species introduced by vessels. Of the seven introduced species of the family Pomacentridae reported in the Mediterranean *(*Osca *et al.,* 2020*),* only two species of the genus *Abudefduf* are known from Greek waters to date. These are: *Abudefduf sexfasciatus* (Lacepède, 1801) reported from the Saronikos Gulf (Aegean Sea) (Giovos *et al*., 2018), and *Abudefduf vaigiensis* (Quoy & Gaimard, 1825) reported from Kythira island (Ionian Sea) (Pirkenseer, 2020). Here we report on the presence of an alleged third species and discuss its potential mode of introduction.

MATERIAL AND METHODS

A collaboration agreement between the Archipelagos Institute of Marine Conservation (https://archipelago.gr/en/) and the Ellenic network on Aquatic Alien Species (ELNAIS: Zenetos *et al*., 2015) in raising public awareness on marine alien species was initiated in 2015.

As a result, many new records provided by citizen scientists have filled in distribution gaps for some of the most invasive species in Greek waters or added new records in Greek waters (Miliou & Loudaros in Ragkousis *et al*., 2020). Here we report on one new record provided by a citizen scientist (Ms. Mairi D. Aga) in September 2020. The report was accompanied by 2 photographs. Identification of the species was confirmed by the ELNAIS expert Maria Corsini-Foka.

RESULTS AND DISCUSSION

On August 23rd 2020, a single specimen of *Abudefduf* was photographed along the south coast of Salamina island (Lat 37.877240, Long. 23.442463) at 2 m depth, during a snorkeling session. The species was tentatively identified as *A. saxatilis* (Linnaeus, 1758).

Abudefduf saxatilis is a tropical and subtropical fish of Atlantic origin that has become a commonly encountered species along the Israel coasts (Tsadok *et al*., 2015). The first occurrence of *A. saxatilis* in the Mediterranean Sea was reported by Azzurro *et al.* (2013) from Spain. Subsequent records are from Malta (Deidun & Castriota, 2014; Vella *et al*., 2016); Turkey (Bilecenoglu, 2016); Israel (Tsadok *et al*., 2015) Italy (Lipej *et al.,* 2019); Slovenia (Lipej *et al.,* 2019); and Libya (Osca *et al*., 2019). For a detailed account of their Mediterranean distribution, see Lipej *et al.* (2019).

Abudefduf saxatilis has been confused in the past with *A. vaigiensis*. The meristic counts and morphometric parameters of two species overlap a lot. As illustrated in Lipej *et al.* (2019) *Abudefduf saxatilis* is morphologically distinguished from *A. vaigiensis* by the following characteristics:

a. 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;
b. the continuous extension of the fifth dark vertical bar from the origin of the dorsal fin to the anal fin in *A. saxatilis*, which is shorter and

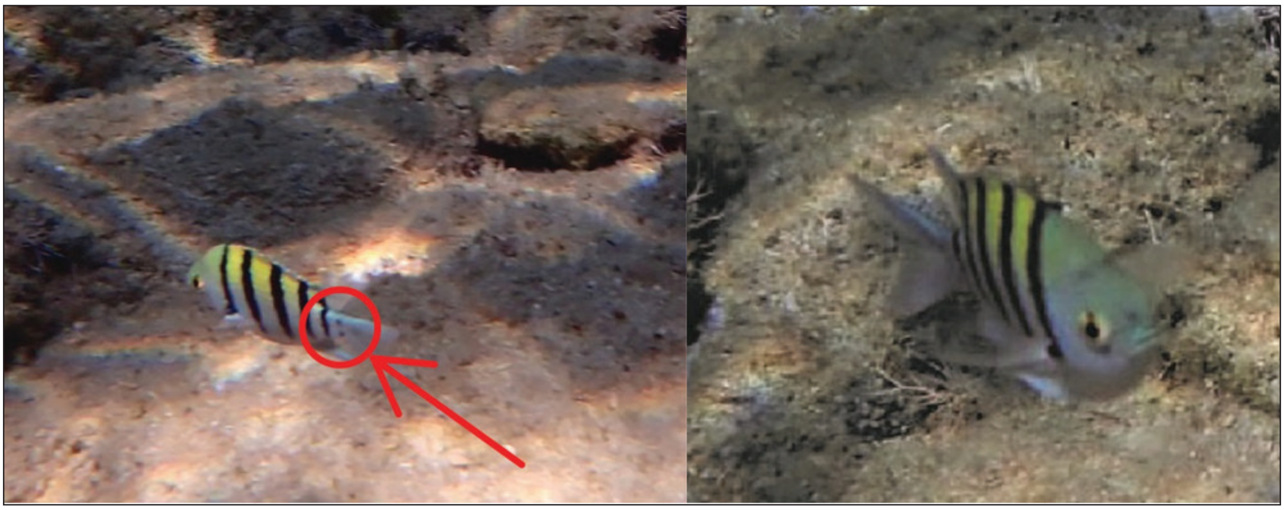

Fig. 1: *Abudefduf* ***cf.*** *saxatilis* ***from Salamina Island. The arrow indicates the two black spots that are the distinguishing features of the species (Photo credit: Mairi D. Aga).***

Sl. 1: *Abudefduf* ***cf.*** *saxatilis* ***iz otoka Salamina. Puščica označuje dve črni piki na repnem korenu, po katerem lahko to vrsto prepoznamo (Foto: Mairi D. Aga).***

discontinued in *A. vaigiensis* and is located on the caudal peduncle;

c. the presence of two black spots on the caudal peduncle (Fig. 1), which are absent in *A. vaigiensis*.

However, some researchers go as far as doubting the presence of consistent meristic or morphometric differences (see Deidun & Castriota, 2014; Osca *et al*., 2019) and, therefore molecular analysis is needed to confirm the correct identification of the species. In the absence of concrete data (only photographic evidence is available) we have provisionally named our finding *Abudefduf* cf. *saxatilis* (Linnaeus, 1758).

The presence of *Abudefduf* cf. *saxatilis* in the Saronikos Gulf cannot be attributed with certainty to any particular pathway because many potential pathways/vectors could be implicated (range expansion, vessel transfer, release from an aquarium). Considering that the closest record is that of Çandarlı bay, Turkey, east Aegean Sea (Bilecenoglu, 2016), and that other alien fishes attributed to aquaria releases have been recorded recently from the Saronikos area (Giovos *et al*., 2018; Karachle *et al*. in Bariche *et al*., 2020), the most plausible explanation is that of release from an aquarium. This is the first record of the species in Greek waters. If its occurrence is due to ship transfer or to an aquarium release (pathways questioned by Lipej *et al*., 2019), it should be considered a new alien species for the area. Evans *et al*. (2020) classify *A. saxatilis* as a range expanding species (unaided introduction via the Gibraltar Strait, since there are at least three records which show an eastward progression in the Mediterranean). We provisionally classify it as crypto-expanding until molecular phylogenetic analysis shed more light.

In case it proves to be a man-induced transfer, it will be added to the list of alien species in the Mediterranean, which according to the latest update includes 666 established species (Zenetos & Galanidi, 2020).

This is yet another case evidencing the potential of citizen scientists to revealing the undetected as highlighted by Azzurro *et al*. (2013), who reported the first finding of *A. saxatilis* from Spain.

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We wish to thank Ms. Mairi D. Aga for providing the information and photographs, and Maria Corsini-Foka for confirming the species identification of the species.

ABUDEFDUF CF. *SAXATILIS* V ZALIVU SARONIKOS (GRČIJA): NENAMEREN ALI NAMEREN VNOS?

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POVZETEK

Primerek seržanta Abudefduf *sp., ki sta ga avtorici provizorično poimenovali kot* Abudefduf *cf.* saxatilis *(Linnaeus, 1758), je bil poleti 2020 prvič opažen v zalivu Saronikos (Grčija). Avtorici razpravljata o razlikovalnih znakih in možnem načinu prihoda te vrste v zaliv v smislu namernega (antropogenega) ali nenamernega vnosa.*

Ključne besede: *Abudefduf* sp., novi zapis o pojavljanju, zaliv Saronikos, prikrito razširjajoča se vrsta, ljubiteljska znanost

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JADRANSKA MORSKA BIODIVERZITETA

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AFTER MORE THAN FORTY-FIVE YEARS A NEW FINDING OF *CYSTOSEIRA FOENICULACEA* F. *LATIRAMOSA* IN THE COASTAL SEA OF SLOVENIA

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ABSTRACT

Canopy-forming macroalgae, especially Cystoseira sensu lato *species, create so-called brown algal forests, which are among the most productive habitats in shallow coastal waters. In the Mediterranean Sea these species have been disappearing over the past two decades due to multiple anthropogenic pressures, and are gradually being replaced by smaller and persistent turf-forming algae. A decrease in the number of species and in the cover of canopy-forming taxa (especially* Cystoseira s.l. *spp.) has been detected over the last ten years also in Slovenian coastal waters. This paper reports a recent finding of* Cystoseira foeniculacea *f.* latiramosa*, which was missing from Slovenian marine waters for more than four decades.*

Key words: *Cystoseira foeniculacea* f. *latiramosa*, new finding, Slovenian sea

DOPO OLTRE 45 ANNI UN NUOVO RITROVAMENTO DI *CYSTOSEIRA FOENICULACEA* F. *LATIRAMOSA* NELLE ACQUE COSTIERE DELLA SLOVENIA

SINTESI

Le macroalghe che modellano la canopia, in particolare le specie di Cystoseira sensu lato*, formano le cosiddette foreste di alghe brune, considerate tra gli habitat più produttivi nelle acque costiere poco profonde. Negli ultimi due decenni queste specie stanno scomparendo dal Mediterraneo e vengono gradualmente sostituite da alghe più piccole e persistenti, che formano un tappeto chiamato turf, a causa delle molteplici pressioni antropiche. Anche nelle acque costiere slovene negli ultimi dieci anni è stata registrata una diminuzione del numero di specie e della copertura dei taxa che formano la canopia (soprattutto* Cystoseria s.l. *spp.). L'articolo riporta il recente ritrovamento di* Cystoseira foeniculacea *f.* latiramosa*, che mancava dalle acque marine slovene da più di quattro decenni.*

Parole chiave: *Cystoseira foeniculacea* f. *latiramosa*, ritrovamento, mare sloveno

INTRODUCTION

Along Mediterranean rocky coasts, canopy-forming brown *Cystoseira sensu lato* species (Orellana *et al*., 2019) play an important role as habitat-builders (Gianni *et al.,* 2013; Blanfuné *et al*., 2019). They form so-called brown algal forests, which are considered among the most productive assemblages in the Mediterranean basin, providing high primary production, food sources, settlement substrata, and shelter for coastal fish assemblages, diverse smaller algae and invertebrates (Orlando-Bonaca & Lipej, 2005; Ballesteros *et al*., 2009; Pitacco *et al*., 2014; Bianchelli *et al.,* 2016).

Forty-one taxa of long-living *Cystoseira s.l.* spp. have been reported for the Mediterranean Sea (Taşkin *et al*., 2012; Cormaci *et al*., 2012). With the exception of *Cystoseira compressa* (Esper) Gerloff & Nizamuddin, all *Cystoseira s.l.* spp. are included in Annex II (List of endangered or threatened marine species in the Mediterranean) of the Barcelona Protocol concerning Specially Protected Areas and Biological Diversity (UNEP, 2019), and in Annex I of the Bern Convention (Council of Europe, 1979).

Especially in the past two decades, many scientists have evaluated the impact of interacting anthropogenic local stressors on coastal ecosystems (Airoldi & Bulleri, 2011; Catra *et al*., 2019). The disappearance of *Cystoseira s.l.* species from shallow rocky bottoms is considered an indication of severe environmental degradation (Iveša *et al.,* 2016; Rindi *et al.,* 2018). Due to incessant anthropogenic pressure, *Cystoseira s.l.* spp. are very often replaced by smaller and less complex algae defined as turf-forming taxa (Perkol-Finkel & Airoldi, 2010). These low-lying algae form a permanent stable state on the bottom, which inhibits the recolonization by canopy-forming species (Gorman *et al.,* 2009; Connell *et al.,* 2014). Some *Cystoseira s.l.* species have already been driven to regional extinction (Thibaut *et al.,* 2015), and despite the implementation of substantial conservation measures, numerous degraded brown algal forests in the Mediterranean Sea have not recovered (Thibaut *et al*., 2005; Perkol-Finkel & Airoldi, 2010).

Fig. 1: Sampling site Rex1 between Koper and Isola, where three thalli of *Cystoseira foeniculacea* ***f.*** *latiramosa* ***were recorded.***
Sl. 1: Vzorčno mesto Rex 1 med Koprom in Izolo, kjer so bile opažene tri steljke vrste *Cystoseira foeniculacea* ***f.*** *latiramosa****.***

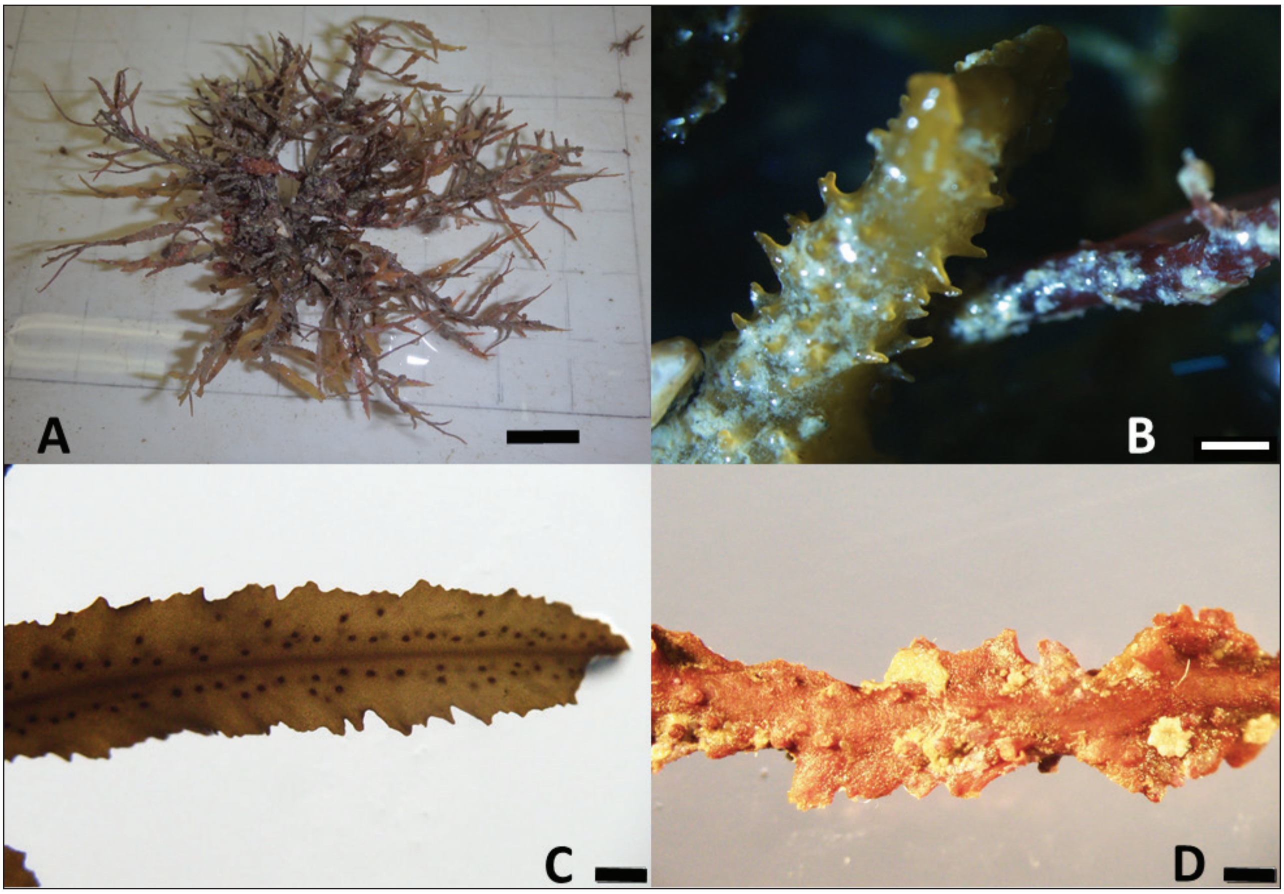

Fig. 2: *Cystoseira foeniculacea* ***f.*** *latiramosa* ***(Slovenia, July 2020, depth range: 3.7-4.3 m). A. Habit (scale bar = 2 cm). B. Spinose apex (scale bar = 1 mm). C. Toothed margin and prominent midrib (scale bar = 1 mm). D. Base of the branches (scale bar = 1 mm).***

Sl. 2: *Cystoseira foeniculacea* ***f.*** *latiramosa* ***(Slovenija, julij 2020, globina: 3,7-4,3 m). A. Videz steljke (merilo = 2 cm). B. Trnast apikalni del (merilo = 1 mm). C. Nazobčan rob in vidna srednja linija (merilo = 1 mm). D. Spodnji del veje (merilo = 1 mm).***

Over the past ten years, negative changes in macrophyte spatial and seasonal diversity and a loss in the cover of canopy-forming taxa (especially *Cystoseira s.l.* spp.) have been detected in Slovenian coastal waters as well (Orlando-Bonaca & Rotter, 2018). Still recurrent in the infralittoral belt are *Treptacantha barbata* (Stackhouse) Orellana & Sansón and *C. compressa*, while other species of this group are already rare. Among the actions planned within a research project related to the evaluation of the status of Adriatic brown algal forests (ARRS, J1-1702) were also to verify the status and distribution of brown algal forests in Slovenian coastal waters, identify the causes of their regression, and propose conservation measures. The current paper reports a recent finding of *Cystoseira foeniculacea* f. *latiramosa* (Ercegovic) A. Gómez Garreta, M.C. Barceló, M.A. Ribera & J.R. Lluch, a species that was missing from Slovenian waters for over four decades.

MATERIAL AND METHODS

The study area is located in the Gulf of Trieste, which is a shallow semi-enclosed embayment extending from Cape Savudrija (Croatia) to Grado (Italy) and comprising the entire Slovenian Sea. Non-destructive SCUBA visual surveys were performed during the years 2019 and 2020 along the rocky coastline, where brown algal forests are still present, within a depth range of 1 m to 10 m. Three thalli of *C. foeniculacea* f. *latiramosa* were found and one was collected on July 27, 2020 at sampling site Rex1 (Fig. 1), in a depth range between 3.7 m and 4.3 m. The plant is stored in the collection of the Marine Biology Station in Piran.

RESULTS AND DISCUSSION

Originally documented in the Adriatic Sea by Ercegović (1952), *C. foeniculacea* f. *latiramosa* had been reported in Slovenian waters only once, in the Strunjan Bay in the year 1972 (Avčin *et al*., 1973). Since 1929, it has been found along western and eastern Mediterranean coasts (historical and newer records reported in Cormaci *et al*., 2012; Rodríguez-Prieto *et al*., 2013; Bouafif *et al*., 2014), but nowadays it is considered rare and endangered, and has already disappeared from some Mediterranean areas (Thibaut *et al*., 2015). Iveša & Devescovi (2015) reported of some small thalli of the species found along the nearest western Istrian coast of Croatia, but just a year later (Iveša et al., 2016) they only reported the presence of *Cystoseira foeniculacea* f. *schiffneri* (currently accepted as *Cystoseira schiffneri* Hamel).

In summer 2020, three thalli of *C. foeniculacea* f. *latiramosa* were found growing in a biocenosis of a photophilic infralittoral algal community on rocky substrate, at site Rex 1 (Fig. 1). These arborescent and epilithic thalli were attached to the rocky substrate by an irregular holdfast. The plant presented as caespitose, up to 15 cm high, with a light to dark brown colour (Fig. 2). The erect axes were cylindrical and spinose, the apices prominent and spinose. Branches were flattened, with a toothed margin and a prominent midrib. Aerocysts and receptacles were not observed. Despite the lack of reproductive organs, the thalli found matched well with the original classification of *C. foeniculacea* f. *latiramosa* (Ercegović, 1952, p. 93, pl. XXVIIa, as *C. discors* subsp. *latiramosa*), and with later reports (Cormaci *et al*., 2012; Bouafif *et al*., 2014).

Although *C. foeniculacea* f. *latiramosa* was previously reported as a typical deep-sea form (from depths over 30 m) (Ercegović, 1952; Rodríguez-Prieto *et al*., 2013), the thalli collected in Slovenian waters were found growing in the upper infralittoral belt, in low-light conditions due to the high resuspension rate of sediments in this area (Orlando-Bonaca *et al*., 2015).

According to the requirements of the Water Framework Directive, a regular monitoring programme for macroalgae has been in progress in Slovenian coastal waters since 2006 (Orlando-Bonaca & Rotter, 2018). Additional samples of macroalgae were collected for various research projects from the seventies of the last century to up to the present day, in a depth range from 1 to 8 m. Since *C. foeniculacea* f. *latiramosa* was never found in any of these samples, we assume the species may have reappeared recently. Given the high relevance of *Cystoseira* spp. and due to their confirmed rapid regression in the Mediterranean basin, every new record (of recolonization or extension of the area) of rare or endangered *Cystoseira* spp. is important in view of the preparation of conservation and restoration measures.

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NOVA NAJDBA VRSTE *CYSTOSEIRA FOENICULACEA* F. *LATIRAMOSA* V OBALNEM MORJU SLOVENIJE PO VEČ KOT ŠTIRIDESETIH LETIH

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POVZETEK

Grmičaste makroalge, zlasti vrste iz rodu Cystoseira *(v širšem smislu), tvorijo tako imenovane gozdiče rjavih alg, ki so med najbolj produktivnimi življenjskimi okolji v plitkih obalnih vodah. V zadnjih dveh desetletjih vrste iz tega rodu hitro izginjajo v Sredozemskem morju, njih pa zaradi številnih antropogenih pritiskov postopno nadomeščajo manjše in obstojne alge, ki tvorijo nizko blazinasto vegetacijo, znano kot turf. Tudi v slovenskih obalnih vodah smo v zadnjih desetih letih zaznali zmanjšanje števila vrst in pokrovnosti grmičastih taksonov (zlasti* Cystoseria s.l. *spp.). Avtorja poročata o najdbi vrste* Cystoseira foeniculacea *f.* latiramosa*, katere obstoja v slovenskih morskih vodah niso potrdili že več kot štiri desetletja.*

Ključne besede: *Cystoseira foeniculacea* f. *latiramosa*, nova najdba, severno Jadransko morje

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FIRST RECORD OF THE ECHIURID *MAXMUELLERIA GIGAS* (M. MÜLLER, 1852) IN SLOVENIAN WATERS (NORTHERN ADRIATIC)

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ABSTRACT

One specimen of the echiurid Maxmuelleria gigas *(M. Müller, 1852) was found in sediments at a depth of 23 m, during a monitoring campaign for macrobenthos in the northern Adriatic Sea in 2020. This finding represents the first record of the species for Slovenian waters.*

Key words: *Maxmuelleria gigas,* soft bottom, macrobenthos, northern Adriatic

PRIMA SEGNALAZIONE DELL'ECHIURIDE *MAXMUELLERIA GIGAS* (M. MÜLLER, 1852) NELLE ACQUE SLOVENE (NORD ADRIATICO)

SINTESI

Un esemplare dell'echiuride Maxmuelleria gigas *(M. Müller, 1852) è stato trovato nel sedimento a 23 m, durante una campagna di monitoraggio del macrobenthos nel nord Adriatico nel 2020. Questo ritrovamento rappresenta la prima segnalazione di questa specie nelle acque slovene.*

Parole chiave: *Maxmuelleria gigas,* fondo mobile, macrobenthos, nord Adriatico

INTRODUCTION

Echiurids, commonly known as "spoon worms" due to their tongue-like extensible proboscis, are a small and poorly known group, represented by 165 exclusively marine species of worldwide distribution (Tilic *et al.,* 2015). They occur in benthic habitats ranging from the littoral zone to the deep sea (Tilic *et al.,* 2015). Traditionally ranked as a phylum of their own, they are now, according to the most recent phylogenetical analyses (Goto *et al.,* 2020), considered as part of the phylum Annelida, even if they lack visible segmentation. In fact, it is now recognized, based on both molecular (Struck *et al.,* 2007; Weigert *et al.,* 2014; Struck *et al.,* 2015) and morphological (Hessling & Westheide 2002; Tilic *et al.*, 2015) evidence, that they are derived members of the Annelida, coming from a common ancestor that secondarily lost segmentation. Six species are currently known (Murina, 1984; Relini, 2008) in the Mediterranean Sea, but only two of them have been reported in the Adriatic Sea: *Bonellia viridis* Rolando, 1821, and *Maxmuelleria gigas* (M. Müller, 1852) both belonging to the family of Bonelliidae Baird, 1868 (Zavodnik, 2017). While both species are reported for Italian (Relini, 2008) and Croatian waters (Zavodnik, 2017), only *B. viridis* was until now reported from Slovenian waters (Lipej & Vrišer, 1999; Sket, 2003).

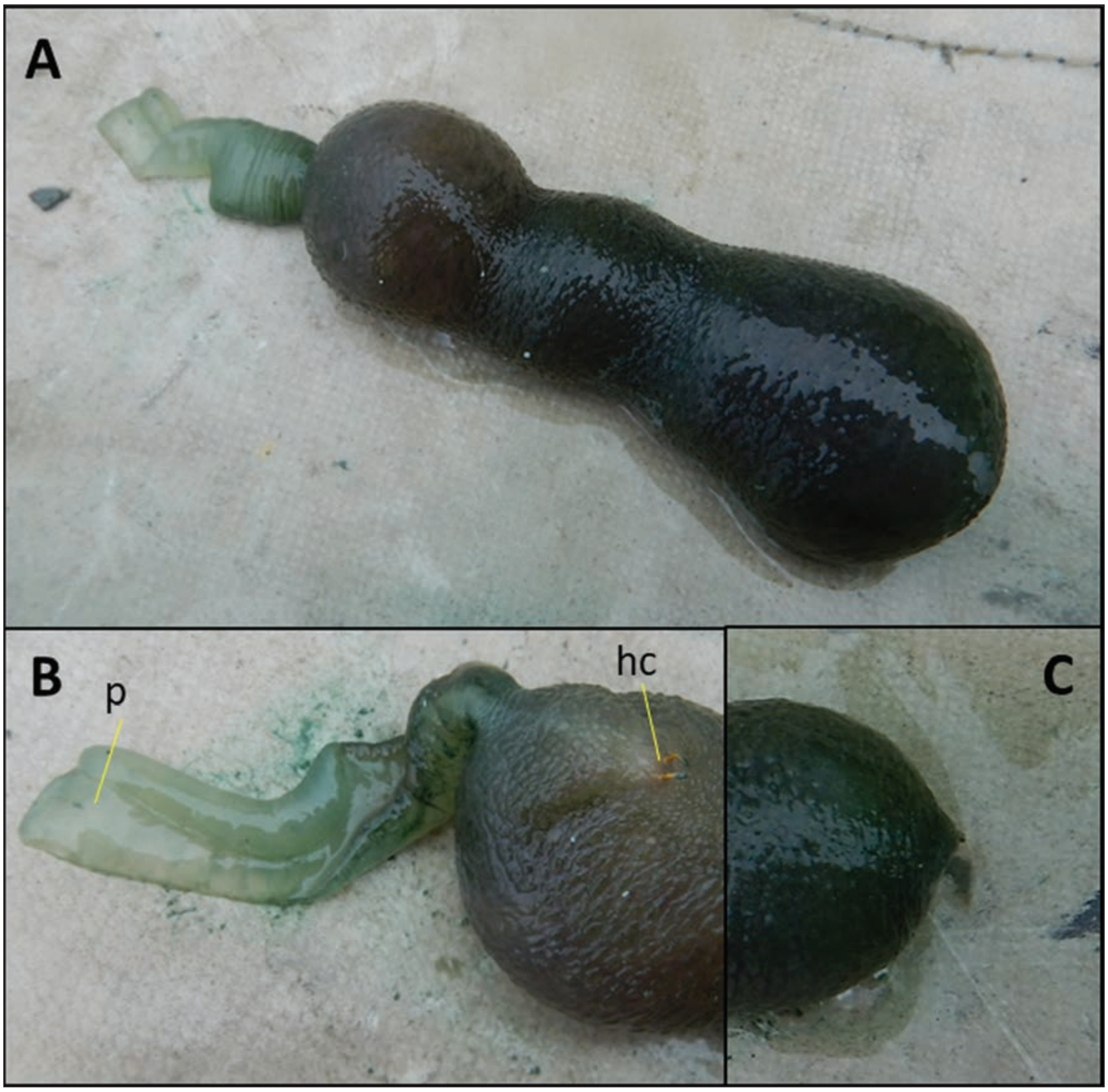

Fig. 1: *Maxmuelleria gigas.* ***A. Entire animal, dorsal view, B. Anterior ventral part, C. Posterior part. Hc = hooked chaetae, p = proboscis.***
Sl. 1: *Maxmuelleria gigas.* ***A. Cela žival s hrbtne strani, B. Sprednja trebušna stran, C. Zadnji del. Hc = kavljaste ščetine, p = rilec.***

MATERIAL AND METHODS

Sampling was performed during a benthic monitoring campaign in summer 2020 in the Gulf of Trieste (northern Adriatic) off the Slovenian coast. Sediment was collected with a Van Veen grab and sieved through a 1 mm mesh. The specimen was found at a depth of 23.5 m at one offshore location (Sed 6: 45°35′606″N, 13°37′456″E), in sediment composed of 53 % silt, 27 % clay, and 20 % sand (Ogorelec *et al.*, 1991). The specimen was immediately photographed and fixed in 70 % ethanol. It is now stored at the Marine Biology Station in Piran.

RESULTS AND DISCUSSION

Taxonomic account

Phylum ANNELIDA, Class POLYCHAETA Grube, 1850

Order ECHIUROIDEA, Family BONELLIIDAE Lacaze-Duthiers, 1858

Genus *Maxmuelleria* Bock, 1942

Species *Maxmuelleria gigas* (M. Müller, 1852)

The specimen of *Maxmuelleria gigas* was about 15 cm in length, with green-coloured unsegmented, papillate sac-like trunk (Fig. 1A), and a single pair of hooked ventral chaetae (Fig. 1B), characteristic of all echiurid species (Tilic *et al.*, 2015). The green colour is due to a pigment called "bonellin" (Goto *et al.*, 2020). The species is distinguishable from other echiurids by the distinct highly expandable non-bifid proboscis (Fig. 1B), and posterior part of the trunk (Fig. 1C) without chaetae (Riedl, 1991). This species lives buried in silty or sandy bottoms, 20-50 m deep (Riedl, 1991). Like most echiurids, *M. gigas* is a deposit feeder (Goto, 2016), collecting organic particles from the sediments with its highly extensible proboscis (Riedl, 1991). Unlike *B. viridis*, which have been investigated more deeply, also in the Adriatic Sea (Zavodnik, 2017), the echiurid *M. gigas* is still poorly known. Originally described as *Thalassema gigas* M. Müller, 1852, and assigned to the family Thalassematidae, it was later moved to the family Bonellidae and assigned to the genus *Maxmuelleria* (WoRMS Editorial Board, 2020). In general, the taxonomy and phylogeny of the echiurids are still object of revision (Goto *et al.,* 2020). Most species belonging to the Bonellidae are characterized by marked sexual dimorphism, with dwarf males residing inside, or attached to, the body of the female (Riedl, 1991). Since this reproductive character is typical of echiurids at bathyal and abyssal depths, Goto (2016) suggested that it could represent a mechanism of adaptation to deep water environments, and that in shallow water echiurids it could be the result of a secondary adaptation of the species after expanding its distribution to shallow waters. But while this phenomenon is well documented for bonellid echiurids with a bifid proboscis, like for those belonging to the genus *Bonellia*, it has not been ascertained yet in the males of the genus *Maxmuelleria* (Goto *et al.,* 2020).

The echiurid *M. gigas* is reported as a Mediterranean and European Atlantic species (Bakalem *et al.*, 2020). Despite being reported as locally abundant by Riedl (1991), there are very few recent records of this species, and only restricted to certain areas of the Mediterranean: central Mediterranean (Relini, 2008; Massi *et al.,* 2011), western Mediterranean (Camp & Ros, 1980; Harriague *et al.,* 2019; Bakalem *et al.,* 2020), central Adriatic (Atkinson *et al.,* 1998; Morello *et al.,* 2007; Relini, 2008), and northern Adriatic (Simonini *et al.*, 2007; Relini, 2008; Zavodnik, 2017). Some records are based only on the burrow type (Atkinson *et al.*, 1998; Morello *et al.,* 2007). The present record is the first for this species in Slovenian waters.

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PRVI ZAPIS O POJAVLJANJU ZVEZDAŠA *MAXMUELLERIA GIGAS* (M. MÜLLER, 1852) V SLOVENSKIH VODAH (SEVERNI JADRAN)

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POVZETEK

Med vzorčenjem makrobentosa v severnem Jadranu v letu 2020 je bil na sedimentnem dnu na globini 23 najden primerek zvezdaša Maxmuelleria gigas *(M. Müller, 1852). Gre za prvo najdbo te vrste v slovenskih morskih vodah.*

Ključne besede: *Maxmuelleria gigas,* mehko dno, makrobentos, severni Jadran

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LE PAPAVERACEAE JUSS. DELLA FLORA ITALIANA: DISTRIBUZIONE REGIONALE E CONSIDERAZIONI FITOGEOGRAFICHE

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SINTESI

Il presente lavoro riporta l'elenco di tutti i taxa appartenenti alla famiglia delle Papaveraceae segnalati in Italia, analizza la distribuzione geografica regionale, individua i principali pattern distributivi, presenta un'analisi fitogeografica e cerca di discutere le origini e movimenti migratori sulla base dei dati bibliografici. Allo stato attuale delle conoscenze, la flora italiana comprende 55 taxa della famiglia ripartiti in 12 generi. La distribuzione regionale è alquanto discontinua: solo 5 taxa sono presenti in tutte le regioni; gli altri in alcuni casi sono presenti in un'unica regione, settore peninsulare o sono caratterizzati da una distribuzione molto variabile. L'analisi corologica ha dimostrato la prevalenza del Contingente geografico Eurasiatico, seguito dal Mediterraneo. La letteratura consultata, ha dimostrato l'esistenza di molte incertezze e differenze di vedute sulle origini e i movimenti migratori seguiti per colonizzare le regioni italiane.

Parole chiave: Papaveraceae, check-list, biogeografia, distribuzione regionale, migrazioni floristiche, origini

PAPAVERACEAE OF ITALIAN FLORA: REGIONAL DISTRIBUTION AND PHYTOGEOGRAPHIC CONSIDERATIONS

ABSTRACT

This work reports the list of all taxa belonging to the Papaveraceae family reported in Italy, analyzes the regional geographical distribution, identifies the main distribution patterns, presents a phytogeographic analysis and tries to discuss the origins and migratory movements on the basis bibliographic data. At the current state of knowledge, the Italian flora includes 55 taxa of the family divided into 12 genera. The regional distribution is somewhat discontinuous: only 5 taxa are present in all regions; the others in some cases are present in a single region, peninsular sector or they are characterized by a highly variable distribution. The chorological analysis has shown the prevalence of the Eurasian Geographic Group, followed by the Mediterranean. The consulted literature has demonstrated the existence of many uncertainties and differences of views on the origins and migratory movements followed to colonize the Italian region.

Key words: Papaveraceae, biogeography, check-list, regional distributions, floristics migrations, origins

INTRODUZIONE

L'obiettivo del presente saggio è di fornire innanzitutto una visione comprensiva sulla distribuzione delle papaveracee presenti nel territorio italiano e in seguito di ipotizzare le epoche in cui avvennero i flussi migratori e le rotte seguite dai vari taxa per raggiungerlo. La famiglia delle Papaveraceae Juss. comprende 44 generi e circa 820 specie; è costituita da piante generalmente erbacee con alcune arbustive, lianose e piccoli alberi; ha una distribuzione cosmopolita ed è maggiormente presente nelle regioni temperate dell'emisfero settentrionale (APG, 2009; Hoot *et al.*, 2015, Sauquet *et al.*, 2015).

La tassonomia delle papaveracee è molto controversa. Nel presente lavoro si adotta quella di APG (2009) e Hoot *et al.* (2015) che prevede la ripartizione in 4 subfamiglie:

- Papaveroideae Eaton con 23 generi e circa 240 specie presenti in tutti i continenti tranne l'Antartide e l'Oceania (Kadereit, 1993; Kadereit *et al.*, 1994; Sauquet *et al.*, 2015).
- Fumarioideae Eaton con 19 generi e 575 specie presenti principalmente nelle regioni temperate dell'emisfero settentrionale e in Sud-Africa. La sua maggiore diversità si osserva nel continente asiatico (Dahl, 1990; Kadereit *et al.*, 1995).
- Hypecoaceae Willkomm & Lange diffuse dal Mediterraneo alla Cina Occidentale con un solo genere e 18 specie (Pérez-Gutiérrez *et al.*, 2015).
- Pteridophyllaceae Nakai costituito dal genere *Pteridophyllum* Nutt. presente nelle foreste giapponesi di Honshu (Lidén 1993a, 1993b).

Molte papaveracee hanno fiori vistosi e sono coltivate a scopo ornamentale. Alcune specie sono utilizzate a fini alimentari, per la produzione di oppio e derivati ad uso farmaceutico.

MATERIALI E METODI

La nomenclatura e distribuzione dei vari taxa segue il portale della flora italiana (2020). I suoi dati sono stati confrontati ed eventualmente integrati da quanto riportato in Celesti-Grapow *et al.* (2010), Bartolucci *et al*. (2018) e Pignatti (2018).

Per la distribuzione dei taxa in Europa e nel Bacino del Mediterraneo si è seguito Aghababian & Lidén (2011) e la nomenclatura da loro adottata è stata posta in sinonimia con quella del portale della flora italiana. Nella realizzazione dell'elenco floristico non sono state considerate le segnalazioni dubbie ed erronee mentre sono state riportate quelle di taxa non ritrovati recentemente.

Per l'assegnazione dei tipi corologici (Tabella 4), in generale si è tenuto conto di Pignatti (2018). Quando le sue tesi sembravano opinabili, a vari taxa si è provveduto ad assegnare un nuovo corotipo sulla base delle distribuzioni dei taxa desunte da: Aeschimann *et al*. (2004), Aghababian & Lidén (2011), Bartolucci *et al*. (2018) e il portale della flora italiana (2020).

Al corotipo Appennino-Balcanico sono stati assegnati i taxa presenti esclusivamente nel territorio delimitato dai seguenti confini fisici (Pezzetta, 2010): 1) per la Penisola Italiana, le isole e l'arco appenninico dalla Liguria all'Aspromonte; 2) per la Penisola Balcanica, Creta, le isole dell'Egeo e il territorio continentale posto a sud dell'asse fluviale che va dalle sorgenti della Sava alle foci del Danubio e dal Mar Nero all'Adriatico-Ionio. Al corotipo Subendemico sono stati assegnati i taxa contraddistinti da un areale che comprende qualche regione del territorio italiano e zone degli Stati vicini.

Al fine di aggiungere ai quadri distributivi regionali, altri dati riguardanti la presenza in più settori li, si è calcolato Il valore medio di presenza (Vm) nelle varie parti d'Italia (nord, centro, sud e isole), ottenuto sommando i dati regionali / il numero delle regioni del settore considerato (2 per le isole, 8 per l'Italia settentrionale, 5 per l'Italia centrale e l'Italia meridionale).

Nella Tabella 5 sono stati fatti dei raggruppamenti dei corotipi definiti "Contingenti Geografici" in base al seguente schema:

- nel Contingente "Endemico e Subendemico" sono inclusi i corotipi con la stessa dicitura;
- nel Contingente "Mediterraneo" sono inclusi i corotipi Mediterraneo-Occidentale, Mediterraneo-Montano, Stenomediterraneo, Eurimediterraneo, Nord-Ovest-Mediterraneo e Sud-Est-Mediterraneo;
- nel Contingente "Eurasiatico" sono inclusi i corotipi Eurasiatico s.s., Eurosiberiano, Europeo-Caucasico, Mediterraneo-Turaniano, Paleotemperato e Sud-Europeo-Sud-Siberiano;
- nel Contingente "Europeo" sono inclusi i corotipi Europeo s.s., Ovest-Europeo, Centro-Europeo, Sud-Est- Europeo e Appennino-Balcanico;
- nel Contingente "Mediterraneo-Atlantico" è incluso il corotipo Subatlantico.

Per evidenziare il campo di variazione delle distribuzioni regionali, si è calcolato l'intervallo di variabilità che è dato dalla differenza tra il valore massimo di taxa segnalati in una regione ed il valore minimo.

Per dimostrare il grado d'influenza che le papaveracee hanno sulle flore regionali è stata calcolata l'incidenza percentuale Ip utilizzando la seguente formula: $Ip = (Nt / Dt) \times 100$, in cui Nt = numero di taxa di papaveracee segnalate in una regione e Dt = numero di taxa totali presenti nella stessa.

Per la costruzione delle Tabelle 2 e 3 si è considerato quanto riportato in Pignatti (2018) riguardo la

Tab. 1: Distribuzione regionale delle Papaveraceae.
Tab. 1: Regionalna razširjenost taksonov iz družine Papaveraceae.

Regioni	**Taxa Papaveraceae**	**Totale taxa della flora regionale**	**Percentuale Papaveraceae sulla flora regionale**
Valle d'Aosta	12	2333	0,51
Piemonte	22	3535	0,64
Lombardia	24	3429	0,7
Trentino Alto Adige	26	3504	0,74
Veneto	21	3338	0,63
Friuli Venezia Giulia	27	3147	0,86
Liguria	26	3080	0,84
Emilia Romagna	19	2843	0,67
Toscana	29	3400	0,85
Marche	25	2540	0,98
Umbria	18	2406	0,75
Lazio	30	3047	0,98
Abruzzo	26	3216	0,81
Molise	23	2327	0,99
Campania	27	2828	0,95
Puglia	27	2577	1,05
Basilicata	21	2607	0,8
Calabria	23	2799	0,82
Sicilia	28	2787	1
Sardegna	30	2441	1,23

distribuzione altitudinale e nei vari tipi di ambienti dei singoli taxa che sono riportati nel volume.

Al fine di avere quadri distributivi più chiari dei corotipi si è deciso di calcolare per ognuno di essi:

- la diffusione che si ottiene sommando tutte le segnalazioni regionali dei taxa di ogni corotipo;
- la diffusione media che si ottiene dividendo la diffusione per il numero di taxa di ogni corotipo.

Il risultato fornisce il valore medio di regioni in cui è presente ogni taxa.

Per confrontare la diversità distributiva dei singoli taxa è stata condotta una classificazione numerica delle regioni, su dati di presenza-assenza, utilizzando il legame medio come algoritmo di clustering e l'indice di Sørensen come coefficiente di somiglianza.

Per la ricostruzione delle origini e dei movimenti migratori e delle rotte seguite si è consultata la bibliografia esistente, tenendo conto delle ipotesi sinora elaborate su tali aspetti, dei reperti fossili e delle ricerche filogenetiche e molecolari. Sulla base di tutti i dati ricavati dalle consultazioni bibliografiche, lo scrivente ha elaborato nuove ipotesi e ove non indicato si è provveduto ad elaborare nuove ipotesi. Per perseguire tali finalità si sono presi in considerazione solo le subfamiglie, generi e specie della flora italiana o che potrebbero avere relazioni di parentela con essa.

RISULTATI E DISCUSSIONE

L'elenco floristico (Supplemento 1) comprende 55 taxa infragenerici, corrispondenti al 0.67 % della flora italiana, che secondo Bartolucci et al. (2018) ammonta a 8195 taxa. Essi sono ripartiti in 12 generi, tra i quali il più ricco è *Fumaria* (18), seguito da; *Papaver* (16), *Corydalis* (7), *Hypecoum* (4), *Glaucium* (2), *Pseudofumaria* (2), *Chelidonium* (1), *Eschscholzia*

(1), *Lamprocapnos* (1), *Meconopsis* (1), *Platycapnos* (1) e *Roemeria* (1).

Solo 5 specie sono segnalate in tutte le regioni italiane: *Chelidonium majus*, *Fumaria capreolata* subsp. *capreolata*, *Papaver dubium*, *P. hybridum* e *P. rhoeas*. Le altre sono presenti in una o più regioni. Nel complesso la distribuzione dei taxa segue un trend decrescente dall'Italia settentrionale a quella meridionale e alle isole. Infatti: nelle regioni settentrionali (dalla Valle d'Aosta all'Emilia Romagna sono presenti 37 taxa corrispondenti al 67,3% delle papaveracee italiane; nelle regioni centrali (dalla Toscana all'Abruzzo) ne sono segnalate 35 (63,6%); nelle regioni meridionali 34 (61,8%) e in Sicilia e Sardegna 31 (56,4%).

A causa delle diverse presenze nelle regioni, il valore medio (Vm) varia. Infatti, è più alto nelle due isole con 29; nell'Italia centrale è di 25,6, nell'Italia meridionale è di 24,2, nell'Italia settentrionale è di 22,1. L'intervallo di variabilità è di 6,9, un valore nel complesso basso.

Dalla Tabella 1 emerge che le regioni più ricche sono la Sardegna e il Lazio con 30 taxa ciascuno. Esse sono seguite da: Toscana (29); Sicilia (28); Campania, Puglia e Friuli Venezia Giulia (27); Abruzzo e Liguria (26); Marche (25); Lombardia (24); Calabria e Molise (23); Lombardia (22); Basilicata e Veneto (21); Emilia Romagna (19); Umbria (18); Valle d'Aosta che chiude con 12 taxa.

L'intervallo di variabilità tra le Regioni con il maggior numero di taxa e quella con il minor numero è di 18 che se paragonato al totale delle specie presenti è del 32,7%. Essi esaminati nel loro complesso confermano una corrispondenza con i valori medi di presenza poiché collocano ai primi posti le regioni insulari e all'ultimo posto una regione dell'Italia settentrionale (la valle d'Aosta). Le altre regioni occupano posizioni intermedie e non evidenziano nel loro complesso un netto trend decrescente da nord a sud.

L'incidenza percentuale (Ip) delle papaveracee sulla flora regionale è molto bassa ed è compresa tra il valore minimo di 0,51 della Valle d'Aosta e quello massimo di 1,23 della Sardegna.

Diverse entità sono segnalate solo in una regione o porzione del territorio italiano. In particolare i seguenti taxa sono segnalati solo in uno dei seguenti settori peninsulari:

- regioni alpine occidentali: *Papaver atlanticum*;
- regioni alpine centro-orientali (dalla Lombardia al Friuli Venezia Giulia): *Corydalis capnoides*, *Fumaria rostellata*, *Meconopsis cambrica*, *Papaver alpinum* subsp. *kerneri*, *P. croceum* e *P. nudicaule*;
- Italia Centrale (dalla Toscana all'Abruzzo): *Fumaria petteri* subsp. *petteri*, *Lamprocapnos spectabilis* e *Papaver degenii*;
- Italia Meridionale (dal Molise alla Calabria): *Fumaria judaica* subsp. *judaica;*
- Sicilia e Sardegna: *Corydalis densiflora* subsp. *densiflora*,

Nelle Regioni di seguito riportate, sono segnalate le seguenti specie, non presenti nelle altre:

- Lombardia: *Papaver nudicaule*;
- Trentino Alto-Adige: *Meconopsis cambrica* e *Papaver croceum*;
- Friuli Venezia Giulia: *Papaver alpinum* subsp. *kerneri*;
- Marche: *Lamprocapnos spectabilis*.

Diverse entità nella penisola italiana raggiungono un limite assoluto del loro areale. Infatti:

- raggiungono il limite orientale di distribuzione geografica: *Corydalis densiflora* subsp. *densiflora*, *Fumaria bicolor*, *F. muralis* subsp. *muralis*, *P. atlanticum* subsp. *atlanticum* e *Platycapnos spicatus*.
- raggiungono il limite occidentale di distribuzione geografica: *Corydalis pumila*, *Papaver alpinum* subsp. *ernesti-mayeri*, *P. alpinum* subsp. *kerneri* e *P. degenii*;
- raggiungono il limite settentrionale di distribuzione geografica: *Corydalis densiflora* subsp. *densiflora* e *Papaver atlanticum* subsp. *atlanticum*;
- raggiungono il limite meridionale di distribuzione geografica: *Corydalis capnoides*, *Fumaria barnolae* subsp. *barnolae*, *Papaver alpinum* subsp. *ernesti-mayeri* e *P. kerneri*.

Altre entità in qualche regione raggiungono un limite distribuzionale che riguarda solo il territorio peninsulare. In particolare, raggiungono il limite settentrionale di distribuzione in:

- Piemonte: *Papaver hybridum*, *Fumaria densiflora* e *F. parviflora*;
- Lombardia: *Corydalis pumila*, *Papaver lecoqi* e *Pseudofumaria alba* subsp. *alba*;
- Trentino Alto Adige: *Chelidonium majus*, *Corydalis capnoides*, *C. cava* subsp. *cava*, *C. intermedia*, *C. solida*, *Eschscholzia californica* subsp. *californica*, *Fumaria capreolata* subsp. *capreolata*, *F. officinalis* subsp. *officinalis*, *F. officinalis* subsp. *wirtgenii*, *F. schleicheri*, *F. vaillantii*, *Papaver alpinum* subsp. *rhaeticum*, *Papaver argemone P. dubium, P. rhoeas subsp. rhoeas*, *P. setigerum* e *Pseudofumaria lutea*;
- Friuli Venezia Giulia: *Fumaria barnolae* subsp. *barnolae, Hypecoum pendulum* e *Papaver alpinum* subsp. *ernesti-mayeri*,
- Liguria: *Fumaria agraria*, *Glaucium corniculatum* subsp. *corniculatum*, *Papaver pinnatifidum*, *Platycapnos spicatus* e *Roemeria hybrida* subsp. *hybrida*;
- Emilia Romagna: *Hypecoum procumbens* subsp. *procumbens*;
- Toscana: *Fumaria bastardi, F. bicolor*, *F. flabellata, F. muralis* e *F. petteri*;
- Marche: *Corydalis densiflora* subsp. *apennina* e *Papaver degeni*;
- Lazio: *Fumaria gaillardotii*, *F. kralikii* e *Hypecoum imberbe*;
- Puglia: *Fumaria judaica* subsp. *judaica*;
- Calabria: *Hypecoum torulosum*.

Tab. 2: Distribuzione delle papaveracee per habitat.
Tab. 2: Razširjenost taksonov iz družine Papaveraceae v različnih habitatih.

Tipo di habitat	Numero taxa	Tipo di habitat	Numero taxa
Prati e campi coltivati	26	Boschi di latifoglie	4
Incolti	21	Boschi di aghifoglie	1
Spiagge e dune marittime	3	Radure di boschi	1
Garighe	1	Rupi	5
Prati aridi	1	Macereti	7
Muri	5		

Raggiungono il limite meridionale di distribuzione in:
- Veneto: *Corydalis capnoides*;
- Lazio: *Roemeria hybrida*;
- Abruzzo: *Papaver alpinum* subsp. *ernesti-mayeri* e *P. degenii*;
- Molise: *Fumaria petteri*;
- Campania: *Papaver argemone* e *P. lecoqii*;
- Puglia: *Corydalis solida* subsp. *solida* e *Fumaria muralis*;
- Basilicata: *Pseudofumaria alba* subsp. *alba*;
- Calabria: *Corydalis cava* subsp. *cava*, *C. densiflora* subsp. *apennina* e *C. pumila*;
- Sicilia: *Chelidonium majus*, *Corydalis intermedia*, *Eschscholzia californica* subsp. *californica*, *Fumaria agraria*, *F. barnolae* subsp. *barnolae*, *F. bastardi*, *F. bicolor*, *F. capreolata* subsp. *capreolata*, *F. densiflora*, *F. flabellata*, *F. gaillardotii*, *F. judaica* subsp. *judaica*, *F. kralikii*, *F. parviflora*, *Glaucium corniculatum* subsp. *corniculatum*, *G. flavum*, *Hypecoum imberbe*, *H. procumbens* subsp. *procumbens*, *H. torulosum*, *Papaver apulum*, *P. dubium*, *P. hybridum*, *P. pinnatifidum*, *P. rhoeas* subsp. *rhoeas*, *P. setigerum*, *P. somniferum* e *Platycapnos spicatus*,
- Sardegna: *Fumaria schleicheri*.

Dalla Tabella 2, emerge che le papaveracee della flora italiana prediligono gli ambiti aperti e soleggiati. Oltre 40 taxa si rinvengono negli ambiti artificiali creati dall'uomo quali i campi coltivati, i prati e le aree ruderali incolte. Un numero di taxa esiguo si rinviene negli ambiti riparati dei boschi di vario tipo. Altrettanto esiguo sono i taxa tipici di rupi, dune marittime, ghiaioni e macereti, ambiti pionieri e generalmente inospitali che richiedono particolari adattamenti anatomici e morfologici.

Dalla Tabella 3, invece si osserva che i taxa sono presenti in tutte le fasce altitudinali comprese dal livello del mare a oltre 2400 metri, con molte entità presenti in più fasce. La maggior ricchezza si ha tra 100 a 900 m d'altitudine con 34 taxa (61,8 %). Nelle fasce tra 900-1800 m, 1800-2400 m e oltre 2400 m sono presenti rispettivamente 20 (36,4 %), 8 (14,5%) e 3 (5,4%) taxa e in quella tra 0 e 100 metri ne sono presenti 32 (58,2 %). Nel complesso tali dati dimostrano che la maggior parte dei taxa è presente negli ambiti collinari e submontani sino all'altitudine di 900 metri.

Tab. 3: Distribuzione delle papaveracee per fasce altitudinali.
Tab. 3: Razširjenost taksonov iz družine Papaveraceae glede na nadmorsko višino.

Altitudine m.	Numero taxa	Altitudine m.	Numero taxa
0-100	32	1800-2400	8
100-900	34	Oltre 2400	3
900-1800	20		

Dalla Tabella 4 risulta che i taxa si ripartiscono in 7 Contingenti Geografici tra cui domina l'Eurasiatico (15 taxa). Esso è seguito dai Contingenti: Mediterraneo (14), Europeo (10), Avventizio (7), Endemico (5), Cosmopolita (2) e Mediterraneo-Atlantico (2).

I taxa del Contingente Endemico sono segnalati solo in ambiti montani con l'unica specie stenoendemica (*Corydalis densiflora* subsp. *apennina*) presente lungo la catena appenninica dalle Marche alla Calabria (esclusa la Puglia).

Per quanto riguarda la distribuzione degli altri Contingenti Geografici si osserva quanto segue:
- Il Contingente Mediterraneo è più rappresentato nell'Italia meridionale e nelle isole con 14 taxa. Nelle regioni dell'Italia centrale e settentrionale sono segnalati 11 taxa ciascuno.
- Il Contingente Eurasiatico nell'Italia meridionale è segnalato con 11 taxa mentre negli altri settori della penisola sono presenti 12 taxa ciascuno.
- Il Contingente Europeo segue un andamento decrescente dall'Italia settentrionale a quella meridionale e alle isole.
- Il Contingente Mediterraneo-Atlantico è assente nell'Italia settentrionale ed è presente con 2 taxa ciascuno in tutti gli altri settori peninsulari.
- Il Contingente Cosmopolita è presente con 4 taxa nell'Italia settentrionale; con 2 ciascuno nell'Italia centrale e meridionale; con un taxa nelle isole.

Nella Tabella 5 sono riportati i valori di abbondanza, ricchezza floristica (numero di specie), diffusione e diffusione media di ogni Contingente geografico. Dalla sua lettura emerge quanto segue:
- il Contingente Endemico è caratterizzato da valori di ricchezza floristica, diffusione e diffusione media molto bassi poiché ogni singolo taxa è presente in un numero di regioni compreso tra 8 e l'unità.

Tab. 4: Ripartizione corologica delle Papaveraceae della flora italiana.
Tab. 4: Horološka delitev taksonov iz družine Papaveraceae v italijanski flori.

Contingenti Geografici	**Tipi Corologici**	**Numero taxa**	**Totale**	**%**
Endemico e Subendemico	Endemico	1	5	9,1
	Subendemico	4		
Mediterraneo	Eurimediterraneo	4	14	25,45
	Stenomediterraneo	5		
	Mediterraneo-Occidentale	2		
	Nord-Ovest-Mediterraneo	1		
	Sud-Est-Mediterraneo	1		
	Mediterraneo-Montano	1		
Eurasiatico	Eurasiatico s.s.	2	15	27,3
	Europeo-Caucasico	1		
	Paleotemperato	4		
	Sud Europeo-Sud Siberiano	1		
	Mediterraneo-Turaniano	6		
	Eurosiberiano	1		
Europeo	Europeo s.s.	2	10	18,2
	Centro-Europeo	2		
	Sud-Est-Europeo	2		
	Ovest-Europeo	1		
	Appennino-Balcanico	3		
Mediterraneo-Atlantico	Subatlantico	2	2	3,63
Avventizio	Avventizio	7	7	12,72
Cosmopolita	Subcosmopolita	2	2	3,63
Totale		55	55	100

- il Contingente Cosmopolita presenta il valore più basso di ricchezza e quello più alto di distribuzione media, a dimostrazione che i suoi taxa anche se poco numerosi, sono quelli che hanno la maggior omogeneità distributiva in tutto il territorio peninsulare.
- il Contingente Avventizio presenta il valore più basso di diffusione media, a dimostrazione che i taxa si sono espansi solo nelle immediate vicinanze dei luoghi in cui sono stati introdotti.
- il Contingente Eurasiatico presenta il più alto valore di ricchezza floristica e diffusione. Anche la diffusione media è molto alta a dimostrazione che nel complesso i suoi taxa nel territorio peninsulare hanno una distribuzione tra le più omogenee.

Origini delle Papaveraceae

Considerazioni generali

Dove e quando le papaveracee si originarono e in che epoca raggiunsero la penisola italiana? La risposta al quesito posto non è semplice e al fine di elaborare ipotesi abbastanza verosimili, lo scrivente similmente a quanto fatto nell'analisi di altre famiglie di piante (Pezzetta & Ciaschetti, 2018, Pezzetta 2019a, 2019b), ha preso in considerazione i fatti e le teorie che seguono.

La storia della flora italiana si ottiene riunendo le storie biogeografiche di tutti i suoi taxa. Alcuni organismi recenti si sono originati in qualche zona

Tab. 5: Ricchezza, diffusione e diffusione media dei raggruppamenti di corotipi.
Tab. 5: Pestrost, razširjenost in povprečna razširjenost skupin horotipov.

Contingenti Geografici	**Ricchezza floristica**	**Diffusione**	**Diffusione media**
Endemico	5	18	3,6
Mediterraneo	14	148	10,6
Eurasiatico	15	178	11,9
Europeo	10	75	7,5
Mediterraneo-Atlantico	2	16	8
Avventizio	7	19	2,7
Cosmopolita	2	29	14,5

della penisola. Altri più antichi provengono da aree diverse della terra e raggiunsero i territori emersi che oggi costituiscono l'Italia nel corso di qualche era geologica passata sfruttando le connessioni territoriali esistenti e/o in presenza di una barriera, con la dispersione a lunga distanza che affida la diffusione degli organi riproduttivi al vento, agli animali, agli uccelli, alle correnti marine e all'uomo. Gli organismi più o meno affini si diversificarono da uno o più antenati comuni presenti all'interno di aree ristrette definite "centri di origine" che sono individuabili utilizzando vari criteri. Nel caso in esame si è tenuto presente che essi coincidono con l'area geografica in cui sono presenti le entità più ancestrali, sono stati trovati reperti fossili più antichi e, una famiglia presenta la maggiore ricchezza tassonomica e diversità ecologica. Da tali ambiti gli antichi progenitori colonizzarono altri territori in cui s'innescarono mutazioni geniche che portarono alla formazione di nuovi taxa. Di conseguenza, oltre al centro d'origine primario si possono avere altri secondari e post-secondari ove sono avvenuti o avvengono i processi di diversificazione biologica. La ricostruzione delle ere geologiche in cui avvennero le migrazioni floristiche non è un compito facile. Infatti, nonostante i progressi delle conoscenze biogeografiche, su tali aspetti permangono ancora diversi lati oscuri. Recentemente vari spunti illuminanti sono stati forniti dalle ricerche di biologia molecolare e sistematica filogenetica che hanno consentito di: 1) ricostruire gli alberi genealogici di vari taxa; 2) individuare i centri d'origine, i territori in cui sono presenti i taxa più antichi, i processi di speciazione e le rotte migratorie seguite per colonizzare le varie parti del globo terrestre. Per la stima dei periodi temporali dei meccanismi evolutivi, di solito si utilizza l'orologio molecolare che prende in considerazione i tempi medi di evoluzione di alcune sostanze proteiche e si basa sul fatto che le mutazioni genetiche avvengono con frequenze generalmente costanti: tenendo conto del numero di variazioni riscontrate, è possibile stimare il tempo trascorso dal momento in cui ebbero inizio (Zuckerkandl & Pauling, 1962). In anni recenti, l'uso di algoritmi ed elaboratori più potenti ha consentito alla filogenetica molecolare di fare enormi progressi: ora è possibile elaborare ipotesi complesse sulle relazioni filogenetiche, i modelli biogeografici di dispersione, espansione, vicarianza e transizioni evolutive riguardanti gruppi che vanno da specie strettamente correlate a intere famiglie di piante. Tuttavia anche queste ricerche presentano vari problemi e non consentono di giungere a un'adeguata accuratezza degli schemi evolutivi a causa di campionamenti incompleti, eventi di estinzioni, evoluzioni non rilevate e inversioni di stato all'interno dei lignaggi (Hoot *et al.*, 2015).

Reperti fossili

I reperti fossili sono elementi utili per poter affermare con molta attendibilità l'epoca e le zone della terra in cui le piante erano presenti e quali potessero essere i loro progenitori. Alcuni fossili appartenenti alla famiglia delle papaveracee sinora ritrovati, sono i seguenti:

- resti di *Palaeoaster inquirenda* Type di fine Cretaceo (74,5-64,5 Ma) rinvenuti nel Nuovo Messico e nel Nord Dakota (Smith, 2001);
- frutti di *Papaverites* sp. Fridrich dell'Eocene rinvenuti a Bonstedt (Germania);
- resti di *Papaveraceaepites thalmanii* Biswas, dell'Eocene inferiore (circa 55-48 Ma) rinvenuti nel nord-est dell'India (Biswas, 1962);
- foglie di *Potomacapnos apeleutheron* Jud & Hickey risalenti a circa 120 Ma, rinvenute a Dutch Gap (Virginia, Stati Uniti d'America) (Jud & Hickey, 2013).

Ai fini del presente lavoro, i reperti considerati non consentono di stabilire con certezza ove era collocato il centro d'origine della famiglia e chi era l'antico progenitore da cui discendono tutti gli altri taxa. Tuttavia sono utili per affermare che alcuni di essi popolavano certe regioni terrestri durante particolari ere geologiche senza escludere che potessero esserci anche prima. Nel caso in esame essi dimostrano che le papaveracee più antiche risalgono al Cretaceo superiore ed erano presenti nel Nord-America. Altri fossili dell'Eocene sono stati rinvenuti in Europa e in India. Nel complesso dimostrano che le papaveracee erano presenti nel Nord-America prima della sua separazione dal continente eurasiatico e probabilmente si originarono durante il Cretacico in un ambito imprecisato della Laurasia. La presenza in India di fossili che risalgono a 55-48 Ma fa supporre che la famiglia esisteva anche in altre zone della terra.

Ricerche filogenetiche e molecolari

Maggiori dettagli riguardanti le origini si ricavano dalle ricerche filogenetiche e molecolari che hanno ricostruito le evoluzioni dei caratteri morfologici delle piante.

Le ricerche di Raven & Axelrod (1974) e Kadereit (1988, 1990a, 1993) hanno confermato che le *Papaveraceae* si originarono nella Laurasia. Riguardo ai tempi esistono pareri difformi. Li *et al.* (2017) hanno ipotizzato che iniziarono a divergere dalle *Ranunculales* attorno a 116,9 Ma; Wikstrom *et al.* (2001) collocano l'inizio del processo a 126 Ma; Anderson *et al.* (2005) a 114-121 Ma; Magallon *et al.* (2015) a 112.9 Ma. Pérez-Gutiérrez *et al.* (2015) invece, hanno ipotizzato che la divergenza iniziò 129 Ma mentre il gruppo corona risale a circa 107 Ma.

Hoot *et al.* (2015) pongono all'inizio di un albero genetico *Pteridophyllum racemosum* Sieb. & Zucc. che si può presumere la specie ancestrale, mentre Valtueña *et al.* (2012) hanno stimato che il genere *Pteridophyllum* Franch. iniziò a differenziarsi circa 82 Ma.

Secondo Kadereit *et al.* (1995) il taxon ancestrale delle *Papaveraceae* era tipico degli ambiti forestali e la diversificazione generica iniziò nella Laurasia prima della sua frammentazione continentale. Il processo di 'aridificazione del Terziario fu uno stimolo importante che accentuò la differenziazione genetica ed ebbe un notevole impatto sulla distribuzione delle piante poiché copri la Terra con vaste distese steppiche in cui si originarono e diffusero le specie erbacee.

Origini delle subfamiglie, tribù e generi della flora italiana

1) Papaveroideae Eaton

Kadereit (1997) ha stimato che la differenziazione delle Papaveroideae iniziò 52 Ma (73-31 Ma) mentre l'età del gruppo della corona comprendente il genere *Papaver* e altri affini (*Roemeria*, *Stylomecon* e *Meconopsis*) risale a circa 26 (44-10) Ma.

Alla subfamiglia appartiene la tribù Papavereae Dumortier che comprende i generi *Argemone* L., *Meconopsis* Vig., e *Papaver* L. (Angiosperm Phylogeny Website visitato il 20-2-2020). Nella flora italiana è rappresentata da 16 taxa del genere *Papaver* e da una specie avventizia appartenente al genere *Meconopsis*, noto anche come il papavero blu dell'Himalaya.

Il genere *Meconopsis* comprende circa 50 specie diffuse in vari altipiani e catene montuose dell'Asia centro-orientale. Spesso alcune entità sono coltivate a fini ornamentali.

Il genere *Papaver* L. a sua volta comprende circa 100 specie ed è presente in gran parte nelle regioni temperate e subtropicali dell'emisfero settentrionale (Asia centrale e sud-occidentale, Europa centro-meridionale e Africa settentrionale) (Judd *et al.*, 2002). La sez. *Meconella* ha una distribuzione artico-alpina comprendente anche la Beringia Nord-Americana. *Papaver aculeatum* Thunb. e *P. californicum* A. Gray sono originari rispettivamente del Sudafrica e del Nord America (Kadereit, 1988; Carolan *et al.*, 2009). Il genere in Europa e nel Bacino del Mediterraneo è presente con 90 specie; raggiunge la maggiore diversità nella penisola anatolica con oltre 35 taxa e nelle regioni del Caucaso con circa 30 (Aghababian & Lidén, 2011). Un importante centro diversità, forse d'origine secondaria è il Mediterraneo Orientale e l'Asia Sud-Occidentale.

Le ricerche filogenetiche di Kadereit *et al*. (2011) hanno dimostrato che nel tardo Oligocene (circa 28 Ma), in concomitanza con un periodo di significativo raffreddamento globale e di maggiore aridità, ci fu la separazione tra un clade con i generi *Meconella* Nutt. ex Torr. & Gray e *Meconopsis* e un altro con *M. cambrica* e varie specie del genere *Papaver*. *Papaver pavonium* che è collocato all'inizio del clade, si originò attorno a 7 Ma e potrebbe essere l'antenato. Per Valtueña *et al*. (2012) un gruppo con varie specie del genere *Papaver* iniziò a differenziarsi circa 10 Ma. Al loro interno le entità più ancestrali potrebbero essere *Papaver rhoeas* e *P. somniferum* che si differenziarono attorno a 7,5 Ma.

Ad avviso di Lavania & Srivastava (1999) le specie delle sezioni *Meconella* e *Meconidium* sembrano essere le più ancestrali in virtù delle loro capsule valvate e dei filamenti gialli.

Le ricerche di Kadereit (1990b) hanno portato alle seguenti conclusioni: le specie del genere *Papaver* della sezione pilosa nell'Asia sud-occidentale e nel Mediterraneo Orientale occupano una posizione basale e probabilmente sono le più antiche; *Papaver rhoeas*, proviene dalle aree del Mediterraneo orientale dove si sarebbe differenziato a causa dell'attività dell'uomo; il centro d'origine di *Papaver lecoqii* potrebbe essere collocato in qualche ambito dell'Europa sud-orientale, centrale o della penisola anatolica occidentale; *Papaver argemone* si sarebbe originato nell'Anatolia occidentale; *Papaver hybridum* che è tassonomicamente più isolato potrebbe avere un'origine europea.

Al fine di una maggiore chiarezza sui processi di speciazione e l'entità ancestrale del genere, si considererà il numero (o i numeri) cromosomico di base da cui in seguito con l'ibridazione e la poliploidia sono derivati gli altri sinora conosciuti. A tal proposito, Bara *et al*. (2007) hanno dimostrato che il genere *Papaver* è caratterizzato da 3 numeri cromosomici di base (n = 6, 7 e 11) e varie entità che l'hanno duplicato. Infatti, in *Papaver pavoninum* 2n = 12, *P. rhoeas* 2n = 14, *P. bracteatum* 2n = 14, *P. orientale* 2n = 28, *P. pseudo-orientale* 2n = 42 e *P. somniferum* 2n = 22. Poiché da n= 6 sono derivati n = 7 e n = 11 segue che *Papaver pavonium* è la specie più antica del gruppo, un fatto che coincide con quanto ipotizzato da Kadereit *et al.* (2011).

Carolan *et al*. (2009) hanno supposto che le foglie finemente sezionate siano un carattere primitivo della sezione *Meconella* cui appartiene il gruppo di *Papaver alpinum*. A loro avviso, la sezione *Argemonidium* cui appartengono le seguenti specie della flora italiana *Papaver apulum*, *P. argemone* e *P. hybridum*, possiede una morfologia fogliare simile. Ciò porta a ipotizzare una relazione filetica tra i due gruppi e che i loro taxa furono tra i primi che si diversificarono. Pignatti (1997, 2018) sostiene che il gruppo di *Papaver alpinum* si è frammentato per evoluzione indipendente delle popolazioni isolate e ha formato un insieme di specie presente su tutte le Alpi. Il taxon alpino più antico del gruppo secondo Kadereit (1990) è *Papaver kerneri*. Ad avviso di Bittkau & Kadereit (2003): *Papaver alpinum* subsp. *ernesti-mayeri* ha un'origine difiletica, ossia si è originato da due taxa primitivi non imparentati tra loro; *Papaver rhoeas*, è probabilmente originario delle steppe dell'Asia occidentale, gli stessi luoghi di diversificazione primaria per molti cereali coltivati.

Alla subfamiglia appartiene anche la tribù delle Chelidonieae Dumortier con i generi *Bocconia* L., *Chelidonium* L., *Glaucium* Mill., *Dicranostigma* Hook. f. E Thomson, *Eomecon* Hance, *Macleaya* R. Br. *Hylomecon* Maxim., *Sanguinaria* L. e *Stylophorum* Nutt. (Kadereit *et al.* 1995; Hoot *et al.* 1997, 2015). Li *et al.* (2017) collocano l'origine del gruppo corona della tribù a circa 47,9 Ma, mentre un clade con i generi *Stylophorum*, *Chelidonium*, *Hylomecon*, *Dicranostigma* e *Glaucium* iniziò a divergere circa 39,35 Ma. Alla flora italiana appartengono i generi *Chelidonium* (1) e *Glaucium* (2 taxa) che si originarono nel continente eurasiatico rispettivamente 24 e 23 Ma (Li *et al*., 2017).

Il genere *Glaucium* comprende 23 specie, ha una distribuzione cosmopolita e raggiunge la maggiore diversità nel Bacino del Mediterraneo e nell'Asia centro-occidentale (Kadereit, 1993). Alla subfamiglia appartiene anche la tribù delle Eschscholtzieae Baillon tipica del Nord America che in Italia è rappresentata da *Eschscholzia californica* subsp. *californica,* un taxon avventizio.

2) Fumarioideae Eaton

La tassonomia della subfamiglia è molto controversa. APG (2009) considera le Fumarioideae e le Hypecoaceae Willkomm & Lange due subfamiglie distinte mentre altri le raggruppano. Pérez-Gutiérrez *et al.* (2015) hanno ipotizzato che il gruppo corona si originò in Asia circa 96 Ma durante la transizione dal Cretaceo Inferiore al Cretaceo Superiore.

Per Sauquet *et al.* (2015) il primo genere della subfamiglia che si differenziò fu *Lamprocapnos* Endl. (esclusivo dell'Asia nord-orientale), seguito da *Ehrendorferia* T. Fukuhara & Lidén e *Dicentra* Bernh. Pérez-Gutiérrez *et al.* (2015) confermano che il genere *Lamprocapnos* è l'antenato delle *Fumarieae* e ipotizzano che iniziò a espandersi tra 75 e 62 Ma.

Le Fumarioideae si ripartiscono nelle tribù *Fumarieae* Dumort che comprende 11 generi e *Corydaleae* Reich. che a sua volta ne comprende 5 (Lidén, 1986; 1993a). L'areale delle Fumarieae si estende dalla Macaronesia all'Afghanistan e presenta una notevole concentrazione di taxa nel bacino del Mediterraneo. Una specie si trova nell'Africa orientale e tre generi sono presenti nel Sud Africa (Pérez-Gutiérrez *et al.*, 2012). La maggior parte dei generi è endemica, presenta una distribuzione ristretta e una forte disgiunzione (Mediterraneo -Sudafrica-Asia centrale). Il gruppo corona si originò circa 74 Ma mentre la diversificazione iniziò attorno a 44 Ma.

Lidén (1986), Kadereit (1993) e Pérez-Gutiérrez *et al.* (2012, 2015) ripartiscono le *Fumarieae* in 3 subtribù: 1) S*arcocapninae* Lidén che presenta una distribuzione Mediterraneo-Ovest-Europea, ha il più importante centro in Spagna, il taxa più orientale (*Ceratocapnos turbinata*) in Palestina e comprende i generi *Sarcocapnos* DC., *Ceratocapnos* Dur., *Platycapnos* (DC) Bernhardi e *Pseudofumaria* Medik.; 2) *Fumariinae* Lidén con i generi *Cryptocapnos* Rech. f., *Fumariola* Korsh., *Rupicapnos* Pomel e *Fumaria* L.; 3) *Discocapninae* che non appartiene alla flora italiana e comprende i generi *Cysticapnos* Mill., *Discocapnos* Cham & Schldl. e *Trigonocapnos* Schlechter.

La maggiore diffusione delle *Sarcocapninae* nel Bacino del Mediterraneo Centro-Occidentale, porta a supporre che tale ambito possa essere il centro d'origine e di dispersione per diversi generi e lignaggi (Pérez-Gutiérrez *et al.,* 2012). Alla flora italiana appartengono i generi: *Corydalis* (7), *Fumaria* (18), *Lamprocapnos* (1), *Platycapnos* (1) e *Pseudofumaria* (2).

Il genere *Fumaria* L. comprende circa 60 specie, ha una distribuzione cosmopolita ma raggiunge la maggiore diversità nella regione mediterranea (Vrancheva *et al*., 2014). Una sua importante caratteristica è l'elevata poliploidia (2n = 16, 32, 48, 64, 72, 80, 112) che ha svolto un importante ruolo nei processi di diversificazione (Lidén, 1986).

Al genere *Platycapnos* (DC.) Bemhardi appartengono 3 specie presenti in un'area che comprende la Macaronesia e il Bacino del Mediterraneo sino all'Italia, ove raggiunge il limite orientale di distribuzione geografica. Il suo antenato si originò alla fine dell'Oligocene (circa 24 Ma) e nel Miocene (circa 10 Ma) iniziò a diversificarsi (Pérez-Gutiérrez *et al*., 2015).

Il genere *Pseudofumaria* Medik. si originò circa 7 Ma (Pérez-Gutiérrez *et al*., 2015) e comprende 4 taxa a distribuzione sud-est-europea. Poichè raggiunge la maggiore diversità nella penisola balcanica, si può supporre che in tale ambito fosse ubicato l'antenato e il centro d'origine.

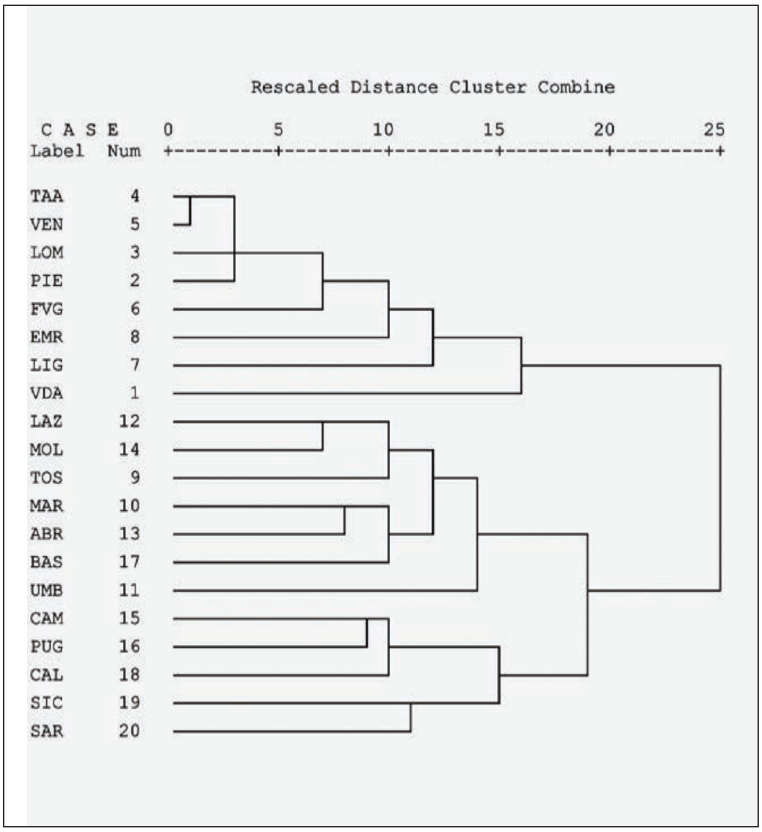

Fig. 1: Classificazione gerarchica delle regioni italiane in base alla somiglianza tra le distribuzioni dei singoli taxa di Papaveraceae. I numeri da 1 a 20 sono le regioni italiane: 1: Valle D'Aosta; 2: Piemonte; 3: Lombardia; 4: Trentino Alto-Adige; 5: Veneto; 6: Friuli Venezia-Giulia; 7: Liguria; 8: Emilia Romagna; 9: Toscana; 10: Marche; 11: Umbria; 12 Lazio; 13: Abruzzo; 14: Molise; 15: Campania; 16: Puglia; 17: Basilicata; 18: Calabria; 19: Sicilia; 20: Sardegna.

Sl. 1: Hierarhična opredelitev italijanskih regij na podlagi podobnosti v razširjenosti posameznih taksonov iz družine Papaveraceae. Številke od 1 do 20 so italijanske regije: 1: Dolina Aoste; 2: Piemont; 3: Lombardija; 4: Trentinsko Zgornje Poadižje; 5: Benečija; 6: Furlanija Julijska krajina; 7: Ligurija; 8: Emilija Romanja; 9: Toskana; 10: Marke; 11: Umbrija; 12 Lacij; 13: Abruci; 14: Molize; 15: Kampanija; 16: Apulija; 17: Bazilikata; 18: Kalabrija; 19: Sicilija; 20: Sardinija.

Il genere *Corydalis* DC. comprende circa 465 specie distribuite nell'emisfero boreale e raggiunge la maggiore diversità nella regione cino-himalajana con 357 specie di cui 252 endemiche (Pérez-Gutiérrez *et al*., 2015; Sauquet *et al.,* 2015). Lidén *et al.* (1995) pongono alla base di un albero filogenetico del genere *Corydalis*, *C. rupestris* che va considerato il taxon ancestrale. Pérez-Gutiérrez *et al.* (2015) collocano a 37 Ma l'inizio del processo di diversificazione e ipotizzano che l'areale primitivo fosse compreso tra la regione himalaiana e una piccola area dell'Asia Orientale.

Al genere *Lamprocapnos* appartiene una sola specie della flora italiana che è sfuggita ai giardini e si è spontaneizzata.

3) Hypecoaceae Willkomm & Lange

Per Pérez-Gutiérrez *et al.* (2015) il gruppo corona delle Hypecoeae si originò nell'Asia Centrale nel lungo periodo compreso tra il Cretaceo e il Paleogene (95.52–44.02 Ma). La maggiore diversità si osserva nel Bacino del Mediterraneo Orientale e la penisola anatolica (Aghababian & Lidén, 2011) da cui probabilmente partirono le ondate migratorie in varie direzioni. Alla flora italiana appartengono 4 specie del genere *Hypecoum* di cui un'avventizia e 3 assegnate al corotipo Paleotemperato.

Le affinità floristiche

Prima di prendere in considerazione i modi e i tempi in cui avvennero migrazioni floristiche, si ritiene opportuno analizzare le somiglianze regionali esistenti poiché potrebbe facilitare l'elaborazione delle ipotesi riguardanti le rotte seguite. Infatti, più è alta la somiglianza e più aumentano le affinità fitogeografiche e le probabilità di essere accomunate da rotte migratorie.

Il dendrogramma di similarità basato sull'indice di Sørensen (Fig. 1) mostra l'esistenza di due cluster principali. Il primo raggruppa tutte le regioni settentrionali e il secondo quelle centro-meridionali. Nel primo cluster emerge che la maggiore somiglianza si ha tra Veneto e Trentino-Alto Adige e poi tra Lombardia e Piemonte. La Valle d'Aosta e la Liguria sono le regioni che presentano la minore somiglianza anche con quelle confinanti.

Nel cluster delle regioni centro-meridionali si osservano due subcluster separati dei quali il primo comprende le regioni dell'Italia centrale, Molise e Basilicata, mentre il secondo Puglia, Campania, Calabria, Sicilia e Sardegna. All'interno del primo raggruppamento le maggiori affinità si osservano tra Lazio e Molise seguite da Marche e Abruzzo. Nel secondo raggruppamento invece la maggiore somiglianza si osserva tra Campania e Puglia.

Dalla Tabella 6 emerge che l'indice di Sørensen è compreso tra il valore massimo di 0,894 che si registra tra Trentino Alto Adige e Veneto e il minimo di 0,333 che si ha tra Valle d'Aosta e Lazio. Nelle regioni settentrionali l'indice di Sørensen oscilla tra

0,894 e 0,564 che si registra tra Friuli Venezia Giulia e Valle d'Aosta a dimostrazione di somiglianze molto variabili e più accentuate.

Nelle regioni dell'Italia centrale l'indice oscilla tra 0,824 che si registra tra Marche e Abruzzo e il valore minimo di 0,682 tra Abruzzo e Umbria. Nelle regioni meridionali l'indice di Sørensen dimostra la minore variabilità e va dal valore massimo 0,815 che si registra tra Campania e Puglia a quello minimo di 0,708 tra Basilicata e Puglia. L'indice di Sørensen tra Sicilia e Sardegna è di 0,737 e dimostra che nonostante la loro insularità, tali regioni presentano una discreta affinità, superiore a quella di varie regioni peninsulari contigue.

Ipotesi sui periodi e le rotte migratorie

Per spiegare com'è avvenuta l'espansione territoriale delle piante in esame, in accordo con quanto riportato in Pezzetta (2015), si è considerato che: le migrazioni foristiche avvengono in coincidenza di connessioni territoriali mentre in presenza di una barriera avviene la dispersione a lunga distanza; le ricerche palinologiche attestano l'epoca in cui i taxa erano presenti nel territorio in esame; le ricerche di biologia molecolare e le ricostruzioni filogeografche consentono di stabilire i territori in cui sono presenti i taxon ancestrali ed evidenziano affinità genetiche tra popolazioni disgiunte che sono spiegabili ammettendo colonizzazioni capaci di superare le barriere naturali frapposte.

Dai dati sinora riportati è emerso che. 1) le papaveracee si originarono nel lungo periodo compreso tra il Cretaceo Inferiore e il Pleistocene; 2) i variegati corteggi floristici analizzati dimostrano che ogni regione è caratterizzata da una propria storia biogeografica; 3) il dendrogramma di similarità conferma l'esistenza in Italia di notevoli differenze floristiche lungo i gradienti est-ovest e nord-sud.

Questi fatti nel loro insieme portano a ipotizzare che: le prime ondate migratorie iniziarono subito dopo che la famiglia apparve sulla terra e continuano ancora oggi, come dimostrano le segnalazioni recenti di *Fumaria vaillantii*, *Papaver apulum*, *Pseudofumaria alba* e altri taxa; 2) la diffusione delle papaveracee lungo la penisola seguì rotte diverse e modi tipici per vari gruppi e singoli taxa. Nei paragrafi seguenti si cercherà di spiegare quali furono e quando avvennero.

Migrazioni del Cretaceo

Le Papaveraceae iniziarono a divergere tra 129 e 112,9 Ma, mentre la subfamiglia più antica, le Pteridophyllaceae ora è presente in un'area ristretta del Giappone. Da tale scenario si può supporre che il centro d'origine è individuabile in qualche ambito dell'Asia Nord-Orientale da cui nel Cretacico inferiore, l'entità ancestrale migrò in varie direzioni. Tra le rotte seguite ci fu una occidentale che in un lunghissimo periodo che va sino al Miocene, permise di raggiungere l'Asia centro-orientale, la regione irano-turanica e il Bacino del Mediterraneo, importanti centri di diversità secondari per l'intera famiglia e primari per vari generi e specie.

Il Cretaceo è considerato il periodo più caldo della storia della Terra con la temperatura media che superava di oltre 7° quella attuale. Il clima caldo e molto umido per l'intensa evaporazione favorí lo sviluppo di una vegetazione subtropicale. Poiché la maggioranza delle papaveracee ora si rinviene negli ambienti sinantropici, aridi, mesofili e submesofili, ne segue che hanno modificato le abitudini primitive e si sono adattate a nuovi habitat.

Ad avviso di Pérez-Gutiérrez *et al.* (2015), tra il tardo Cretaceo e il primo Paleogene iniziò la dispersione dell'antenato delle *Hypecoeae* dall'Asia orientale verso l'Asia centrale, la Regione Irano-Turanica e il Bacino del Mediterraneo ove continuarono i processi di diversificazione.

Migrazioni del Terziario

Durante l'era Terziaria che comprende il lungo periodo che va da 65,5 a circa 2,6 Ma, si formò la penisola italiana e avvennero sulla terra vari sconvolgimenti paleogeografici accompagnati dalle estinzioni di organismi viventi molto antichi, la comparsa di nuove famiglie di piante ed animali e la loro diffusione geografica. Diverse famiglie vegetali continuarono a migrare dall'Asia al Bacino del Mediterraneo ove in centri secondari si svilupparono nuovi processi di differenziazione genetica. In qualche periodo imprecisato dell'era è da presumere che alcuni taxa ancestrali delle papaveracee raggiunsero qualche zona tra le terre emerse che oggi costituiscono la penisola italiana e forse le fumaroidee, essendo più antiche, furono le prime a colonizzarle.

Ad avviso di Pérez-Gutiérrez *et al*. (2015) durante il Luteziano (43.69–41.89 Ma) il gruppo corona delle *Fumariae* migrò dall'Asia Orientale a quella centrale ove, in un periodo di circa 4 Ma si diversificò in vari generi e lignaggi. L'espansione successiva verso il Bacino del Mediterraneo avvenne in due momenti seguendo rotte diverse. Il primo evento interessò le S*arcocapninae*, risale al primo Oligocene (33-26 Ma), seguì una rotta che lambiva le sponde settentrionali della Paratetide e durò 2 milioni di anni (26–24 Ma). Le disgiunzioni Est- Ovest Mediterranee che esistono tuttora nella subtribù sono la conseguenza delle interruzioni del ponte terrestre tra le due parti provocate da più fasi di trasgressioni marine.

Il secondo evento interessò le Fumariinae che a metà Eocene migrarono dall'Asia Centrale alla

Tab. 6: Valore dell'indice di Sorensen tra le Regioni Italiane.
Tab. 6: Vrednosti Sorensenovega indeksa med italijanskimi regijami.

Caso	**Indice di Sorensen**																			
	VDA	PIE	LOM	TAA	VEN	FVG	LIG	EMR	TOS	MAR	UMB	LAZ	ABR	MOL	CAM	PUG	BAS	CAL	SIC	SAR
VDA	1.00	.706	.667	.632	.727	.564	.579	.645	.488	.432	.467	.333	.474	.400	.462	.410	.485	.343	.400	.429
PIE	.706	1.00	.870	.833	.884	.776	.708	.732	.667	.638	.600	.500	.667	.533	.653	.612	.651	.533	.560	.538
LOM	.667	.870	1.00	.840	.889	.824	.720	.791	.717	.694	.619	.556	.720	.596	.667	.588	.667	.553	.500	.519
TAA	.632	.833	.840	1.00	.894	.717	.731	.711	.655	.588	.500	.500	.654	.531	.642	.604	.596	.531	.519	.500
VEN	.727	.884	.889	.894	1.00	.792	.766	.800	.680	.652	.564	.510	.681	.545	.625	.625	.667	.545	.531	.471
FVG	.564	.776	.824	.717	.792	1.00	.755	.783	.786	.731	.667	.632	.755	.640	.630	.630	.667	.560	.509	.491
LIG	.579	.708	.720	.731	.766	.755	1.00	.756	.764	.627	.545	.607	.692	.571	.717	.717	.638	.612	.667	.643
EMR	.645	.732	.791	.711	.800	.783	.756	1.00	.750	.773	.703	.612	.711	.667	.652	.696	.650	.619	.553	.571
TOS	.488	.667	.717	.655	.680	.786	.764	.750	1.00	.778	.723	.780	.764	.808	.750	.750	.760	.654	.667	.678
:MAR	.432	.638	.694	.588	.652	.731	.627	.773	.778	1.00	.791	.800	.824	.792	.769	.731	.783	.750	.604	.618
UMB	.467	.600	.619	.500	.564	.667	.545	.703	.723	.791	1.00	.708	.682	.780	.711	.622	.718	.634	.478	.625
LAZ	.333	.500	.556	.500	.510	.632	.607	.612	.780	.800	.708	1.00	.786	.830	.737	.737	.706	.755	.655	.733
ABR	.474	.667	.720	.654	.681	.755	.692	.711	.764	.824	.682	.786	1.00	.776	.755	.717	.809	.776	.667	.607
MOL	.400	.533	.596	.531	.545	.640	.571	.667	.808	.792	.780	.830	.776	1.00	.720	.720	.818	.783	.627	.679
CAM	.462	.653	.667	.642	.625	.630	.717	.652	.750	.769	.711	.737	.755	.720	1.00	.815	.750	.800	.691	.737
PUG	.410	.612	.588	.604	.625	.630	.717	.696	.750	.731	.622	.737	.717	.720	.815	1.00	.708	.800	.800	.737
BAS	.485	.651	.667	.596	.667	.667	.638	.650	.760	.783	.718	.706	.809	.818	.750	.708	1.00	.773	.694	.588
CAL	.343	.533	.553	.531	.545	.560	.612	.619	.654	.750	.634	.755	.776	.783	.800	.800	.773	1.00	.745	.679
SIC	.400	.560	.500	.519	.531	.509	.667	.553	.667	.604	.478	.655	.667	.627	.691	.800	.694	.745	1.00	.793
SAR	.429	.538	.519	.500	.471	.491	.643	.571	.678	.618	.625	.733	.607	.679	.737	.737	.588	.679	.793	1.00

regione irano-turanica e tra il tardo Oligocene e il Miocene medio (26–17 Ma), attraverso la placca arabica raggiunsero l'Africa settentrionale e il Bacino del Mediterraneo.

Il processo di aridificazione terrestre del Terziario favorí la diversificazione ecologica, la differenziazione genetica e l'espansione geografica dal centro d'origine ad altre zone della terra di una flora steppica comprendente vari generi tra cui *Papaver* che migrò dall'Asia Centrale in direzione occidentale. Kadereit *et al*. (2011) hanno ipotizzato che l'antenato della subfamiglia *Papaveroideae* era tipico degli ambiti mesofili e le trasformazioni ecologiche del Terziario favorirono la sua espansione e diversificazione.

Le migrazioni floristiche di alcune papaveracee probabilmente avvennero anche verso la fine del Miocene, in particolare durante il Messiniano che durò da 7,2 a 5,3 Ma. Allo stato attuale non esistono ritrovamenti fossili dimostrativi che all'epoca qualche taxa della famiglia era presente in Italia e di conseguenza, le ipotesi che seguono non hanno fondamenta di assoluta certezza.

Un taxon che in tale periodo probabilmente beneficiò del prosciugamento del mare, la formazione di ambienti alofili e si diffuse lungo le spiagge mediterranee è stato *Glaucium flavum*.

Potrebbero essere giunte durante il Messiniano dal ponte terrestre che collegava l'Algeria alla Sicilia e quest'isola al resto d'Italia varie entità di origine mediterranea tra cui:

- il gruppo di piante di origini centro-mediterranee comprendente *Fumaria bicolor*, *F. flabellata* e *F. gaillardotii*;
- il gruppo di piante diffuso dal Mediterraneo orientale alle regioni adriatiche comprendente *Fumaria macrocarpa*, *F. judaica*, *F. petteri* e *F. kralikii*.

Non è da escludere che le migrazioni di tali taxa avvennero in epoche successive quando la costa nord-africana era molto più vicina alla Sicilia rispetto all'epoca attuale, oppure che furono favorite dall'uomo durante l'Olocene. Se effettivamente ci fu una migrazione olocenica, si dimostra che le piante in oggetto si sono adattate a habitat diversi da quelli d'origine. Infatti, in Italia, ora si rinvengono nei terreni coltivati mentre nei luoghi d'origine attecchiscono in ambiti naturali non modificati dall'uomo.

Altre migrazioni floristiche avvennero durante il Pliocene, quando il clima si fece più fresco e diverse specie tipiche di ambienti temperati colonizzarono il territorio peninsulare che all'epoca era molto simile alla configurazione attuale. È ipotizzabile che durante il Pliocene e le fasi calde del Pleistocene, i taxa degli elementi microtermici e mesotermici della flora italiana (Nordico, Eurasiatico e mesotermici) raggiunsero la penisola in seguito a migrazioni multiple. Di conseguenza le papaveracee dei contingenti Euroasiatico ed Europeo tipiche dei boschi mesofili e degli ambienti aridi e steppici, favorite dal clima più fresco e dai collegamenti terrestri, si diffusero in diverse regioni peninsulari.

Tra la fine del Pliocene e l'inizio del Pleistocene, l'antenato del gruppo di *Papaver alpinum* dalle montagne centro-asiatiche migrò in direzione occidentale e raggiunse le Alpi dove iniziò a differenziarsi (Kadereit, 1990; Schönswetter *et al.*, 2009).

Migrazioni del Quaternario

Il Quaternario (o Neozoico) è il periodo geologico più recente, iniziò circa 2,6 Ma e si ripartisce in Pleistocene che durò sino a 11700 anni fa e Olocene tuttora in corso. Durante il Pleistocene, le particolari condizioni climatiche, i ripetuti cicli glaciali e interglaciali, i ponti terrestri che s'instaurarono, l'isolamento geografico di vari gruppi di piante, le mutazioni geniche e altri fattori provocarono profonde trasformazioni nella distribuzione degli organismi viventi poiché favorirono le estinzioni, gli accantonamenti e le condizioni per altre migrazioni floristiche e i processi che portarono alla formazione di nuove specie.

Durante le fasi più fredde vari taxa tipici dei climi temperati sopravvissero in aree rifugio della penisola iberica, l'Europa Sud-Orientale, l'Italia centro-meridionale e altri ambiti del Bacino del Mediterraneo da cui in seguito ripartì la loro espansione (Schmitt, 2007). Durante qualche periodo interglaciale, secondo Tammaro (1992), dal Mediterraneo Orientale migrò verso il Gran Sasso *Fumaria parviflora* insieme ad altre specie.

Nel Pleistocene probabilmente *Papaver degeni*, *P. ernesti mayeri* e *Pseudofumaria alba* susp. *alba* raggiunsero la catena appenninica. È ipotizzabile che *Papaver ernesti mayeri* dalla catena alpina raggiunse l'Appennino Centrale mentre gli altri 3 taxa migrarono dalla penisola balcanica attraverso qualche ponte terrestre che si creò con la regressione marina. Non è pensabile che la colonizzazione sia avvenuta in precedenza per vari motivi. Innanzitutto il fatto che il genere *Papaver* essendosi originato tra 10 e 7 Ma in qualche ambito dell'Asia centrale, per raggiungere la catena alpina e la penisola balcanica, attecchirvi stabilmente, frantumarsi in nuovi taxa e poi migrare verso altri territori impiegò diversi milioni di anni. Inoltre parte consistente della catena appenninica si formò durante il Pliocene e quindi non è possibile che piante di alta quota presenti sulle Alpi o i Balcani abbiano potuto raggiungerlo prima della sua emersione.

Probabilmente nel Pleistocene, il genere *Pseudofumaria,* dalla penisola balcanica migrò in direzione occidentale raggiungendo anche alcune regioni italiane. Poiché i taxa sono tipici di ambiti rupestri, i movimenti migratori avvennero tra catene e rocce collegate tra loro o affidando i semi al trasporto del vento. *Pseudofumaria alba* durante l'era glaciale raggiunse la penisola sfruttando le connessioni territoriali che si crearono tra il Gargano, le isole Termiti e la Dalmazia o più a sud attraverso il ponte salentino-albanese. In seguito il taxon raggiunse le altre regioni peninsulari ma si estinse in Puglia. *Pseudofumaria alba* è caratterizzato dal numero cromosomico 2n= 32 mentre *P. lutea* da 2n = 64 (Lidén, 1986). Di conseguenza si può supporre che il secondo taxon si sia generato dal primo per raddoppio del corredo cromosomico e durante qualche fase calda dell'era glaciale sia migrato dalla penisola balcanica in direzione nord-occidentale sino a occupare l'areale attuale.

Altre migrazioni sono avvenute nell'Olocene, un periodo nel complesso caratterizzato da: la crescita del livello marino e della temperatura; l'arretramento delle linee costiere e dei ghiacciai alpini; l'espansione dei relitti terziari sopravvissuti in stazioni di rifugio; la formazione di nuovi taxa; la diffusione di entità di varie origini geografiche, in diversi casi favorita dall'attività dell'uomo. A circa diecimila anni fa va collocato lo sviluppo dell'agricoltura, della pastorizia e l'avvio della diffusione delle piante che crescono nei campi coltivati, lungo le strade, vicino gli insediamenti e nelle zone ricche di sostanze organiche (Manzi, 2012).

La coltura del frumento iniziò in Mesopotamia, si allargò alle zone del Mediterraneo e portò alla diffusione di varie archeofite definite da Poldini (2009) "relitti culturali" che testimoniano il passaggio dell'uomo dalla fase nomade legata alla caccia a quella agricola stanziale. A questa categoria appartengono varie specie dei generi *Fumaria* e *Papaver*. Negli scavi dell'età del bronzo (3400-600 a.C.) fatti in Abruzzo sono stati rinvenuti resti di *Fumaria* s.p. a dimostrazione che all'epoca il genere era diffuso (Manzi, 2017).

Le seguenti specie di origini occidentali durante l'Olocene potrebbero aver raggiunto la penisola italiana a causa dell'attività dell'uomo: *Fumaria bastardii*, *F. muralis Papaver setigerum* e *Platycapnos spicatus*.

Ad avviso di Arrigoni & Viegi (2011) *Papaver somniferum è un'archeofita e Roemeria hybrida* una neofita che si diffuse dopo la scoperta dell'America. Altre ricerche hanno dimostrato che durante il Neolitico *Papaver somniferum* era coltivato. In Italia alcuni suoi resti sono stati rinvenuti in vari insediamenti preistorici del VI e V millennio a. C. (Rottoli, 2006; Gobbo, 2010; Saunders, 2013).

Nel 1987 e nel 2015 in due siti del Carso triestino e isontino è stata rinvenuta *Pseudofumaria alba* la cui presenza secondo Polli (2018) è dovuta anche al mutare del clima che ha consentito il recente favorevole insediamento nei luoghi di ritrovamento.

L'espansione recente di taxa di varie famiglie di piante, ivi comprese le papaveracee avviene anche con l'esercizio ferroviario che attraverso il trasporto delle merci favorisce la diffusione dei semi e, nelle vicinanze degli scali e i binari crea le condizioni favorevoli per il loro insediamento. Già alla fine del XIX secolo Marchesetti (1882) si dimostrò un pioniere in tali ricerche, segnalando presso lo scalo ferroviario di Campo Marzio (Trieste): *Fumaria officinalis*, *F. vaillantii*, *Glaucium flavum*, *Hypecoum pendulum*, *Papaver argemone*, *P. hybridum* e *P. dubium*. A questo studio pionieristico si aggiungono altri fatti a partire da circa 30 anni fa che comprendono le seguenti specie:

- *Papaver dubium, P. rhoeas*, *Fumaria capreolata* subsp. *capreolata* **e** *F. officinalis* subsp. *wirtgenii* segnalate da Cornellini & Petrella (1994) nella stazione di Roma Ostiense;
- *Fumaria officinalis* e *Papaver rhoeas* segnalate da Martini & Pericin presso lo scalo del Porto Vecchio di Trieste e da Alessandrini *et al.* (2011) in diverse stazioni ferroviarie emiliano-romagnole*;*
- *Fumaria vaillantii* che è stata trovata da Alessandrini (2016) nello scalo di San Donato (Bo);
- *Glacium flavum* segnalata da Scassellati et al. (2007) nelle stazioni ferroviarie di Terni, Roma Termini e Napoli;
- *Papaver apulum* segnalata da Verona (2004) nella stazione di Udine e da Costalonga (2007) presso lo scalo ferroviario di Sacile, un Comune della Provincia di Pordenone;
- *Papaver somniferum* e *P. rhoeas* segnalate da Licitra e Napoli (2011) presso le "ferrovie" di Ragusa (Sicilia);
- *Papaver setigerum* segnalata da Olivieri (2016) ai margini di una massicciata ferroviaria posta nel Comune di Francavilla a Mare (CH).

Altre segnalazioni sono state fatte lungo i bordi di strade e persino nei cimiteri, a dimostrazione che diverse entità si diffondono facilmente negli ambiti antropizzati. Alla espansione recente di alcune papaveracee contribuisce il loro uso insieme ai semi di altre piante per la per la costituzione di prati misti e fioriti con i quali si tenta la rinaturalizzazione, il recupero e la valorizzazione estetico-paesaggistica delle aree degradate, degli ambienti urbani, peri-urbani e marginali. Tra le specie di solito utilizzate c'è *Papaver rhoeas*.

Purtroppo, accanto alle entità che si espandono ci sono altre che diventano rare. Tra queste diverse papaveracee dei campi coltivati che a causa del largo impiego di prodotti chimici nell'agricoltura e della riduzione delle aree agricole, ora sono meno diffuse. Infatti, ora vari taxa dei generi *Papaver* (*P. apulum, P. rhoeas*, *P. hybridum*) e del genere *Fumaria*, (*F. officinalis*, *F. vaillantii*, etc.) nonostante che in generale continuano ad essere presenti in quasi tutte le regioni italiane, sono sempre meno diffuse all'interno delle aree agricole e si rinvengono nelle zone ruderali e nei terreni abbandonati.

Modalità di dispersione

La dispersione dei semi di papaveracee nell'ambiente avviene con le seguenti modalità:

- la mirmemocoria che si ha quando i semi sono trasportati dalle formiche;
- l'ornitocoria in cui i semi sono trasportati dagli uccelli;
- l'anemocoria che si ha quando la dispersione è favorita dal vento;
- l'autocoria in cui una pianta disperde autonomamente i suoi semi senza aiuti esterni;
- la bolocoria in cui i semi per l'esplosione del frutto, sono lanciati a distanze più o meno grandi;
- l'atelocoria che si ha quando i semi cadono per gravità vicino alla pianta madre;
- l'idrocoria che si ha quando i semi sono trasportati dall'acqua.

La diffusione mirmemocora è adottata da 20 generi di papaveracee (Lengyel *et al.,* 2010), tra cui appartengono alla flora italiana: *Chelidonium, Corydalis* e *Pseudofumaria*. Essa è favorita dalla presenza nei semi di particolari escrescenze del funicolo o del tegumento esterno detti arilli o elaiosomi nutrienti. La loro funzione è di attrarre le formiche e spingerle a trasportare i semi nei nidi ove gli arilli stessi sono mangiati. Ciò che resta si deposita all'esterno del nido ove si riproduce (Fukuhara, 1999; Lengyel *et al*., 2010).

I semi senza arilli possono essere dispersi dal vento, dagli uccelli, dall'uomo e dalle acque consentendo di superare lunghe distanze. I semi di varie specie del genere *Fumaria* possono essere dispersi a lunga distanza dall'uomo e a corto raggio dalle formiche.

La dispersione idrocora invece è adottata da *Glaucium flavum* che può affidare il trasporto dei semi alle correnti marine (Martin 1996) mentre sulla terraferma si diffondono per gravità. I dati riportati sulle modalità di dispersione sono compatibili con le ipotesi formulate sulle rotte migratorie seguite dai vari taxa e contribuiscono a renderle più verosimili.

CONCLUSIONI

Gli studi citati dimostrano che le papaveracee della flora italiana hanno raggiunto l'attuale grado di diversità e distribuzione in seguito a molteplici ondate migratorie. Restano ancora molte incertezze sulle rotte seguite per raggiungere la penisola italiana e l'epoca in cui avvennero.

All'interno delle regioni peninsulari è segnalata un'unica specie stenoendemica. Questo fatto porta ad affermare che per la famiglia di piante in esame, la penisola italiana è un piccolo centro di diversità forse terziario o quaternario.

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Supplemento 1: Distribuzione delle Papaveraceae nelle regioni italiane.
Priloga 1: Razširjenost taksonov iz družine Papaveraceae v italijanskih regijah.

	Taxa	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
		VDA	**PIE**	**LOM**	**TAA**	**VEN**	**FVG**	**LIG**	**EMR**	**TOS**	**MAR**	**UMB**	**LAZ**	**ABR**	**MOL**	**CAM**	**PUG**	**BAS**	**CAL**	**SIC**	**SAR**
1	Chelidonium majus L. - Eurasiatico	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2	Corydalis capnoides (L.) Pers. - Eurosiberiano				1	1															
3	Corydalis cava (L.) Schweigg. & Körte subsp. cava - Europeo-Caucasico		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		
4	Corydalis densiflora C.Presl subsp. apennina F.Conti, Bartolucci & Uzunov - Endemico										1	1	1	1	1	1		1	1		
5	Corydalis densiflora C.Presl subsp. densiflora - Subendemico																			1	1
6	Corydalis intermedia (L.) Mérat - Centro-Europeo	1	1	1	1	1	1	1	1	1				1				1		1	
7	Corydalis pumila (Host) Rchb. - Centro-Europeo			1			1		1	1	1	1	1	1	1				1		1
8	Corydalis solida (L.) Clairv. subsp. solida - Europeo	1	1	1	1	1	1	1	1	1						1	1				
9	Eschscholzia californica Cham. subsp. californica - Avventizio		1	1	1	1	1	1	1	1	1			1			1			1	
10	Fumaria agraria Lag. - Stenomediterraneo							1								1	1		1	1	1
11	Fumaria barnolae Sennen & Pau subsp. barnolae - Nord-Ovest-Mediterraneo						1	1	1	1	1	1	1		1		1				1
12	Fumaria bastardii Boreau - Subatlantico									1	1	1	1		1	1	1	1	1	1	1
13	Fumaria bicolor Sommier - Stenomediterraneo									1			1		1					1	1
14	Fumaria capreolata L. subsp. capreolata - Eurimediterraneo	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
15	Fumaria densiflora DC. - Subcosmopolita.		1				1			1	1	1	1	1	1	1	1	1	1	1	1
16	Fumaria flabellata Gasp. - Stenomediterraneo									1	1		1	1	1	1	1	1	1	1	1
17	Fumaria gaillardotii Boiss. - Stenomediterraneo												1	1	1		1	1	1	1	1
18	Fumaria judaica Boiss. subsp. judaica - Sud-Est-Mediterraneo																1			1	
19	Fumaria kralikii Jord. - Sud-Europeo-Sud Siberiano												1								1
20	Fumaria muralis W.D.J.Koch subsp. muralis - Subatlantico									1		1				1	1				1
21	Fumaria officinalis L. subsp. officinalis - Paleotemperato	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1	1
22	Fumaria officinalis L. subsp. wirtgenii (W.D.J.Koch) Arcang. - Subcosmopolita			1	1	1	1	1	1	1	1		1	1	1	1	1	1	1		
23	Fumaria parviflora Lam. - Mediterraneo-Turaniano		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
24	Fumaria petteri Rchb. subsp. petteri - Appennino-Balcanico									1			1		1						
25	Fumaria rostellata Knaf - Sud-Est-Europeo				1																
26	Fumaria schleicheri Soy.-Will. - Eurasiatico	1	1	1	1	1		1													1
27	Fumaria vaillantii Loisel. - Mediterraneo-Turaniano	1	1	1	1	1	1	1	1	1	1			1	1	1	1	1	1	1	1
28	Glaucium corniculatum (L.) Rudolph subsp. corniculatum - Mediterraneo Montano							1					1	1		1	1		1	1	1
29	Glaucium flavum Crantz - Eurimediterraneo		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
30	Hypecoum imberbe Sm. - Paleotemperato												1				1			1	1
31	Hypecoum pendulum L. - Avventizio						1	1													
32	Hypecoum procumbens L. subsp. procumbens - Paleotemperato								1		1		1			1	1		1	1	1
33	Hypecoum torulosum Å.E.Dahl - Paleotemperato																		1	1	
34	Lamprocapnos spectabilis (L.) Fukuhara - Avventizio										1										
35	Meconopsis cambrica (L.) Vig. - Avventizio				1																
36	Papaver alpinum subsp. ernesti-mayeri Markgr. Subendemico						1							1							
37	Papaver alpinum subsp. kerneri (Hayek) Fedde - Subendemico						1														
38	Papaver alpinum subsp. rhaeticum (Leresche) Nyman - Alpico		1	1	1	1	1														
39	Papaver apulum Ten. - Sud-Est-Europeo		1	1	1	1	1	1		1	1		1	1		1	1	1	1	1	
40	Papaver argemone L. - Mediterraneo-Turaniano	1	1	1	1	1	1	1	1	1	1	1	1	1		1					1
41	Papaver atlanticum (Ball) Cosson subsp. atlanticum - Avventizio		1																		
42	Papaver croceum Ledeb. - Avventizio				1																
43	Papaver degenii (Urum & Jav.) Kuzm. - Appennino-Balcanico.										1		1	1							
44	Papaver dubium L. - Mediterraneo-Turaniano	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
45	Papaver hybridum L. - Mediterraneo-Turaniano	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
46	Papaver lecoqii Lamotte - Ovest-Europeo		1	1	1											1					1
47	Papaver nudicaule L. - Avventizio			1																	
48	Papaver pinnatifidum Moris - Stenomediterraneo							1		1								1		1	1
49	Papaver rhoeas L. subsp. rhoeas - Eurimediterraneo	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
50	Papaver setigerum DC. - Mediterraneo-Occidentale				1			1		1			1	1	1	1	1		1	1	1
51	Papaver somniferum L. - Eurimediterraneo		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
52	Platycapnos spicatus (L.) Bernh. - Mediterraneo-Occidentale							1								1				1	1
53	Pseudofumaria alba (Mill.) Lidén subsp. alba - Appennino-Balcanico			1			1			1	1	1	1	1	1	1		1			
54	Pseudofumaria lutea (L.) Borkh. - Europeo	1	1	1	1	1	1														
55	Roemeria hybrida (L.) DC. subsp. hybrida - Mediterraneo-Turaniano						1	1		1			1								
56	**Totale**	12	22	24	26	21	27	26	19	29	25	18	30	26	23	27	27	21	23	28	30

DRUŽINA PAPAVERACEAE JUSS. V ITALIJANSKI FLORI: REGIONALNA RAZŠIRJENOST IN FITOGEOGRAFSKA OPREDELITEV

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POVZETEK

Avtor v pričujočem delu navaja seznam vseh taksonov iz družine Papaveraceae, ki so bili potrjeni v Italiji. Nadalje analizira njihovo geografsko razširjenost, opredeljuje glavne vzorce razširjenosti, posreduje fitogeografsko analizo in poskuša razpravljati o izvoru in glavnih premikih glede na objavljene vire. Sodeč po trenutnem poznavanju šteje italijanska flora 55 taksonov iz 12 rodov te družine. Regionalna razširjenost je nezvezna; le 5 taksonov je navzočih v vseh regijah, drugi pa se pojavljajo le v eni regiji, polotoškem sektorju ali pa je razširjenost zelo variabilna. Horološka analiza je pokazala prevladovanje evrazijskih elementov, ki mu sledijo sredozemski. Razpoložljive objave so obelodanile veliko negotovosti in različnih pogledov na izvor in premike pri naseljevanju italijanskih regij.

Ključne besede: Papaveraceae, seznam vrst, biogeografija, regionalna razširjenost, floristične migracije, izvor

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MORPHOLOGICAL CHARACTERIZATION OF *OROBANCHE CRENATA* IN CARROTS AND LEGUMES (FABA BEAN AND CHICKPEA): INDICATIONS OF POTENTIAL GENETIC DIFFERENTIATION TOWARDS HOST PLANTS

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ABSTRACT

Carrot is an important root vegetable crop in Morocco. Recently, it has been reported to have been attacked by the parasitic plant Orobanche crenata*, which is known for infesting legumes. The aim of this study is to provide a morphological comparison between carrot-hosted, and faba bean- and chickpea-hosted* O. crenata *plants according to quantitative and qualitative parameters. High genetic variability was observed in the qualitative traits of parasitic plants at intra- and inter-host levels. In fact, differences in the color of stem, leaves, petals, calyx, sepals, central bract of flowers, stigma lobes, and anthers were observed. In contrast, the variability of quantitative traits was low. For instance, variation between parasitic plants by type of host crop was only significant in collar circumference and sucker circumference. The results of this study could be tentatively explained by host-parasite specific interaction and adaptation.*

Key words: Carrot, chickpea, faba bean, genetic variability, morphological comparison, *Orobanche crenata*

CARATTERIZZAZIONE MORFOLOGICA DI *OROBANCHE CRENATA* IN CAROTE E LEGUMI (FAVE E CECI): INDICAZIONI DI POTENZIALE DIFFERENZIAZIONE GENETICA A SECONDA DELLE PIANTE OSPITANTI

SINTESI

La carota è un importante raccolto di ortaggi a radice in Marocco. Recentemente è stato segnalato che è stata attaccata dalla pianta parassita Orobanche crenata*, nota per infestare i legumi. Lo scopo di questo studio è quello di fornire un confronto morfologico tra piante di* O. crenata *ospitate da carote e da piante di fave e ceci, secondo parametri quantitativi e qualitativi. È stata osservata un'elevata variabilità genetica nei tratti qualitativi delle piante parassite a livello di intra- e inter-ospite. Sono state infatti osservate differenze nel colore del fusto, delle foglie, dei petali, del calice, dei sepali, della brattea centrale dei fiori, dei lobi dello stigma e delle antere. Al contrario, la variabilità dei tratti quantitativi è risultata bassa. Ad esempio, la variazione tra le piante parassite per tipo di coltura ospite era significativa solo nella circonferenza del colletto e nella circonferenza della ventosa. I risultati di questo studio potrebbero essere provvisoriamente spiegati dall'interazione e dall'adattamento specifici per il rapporto ospite-parassita.*

Parole chiave: Carota, ceci, fave, variabilità genetica, confronto morfologico, *Orobanche crenata*

INTRODUCTION

The carrot (*Daucus carota* L.) is a biennial dicotyledonous plant belonging to the Apiacea family. This family includes approximately 445 genera and 3700 species (Downie & Katz-Downie, 1996). The carrot is cultivated in all temperate regions of the world and even in subtropical zones during the fresh season (Chaux & Foury, 1994). It is considered among the ten most important vegetable crops in the world, in terms of production area (about 1.2 million hectares) and market value (Simon *et al.*, 2008). The carrot is cultivated for its roots, used as human food for its richness in carotenoids, -carotene in particular, which protects from vision disturbances and maintains the good condition of the skin and other parts of the organism. It contains high levels of carbohydrates and other vitamins (B, C, K). Carrot root is widely used in children nutrition thanks to its fiber content adapted to the consumption methods (salads, fresh, cooked, juices, etc.) (Villeneuve, 1999).

The carrot plant is part of the host range of *Orobanche crenata*. This parasitic plant threatens carrot farming especially in the Mediterranean region including North Africa, the Near East and western Asia, with quite recent introductions into Sudan and Ethiopia (Babiker *et al.*, 2007). It infests the most important legume crops of the Mediterranean, particularly faba bean, lentil, chickpea, vetch, and field pea, but also carrot (Schaffer *et al.*, 1991). It reduces the yield and destroys the quality of carrot root (Schaffer *et al.*, 1991). Recently in Morocco, there have been reports of carrot fields (9000 ha) infested by *O. crenata*. The infested areas are Chaouia (*north*-central *Morocco*) and south of Doukkala (north-western Morocco), accounting for more than 60% of the acreage of the carrot crop. Meanwhile, no infestation has been reported in the remaining cultivation areas: Gharb (western Morocco), Tadla (central Morocco), Sous (central-south Morocco), and Sais (Chedadi *et al.*, 2019). *O. crenata* causes significant yield decreases ranging from 15 to 21%. The economic loss has been estimated to run between 2600 and 3400 USD/ha (Chedadi *et al.*, 2020).

O. crenata belongs to the genus of *Orobanche*. This genus contains more than 150 species (Musselman, 1980), but only five of them are considered dangerous for agricultural production, namely, *O. crenata, O. cumana, Phelipanche aegyptiaca, Phelipanche ramosa*, and *O. minor* (Perez-de-Luque *et al.*, 2004). The differentiation between these species is based on morphological criteria (stem, leaves or bracts, flower, hairiness, stigma, anthers, corolla, stigma lobes, etc.) as described in plant identification and taxonomic keys (Parker, 2013; Foley, 2000). There is a wide genetic variability within broomrape populations of the same species in the color or size of the corolla, degree of pubescence, and some other morphological characters (Musselman, 1994). This variability can be influenced by the host range and preference host (Joel, 2000). *O. crenata* populations exhibit high variability in several characters: color of stem, flowers, and stigma, density of flowers on the stem, and size of plant (length and diameter) (Cuebro, 1979). The variability in *O. crenata* is not only morphological, it is also associated with parasitism; in fact, host-parasite interaction effects have been observed that have quantitative impact on the variability (Abdallah & Darwich, 1994). For instance*, O. crenata* plants can reach greater vegetative vigor and height in faba beans and produce 10 times more seeds than in lentils (Kroschel, 2001). The *O. crenata* height can range from 30 to 100 cm. The plant has a hairy stem with leaves reduced to bracts. The bracts are simple and alternate, their upper and lower surfaces hairy. The inflorescence is a spike carrying flowers of 1.5 to 3 cm in length. Petals are fused and hairy. The color of the corolla varies from yellowish white to purple (Servais & Seba, 2020).

The morphological characteristics are important parameters allowing easy identification of genetic diversity in inter- and intra-population studies. Most qualitative traits have been reported as inherited following monogenic models in different plants, thus providing useful information for the description and identification of biological material and the classification of the species, as well as for the comparison of individuals within the same species (Andersson *et al.*, 2006).

To our knowledge, the available literature contains no published reports of comparisons between *O. crenata* plants attacking carrots and those attacking legumes. Thus, our study aims at providing a morphological comparison between plants of *O. crenata* hosted by two legumes, faba bean (*Vicia faba*) and chickpea (*Cicer arietinum*), and those hosted by the carrot, using quantitative and qualitative descriptive parameters to investigate the differences and similarities between them and to explore the hypothesis of possible genetic differentiation according to the host plant.

MATERIAL AND METHODS

For comparing legume-hosted and carrot-hosted *O. crenata* plants, a total of 90 plants of *O. crenata* were collected from carrot, faba bean and chickpea fields in the Chaouia area, located in the Casablanca-Settat region (33° 32′ 00″ North, 7° 35′ 00″ West of Morocco). For each crop, 10 plants were randomly collected from three different fields.

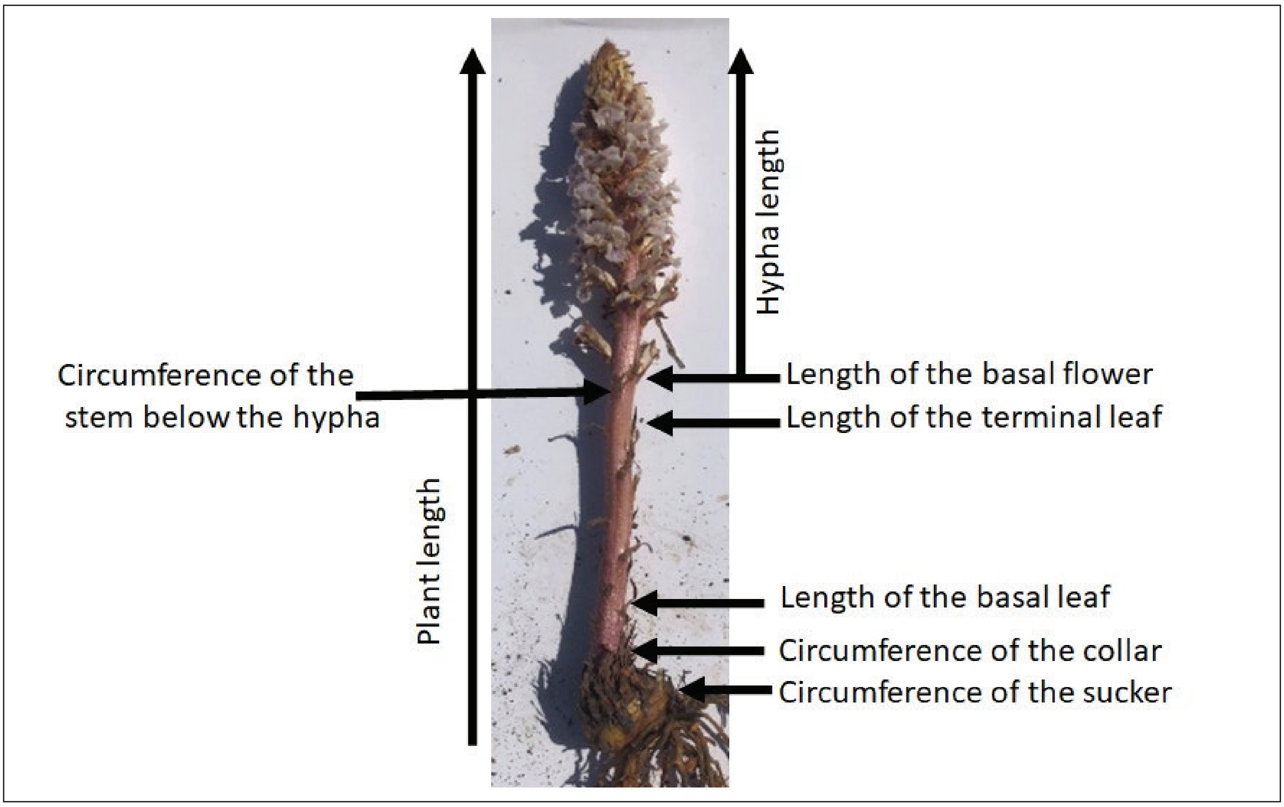

Fig. 1: Illustration of quantitative parameters measured in* O. crenata *plants for the purpose of morphological description.
Sl. 1: Izmerjeni kvantitativni parametri pri rastlinah* O. crenata *za morfološki opis.

The morphological characterization of the collected *O. crenata* plants was carried out based on both quantitative and qualitative traits according to the descriptor Tilo botanica (Servais & Seba, 2020). The measured quantitative characters (Fig. 1) included: plant height (PH), sucker circumference (SC), collar circumference (CC), stem circumference below the hypha (CTH), length of basal leaf (LFB) and terminal leaf (LFT), basal flower length (LFBA), hypha length (LH), number of anthers (NE), and number of stigma lobes (NLS).

The studied qualitative characters included the color of stem, leaves, petals, calyx, sepals, top of the central bract, base of the central bract, sides of the central bract, anthers, stigma of lobes, and the presence or absence of hair at anthers, petals, sepals and ovary filaments.

The descriptive data analysis was performed using Excel 2016 for each trait. Averages, standard deviations, coefficients of variation, and frequency of distribution were calculated. To estimate the extent of morphological diversity and differentiation among and between *O. crenata* populations, morphological diversity (MD) based on Simpson index (1) and phenotypic differentiation (PD) (2) index between each two consecutive *O. crenata* populations were calculated for the qualitative traits using the following formulas:

$$(1)\ \mathbf{MD} = \mathbf{1} - \sum_{\mathbf{1}}^{s} (\boldsymbol{pi})^2$$

pi is the proportion of the total number of individuals in the population with the ith morphological character state, and s is the total number of morphological character states (Casas *et al.*, 2006; Blancas *et al.*, 2009).

$$(2)\ \mathbf{PD_{1-2}} = \mathbf{ln}\,\frac{\mathbf{xiyj}}{\sqrt{\left(\sum_{\mathbf{1}}^{\mathbf{s1}}(\mathbf{xi})^2 \sum_{\mathbf{1}}^{\mathbf{s2}}(\mathbf{yj})^2\right)}}$$

xi and yj are frequencies of individuals with the i^{th} and j^{th} morphological character state in populations 1 and 2, s_1 and s_2 are the total number of morphological character states for a given qualitative trait in the two respective populations, ln is the Napierian logarithm (Blancas *et al.*, 2009).

For each *O. crenata* population and each trait, the average morphological diversity index was calculated. Average phenotypic differentiation between pairwise populations was estimated for each trait.

Tab. 1: Average, minimum, maximum, and coefficient of variation of quantitative parameters measured in* O. crenata *host plants: carrot, chickpea, and faba bean.
Tab. 1: Povprečje, minimum, maksimum in koeficient variacije kvalitativnih parametrov, izmerjenih pri gostiteljih pojalnikov* O. crenata*: korenju, čičeriki in bobu.

Host crops		**PH (cm)**	**SC (cm)**	**CC (cm)**	**CTH (cm)**	**LFB (cm)**	**LFT (cm)**	**LH (cm)**	**LFBA (cm)**
Carrot	A.	47.7a±9.86	9a±2.17	3.9a±0.70	3.2a±0.67	2a±0.36	1.7a±0.37	20.7a±7.08	2.3a±0.28
	Min	28	5.1	2.8	1.9	1.5	1	10	1.9
	Max	66.4	16	5.5	5.1	3.2	2.5	37	3
	CV	21%	24%	18%	21%	17%	22%	34%	12%
Faba bean	A.	44.9a±12.59	7.1b±1.95	3.3b±0.62	3a±0.59	2a±0.30	1.7a±0.27	23.7a±8.73	2.5a±0.53
	Min	27.1	4.6	2.5	2.3	1.5	1.1	8.6	1.1
	Max	84.5	14.6	4.9	4.9	3	2.2	43.9	3.4
	CV	28%	27%	19%	19%	15%	16%	37%	22%
Chickpea	A.	44.3a±9.30	6.9b±1.63	3.4b±0.53	3.1a±0.43	1.9a±0.32	1.7a±0.68	25a±7.33	2.6a±0.47
	Min	21.2	3.3	2.4	2.4	1.2	1.1	9.9	1.1
	Max	62.5	10.2	4.8	3.8	2.6	2.2	37.9	3.2
	CV	21%	24%	16%	13%	17%	16%	29%	18%

Considering all the characters, a discriminant factor analysis, using SPSS 19.0 for Windows, was performed to test the hypothesis of genetic differentiation in the studied *O. crenata* populations according to their membership to the predefined groups, which corresponded to classes of host plant (carrot, faba bean, and chickpea). All recorded characteristics of *O. crenata* plants were considered as descriptive variables, and the crop class as the explained variable. The corresponding eigenvalues of discriminant functions, significant levels, and correlations to descriptive variables were analyzed and a graphic representation of the collections was produced to display the obtained results. For further confirmation and comparison, a hierarchical classification of different *O. crenata* accessions, based on Nei & Li's (1979) genetic distance from a binary matrix of presence/absence of descriptive qualitative trait classes, was carried out using TREECON for Windows (Vandepeer & Dewachter, 1994). Bootstrap analysis with 100 iterations was used to test the confidence and faithfulness of the obtained groupings.

RESULTS

Variation in quantitative traits

Averages, minimum, maximum, and coefficients of variation were reported for quantitative traits (Tab. 1). Significant variation was observed in the circumference of the sucker between legume- and carrot-hosted plants. In the the two legumes, faba bean and chickpea, it was almost identical, with averages of 7.1 and 6.9 cm, respectively, while in carrot-hosted *O. crenata* the average was higher by 2 cm, namely 9 cm (Fig. 2). Significant variation was also observed in the circumference of the collar. Although the difference was not statistically significant (F=0.09), the hypha length (LH) value in *O. crenata* plants collected in carrot fields was lower than in plants from faba bean and chickpea fields (20.7, 23.7, and 25 cm, respectively). Likewise the plant height: although the differences by crop type regarding this parameter were not statistically significant, *O. crenata* collected in carrot fields were taller, averaging about 47.7 cm, than those collected in faba bean and chickpea fields, averaging about 44.9 and 44.3 cm, respectively (Tabs. 1 & 2).

With regard to other quantitative parameters (number of anthers and number of stigma lobes), the plants of *O. crenata* exhibited the same values, 4 and 2, respectively, regardless of the host plant.

Variation in qualitative traits

Color of leaves

During our survey, we observed three colors of leaves among the studied *O. crenata* population col-

Tab. 2: Variance analysis of *O. crenata* ***quantitative traits according to the three host crops. Means significantly different at P ≤ 0.05. Plant height (PH), sucker circumference (SC), collar circumference (CC), stem circumference below the hypha (CTH), length of the basal leaf (LFB) and terminal leaf (LFT), hypha' length (LH), basal flower length (LFBA).***
Tab. 2: Analiza variance kvantitativnih znakov pojalnikov *(O. crenata)* ***glede na tri gostiteljske kulture. Srednje vrednosti so statistično značilne na nivoju P ≤ 0.05. Višina rastline (PH), obseg sesalnih korenin (SC), obseg ovratnika (CC), obseg stebla pod hifo (CTH), dolžina bazalnega (LBF) in terminalnega lista (LFT), dolžina hife (LH) in dolžina bazalnega cveta (LFBA).***

Source of variation	Traits	Sum of squares	Degree of freedom	Mean squares	F	Signification *
Treatment (host crop)	**PH**	193.8	2	96.9	0.82	0.44
Error		10173.4	87	116.9		
Total		10367.2	89			
Treatment (host crop)	**SC**	85.2	2	42.6	11.2	0.0001
Error		330.7	87	3.8		
Total		416	89			
Treatment (host crop)	**CC**	5.87	2	2.6	6.8	0.002
Error		34.3	87	0.3		
Total		39.7	89			
Treatment (host crop)	**CTH**	0.69	2	0.34	1.04	0.35
Error		29	87	0.33		
Total		29.7	89			
Treatment (host crop)	**LFB**	0.41	2	0.2	1.91	0.15
Error		9.48	87	0.1		
Total		9.9	89			
Treatment (host crop)	**LFT**	0.007	2	0.003	0.036	0.965
Error		8.3	87	0.096		
Total		8.3	89			
Treatment (host crop)	**LH**	294.8	2	147.4	2.3	0.09
Error		5353.9	87	61.5		
Total		5648.7	89			
Treatment (host crop)	**LFBA**	1.15	2	0.5	2.8	0.06
Error		17.9	87	0.2		
Total		19	89			

lected from the three crops (carrot, faba bean and chickpea): dark brown, brown, and light brown. All three colors were found in *O. crenata* plants in carrots and faba beans, while those in chickpeas only displayed the brown and light brown colors. *O. crenata* plants with brown leaves were the most frequent, with a frequency of 83%, while dark brown and light brown leaves were present at frequencies of 6% and 11%, respectively (Tab. 3).

Stem color

The color of the stem varied in all three crops (Tab. 4, Fig. 3), from dark purple, purple and light purple to pale yellow. The respective frequencies of the colors were 28, 42, 18 and 12%. *O. crenata* plants with purple and dark purple stems were the most frequent among the population studied, with a frequency of about 70%.

Fig. 2: Different circumferences of the sucker observed among the studied *O. crenata* ***populations in carrot crops.***
Sl. 2: Različni obsegi sesalnih korenin pri raziskanih pojalnikih *O. crenata* ***v kulturah korenja.***

Tab. 3: Frequency distribution of leaf color among the studied *O. crenata* ***populations.***
Tab. 3: Frekvenčna porazdelitev barve listov raziskanih pojalnikov vrste *O. crenata.*

	Carrot	Faba bean	Chickpea	Total
Dark brown	13%	3%	0%	6%
Light brown	13%	13%	7%	11%
Brown	73%	83%	93%	83%

Tab. 4: Frequency distribution of stem color among the studied *O. crenata* ***populations.***
Tab. 4: Frekvenčna porazdelitev barve stebla raziskanih pojalnikov vrste *O. crenata****.***

	Carrot	Faba bean	Chickpea	Total
Dark purple	30%	23%	30%	28%
Purple	47%	33%	46%	42%
Light purple	10%	27%	17%	18%
Pale-yellow	13%	17%	7%	12%

Fig. 3: Different stem colors observed among the studied *O. crenata* ***populations in carrot crops.***
Sl. 3: Različna obarvanost stebla pri raziskanih pojalnikih *O. crenata* ***v kulturah korenja.***

Tab. 5: Frequency distribution of corolla color among the studied* O. crenata *populations.
Tab. 5: Frekvenčna porazdelitev barve cvetnega odevala raziskanih pojalnikov vrste* O. crenata*.

	Carrot	Faba bean	Chickpea	Total
White striped purple	47%	33%	46%	42%
White striped dark purple	30%	23%	30%	28%
White striped light purple	10%	27%	17%	18%
Off-white	13%	17%	7%	12%

Tab. 6: Frequency distribution of sepal color among the studied* O. crenata *populations.
Tab. 6: Frekvenčna porazdelitev barve čašnih listov raziskanih pojalnikov vrste* O. crenata*.

	Carrot	Faba bean	Chickpea	Total
Dark purple	30%	23%	30%	28%
Purple	44%	33%	47%	41%
Light purple	13%	27%	17%	19%
Pale-yellow	13%	17%	6%	12%

Fig. 4: Color of flower components (calyxes, sepals, central bract, petals, and stigma lobes) observed among the studied* O. crenata *populations.
Sl. 4: Barva cvetnih elementov (čaše, venčni in cvetni listi, brakteje in brazde) pri raziskanih pojalnikih* O. crenata *v kulturah korenja.

Corolla color

Four different colors of flower petals were observed among the plants of *O. crenata* (Tab. 5; Figs. 4 & 5): white petals with purple streaks, purple with dark or light purple streaks, and off-white petals. The frequency distribution among the three classes of crops was 47%, 30%, 10%, and 13%; 33%, 23%, 27% and 17%; and 46%, 30%, 17%, and 7% for populations from carrot, faba bean and chickpea fields, respectively.

During our investigation, we noticed significant association between stem color and petal color. In fact, all dark purple stemmed plants had white petals streaked with dark purple, purple stemmed ones had white petals streaked with purple, light purple stemmed plants had white petals streaked with light purple, and in pale yellow stemmed plants the petals were off-white.

Color of sepals

The analysis of the observed proportions showed that the sepals displayed the same colors but with different frequencies in different crops. Their total frequencies were 28% for dark purple, 41% for purple, 19% for light purple, and 12% for pale yellow (Tab. 6).

Central bract of flower

The central bract of the flower lacked a uniform color, instead, it displayed several colors of differ-

Fig. 5: Variability in* O. crenata *flowers and stems observed in a single carrot field in Morocco (Chaouia region).
Sl. 5: Variabilnost cvetov in stebel* O. crenata *iz nasada korenja v Maroku (predel Chaouia).

ent intensity between its top, base and sides. With regard to the top of the central bract (Tab. 7), up to five different colors were recorded: dark brown, brown, pale yellow, dark purple, and purple. The commonest among the three studied populations were *O. crenata* plants with a brown (54%) and purple (33%) central bract top. A purple central bract top was the most frequent in *O. crenata* populations from chickpea fields. The dark brown color was only observed in *O. crenata* plants from carrot fields; the same population lacked individuals with purple and dark purple central bract top.

Tab. 7: Frequency distribution of color of the top of the central bract among the studied* O. crenata *populations.
Tab. 7: Frekvenčna porazdelitev vrha osrednje brakteje pojalnikov vrste* O. crenata*.

	Carrot	Faba bean	Chickpea	Total
Dark brown	3%	0%	0%	1%
Brown	87%	60%	17%	54%
Pale-yellow	10%	13%	3%	9%
Dark purple	0%	4%	3%	3%
Purple	0%	23%	77%	33%

Tab. 8: Frequency distribution of color of the base of the central bract among the studied* O. crenata *populations.
Tab. 8: Frekvenčna porazdelitev barve baze osrednje brakteje raziskanih pojalnikov vrste* O. crenata*.

	Carrot	Faba bean	Chickpea	Total
Purple	13%	13%	20%	16%
Pale-yellow	87%	77%	77%	80%
Brown	0%	3%	0%	1%
White	0%	7%	3%	3%

With regard to the base of the central bract (Tab. 8), four colors were observed: purple, pale yellow, brown, and white. The commonest was pale yellow (80%), followed by purple (16%), while the brown and white colors were rare. The brown color was only found in *O. crenata* populations from faba bean fields; white and brown were absent in populations from carrot fields.

Four different colors were identified with regard to the sides of the central bract (Tab. 9): dark purple, light purple, pale yellow, and brown. *O. crenata* plants with pale yellow and brown lateral parts of the central bract accounted for more than 90% of the studied populations, the dark purple and light purple ones for less than 10%. The latter two colors were absent in *O. crenata* plants from chickpea fields, the light purple in those from carrot fields. The carrot-hosted *O. crenata* populations exhibited a higher share of pale yellow (70%).

Stigma lobe color

The stigma lobes of the studied *O. crenata* populations exhibited multiple colors (Tab. 10; Fig. 4); we observed up to six of them: dark purple, purple, brown, light brown, yellow, and black. The total frequencies of these colors were, respectively, 12%, 27%, 34%, 1%, 25%, and 1%. Light brown and black stigma lobes were not present in *O. crenata* populations from chickpea and carrot fields.

Tab. 9: Frequency distribution of the color of the sides of the central bract among the studied* O. crenata *populations.
Tab. 9: Frekvenčna porazdelitev barve strani centralne brakteje raziskanih pojalnikov vrste* O. crenata*.

	Carrot	Faba bean	Chickpea	Total
Dark purple	17%	3%	0%	7%
Pale-yellow	70%	37%	37%	48%
Brown	13%	57%	63%	44%
Light purple	0%	3%	0%	1%

Anther color

The colors observed in anthers were brown, black, dark gray, and purple (Tab. 11). *O. crenata* plants with black anthers represented more than 50% of all studied populations. The purple color was rare and represented only 6% of all individuals. It was not found in populations from carrot fields.

Plant pubescence

All *O. crenata* specimens collected from the three different crops displayed pubescence in different parts of the plant: leaves, petals, sepals, ovary filaments, and stamens.

Morphological diversity and phenotypic differentiation of qualitative traits

The morphological diversity index ranged from 0.2311 in relation to the color of the base of the

Tab. 10: Frequency distribution of stigma lobe color among the studied* O. crenata *populations.
Tab. 10: Frekvenčna porazdelitev barve brazd raziskanih pojalnikov vrste* O. crenata*.

	Carrot	Faba bean	Chickpea	Total
Dark purple	26%	10%	0%	12%
Purple	40%	13%	27%	27%
Brown	17%	37%	50%	34%
Light brown	0%	3%	0%	1%
Yellow	17%	34%	23%	25%
Black	0%	3%	0%	1%

central bract to 0.7133 in the stigma lobe color in the carrot-hosted *O. crenata* population, with an average of 0.5382. It ranged from 0.2867 in relation to leaf color to 0.7356 for the four following traits: stem color, corolla color, calix color, and sepal color in the faba bean-hosted *O. crenata* population, with an average of 0.6100, the highest among the three populations. In the chickpea-hosted population, the average was 0.5127, with values ranging from 0.1244 to 0.6600 (Tab. 12).

The highest phenotypic differentiation indices were observed in carrot-hosted *O. crenata* populations, with average values of 0.2447 between carrot versus chickpea populations, followed by 0.1317 between carrot versus faba bean populations. While in legume pairwise populations (faba bean-chickpea), the average phenotypic differentiation index observed was only 0.0978. Higher differentiation indices were observed in relation to the following traits in the carrot-legume pairwise (Tab. 12): color of the lateral parts of the flower's central bract, stigma lobe color, anther color, and color of the top of the central bract.

Discriminant factor analysis and hierarchical classification

These two analyses were carried out to test the hypothesis of differentiation of individuals in *O. crenata* populations from separate groups. The two discriminating functions of the analysis were significant. The first discriminating function was highly significant (Wilks Lambda: 0.218; Chi-square: 117.966; P: 0.000) with an eigenvalue of 2.60 explaining 90.5% of the total variability and corresponding to a correlation of 0.85. A mild, yet significant genetic differentiation was observed in the studied morphological characters for *O. crenata* from carrot fields compared to those from legume-planted (faba bean, chickpea) fields (Fig. 6).

Tab. 11: Frequency distribution of anther color among the studied* O. crenata *populations.
Tab. 11: Frekvenčna porazdelitev barve prašnikov raziskanih pojalnikov vrste* O. crenata*.

	Carrot	Faba bean	Chickpea	Total
Brown	13%	33%	7%	18%
Black	40%	47%	73%	53%
Dark gray	47%	13%	10%	23%
Purple	0%	7%	10%	6%

The second discriminating function was correlated with the following explanatory variables: color of anther, color of the top central bract, length of basal flower, circumference of collar, circumference of sucker, and length of inflorescence. The dif-

Tab. 12: Morphological diversity and phenotypic differentiation of qualitative traits among the studied* O. crenata *populations.
Tab. 12: Morfološka raznolikost in fenotipska diferenciacija kvalitativnih znakov med populacijami pojalnika vrste* O. crenata*.

Crops	Leaf color	Stem color	Corolla color	Calyxes' color	Sepals' color	Top part of the central bract of the flowers color	Down part of central bract of the flowers color	Side parts of the flowers' central bract color	Stigma' lobes color	Stamens' anther color	Average
Morphological diversity index											
Carrot	0.4267	0.6578	0.6644	0.6867	0.6867	0.2378	0.2311	0.4733	0.7133	0.6044	0.5382±0.18
Faba bean	0.2867	0.7356	0.7356	0.7356	0.7356	0.5667	0.3889	0.5422	0.7244	0.6489	0.6100±0.16
Chickpea	0.1244	0.6600	0.6600	0.6600	0.6600	0.4644	0.3711	0.4644	0.6244	0.4378	0.5127±0.17
Phenotypic differentiation index											
Carrot-faba bean	0.0097	0.0639	0.0820	0.0558	0.0558	0.0747	0.0048	0.3741	0.3570	0.2394	0.1317±0.10
Carrot-chickpea	0.0217	0.0164	0.0132	0.0094	0.0094	1.2668	0.0061	0.4427	0.3601	0.3013	0.2447±0.39
Faba bean-chickpea	0.0046	0.0489	0.0645	0.0645	0.0645	0.4961	0.0053	0.0037	0.0810	0.1447	0.0978±0.14

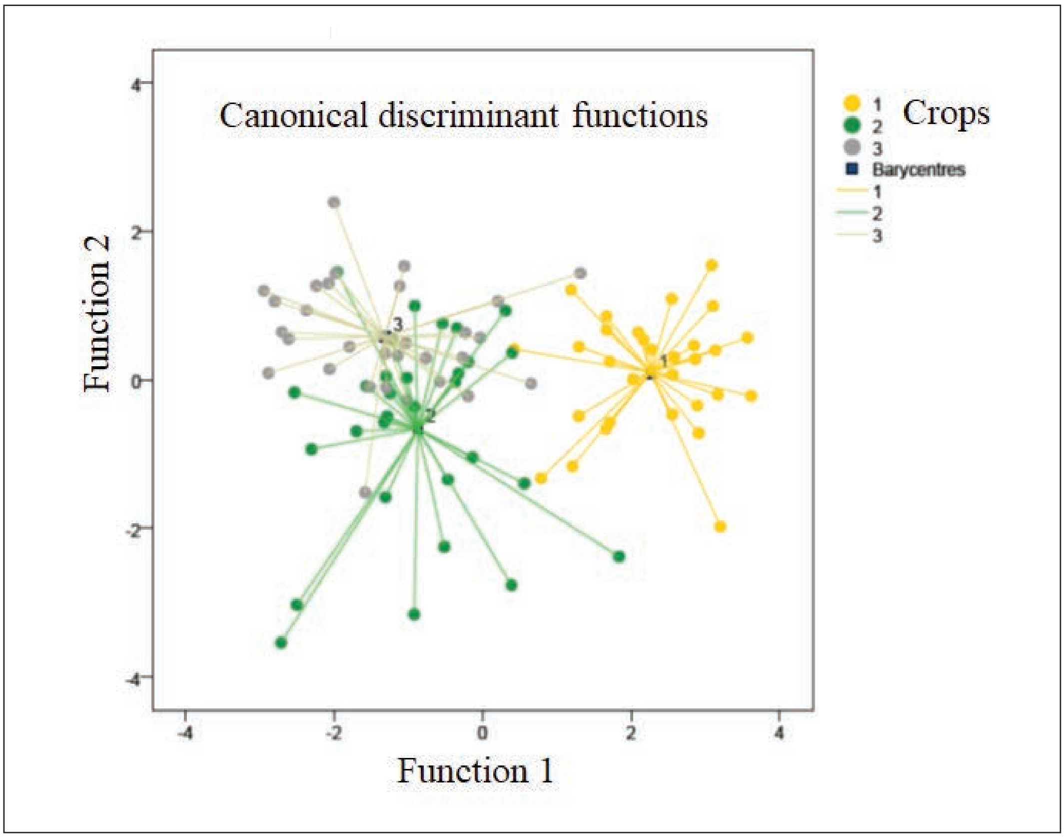

Fig. 6: Genetic differentiation among *O. crenata* **populations according to the host plant: carrot (1), faba bean (2), chickpea (3).**
Sl. 6: Genetska diferenciacija znotraj populacij pojalnikov vrste *O. crenata* **glede na vrsto gostitelja: korenje (1), bob (2), čičerika (3).**

ferentiation observed is largely explained by these variables.

With regard to the hierarchical analysis, distances in qualitative traits in all individuals from the three populations corresponding to the three host crops were used to build a classification tree showing similarities between these individuals. Although no separate clustering by host crop was obtained, six different groups were observed (Fig. 7). Interestingly, two of these groups were largely composed of *O. crenata* accessions hosted by carrot (G2 and G4).

G2 had a moderately high bootstrap value of 68 and contained exclusively 11 accessions of carrot-hosted *O. crenata*, and G4 was composed of two subgroups also containing exclusively 9 accessions of *O. crenata* collected from carrot fields. The two subgroups had high bootstrap values of 84 and 95. Another small subgroup of four *O. crenata* accessions from carrot fields were clustered together in group G6 with a bootstrap value of 85. The total of differentiated carrot-hosted *O. crenata* accessions accounted for 79% of the population.

DISCUSSION

Statistical analyses of different morphological parameters (qualitative and quantitative) showed slight genetic differences between carrot-hosted populations of *O. crenata* and those hosted by faba bean and chickpea. This was highlighted by moderate but significant genetic differentiation associated with host plants, displayed through functional discriminant analysis and hierarchical clustering that were based on genetic distances from qualitative traits. A morphological comparison of carrot-hosted *O. crenata* populations with those hosted by faba bean and chickpea showed a mild difference based on several morphological characters. We found that populations of *O. crenata* collected from carrot fields presented greater average plant height, circumference of the sucker, circumference of the collar, circumference of the stem below the hypha, and length of the basal leaf compared to populations collected from faba bean and chickpea fields. Moreover, further morphological differences between these populations (carrot-hosted and legume-hosted)

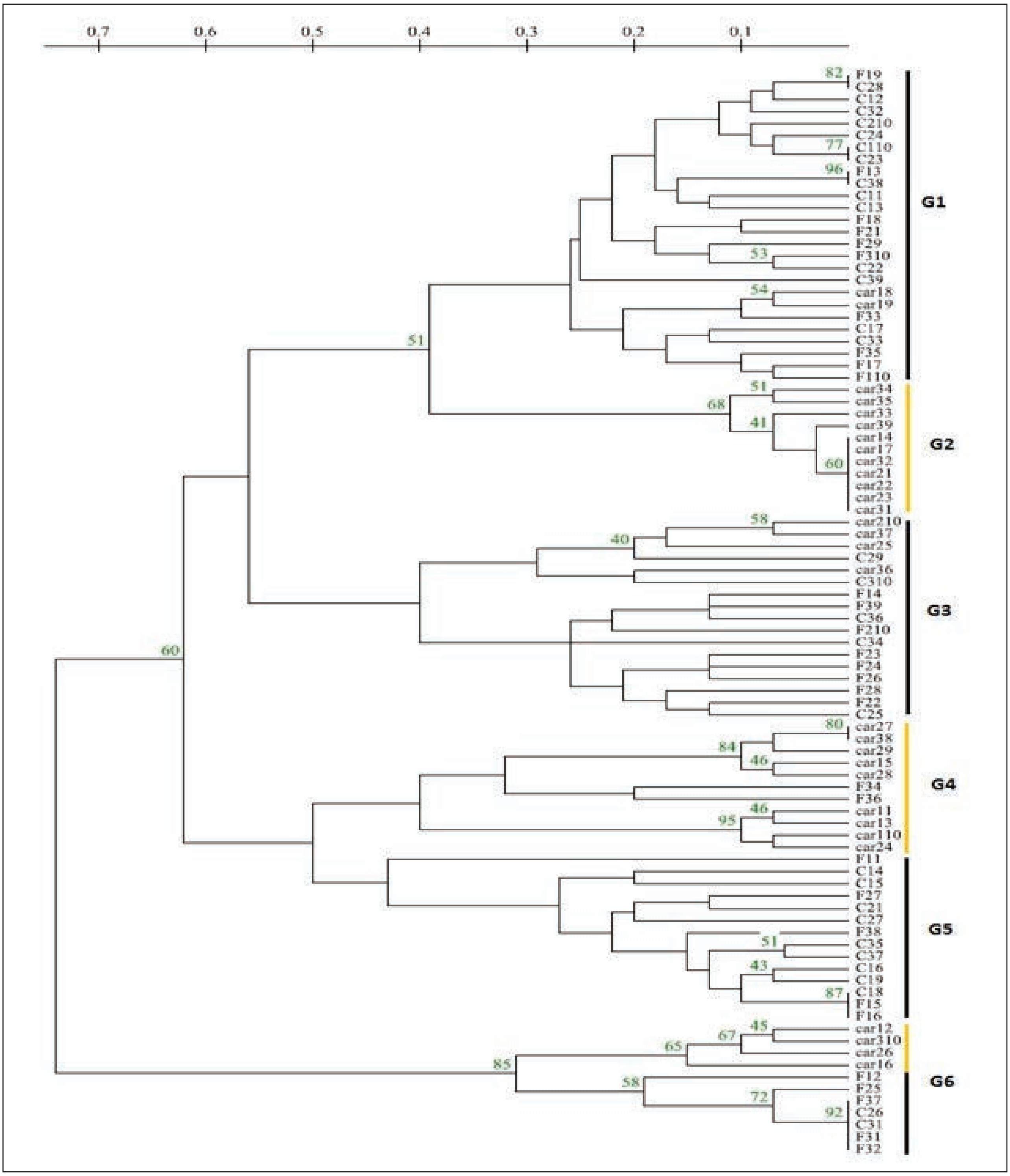

Fig. 7: Association between** O. crenata **accessions as revealed by the unweighted pair group method with arithmetic mean (UPGMA) cluster analysis based on Nei and Li's (1979) genetic distance calculated from qualitative descriptive traits. Bootstrap values are given at the nodes. Continuous lines right of the figure indicate groups; orange color corresponds to carrot-hosted** O. crenata **accessions clustered together. F: faba bean, C: chickpea, and car: carrot.

Sl. 7: Povezava med zajedanjem vrste** O. crenata **na podlagi metode neuravnoteženih parov skupin z klastersko analizo aritmetične sredine (UPGMA) na podlagi genetske distance, izračunane na podlagi kvalitativnih opisnih znakov po Nei & Li's (1979).

were observed. With regard to the color of the top of the central bract, dark brown was only present in populations from carrot fields, while purple and dark purple tops of the central bract, white bases of the central bract, and white and purple anthers were only observed in faba bean- and chickpea-hosted populations. This potential genetic differentiation was also indicated by the highest phenotypic differentiation indices obtained for carrot-faba bean and carrot-chickpea pairwise populations, especially in relation to the above cited traits, in which the difference was obvious.

Morphological characterization showed a genetic variability in *O. crenata* plants collected from three different crops (carrot, faba bean, and chickpea) of the same region, and even within the same crop. This could be explained by the presence of different ecotypes of the species *O. crenata*. Domina (2018) confirmed this result, observing a variation in shape and size of flowers, number of flowers, density of the inflorescence, shape of the calyx, and color of the corolla and stigma of *O. crenata* from fields cultivated with faba bean, chickpea*, Pisum sativum*, and *Lathyrus clymenum*. Also, Joel (2000) mentioned that variability can be influenced by the host range and preference host. Our results are in agreement with those of Román *et al*. (2001), which were based on molecular analysis. These authors found a polymorphism rate of 91% while using RAPD markers to study the genetic diversity of six populations of *O. crenata* collected from faba bean fields on different sites located in the south of Spain (Andalusia). Employing the same molecular techniques, Ennami *et al*. (2017) detected genetic diversity in six *O. crenata* populations collected from faba bean and lentil fields in three regions of Morocco (Taza, Meknes ,and Settat). They showed an intra-population variability of 81% and 82% for populations in faba beans and lentils, respectively.

CONCLUSIONS

The study demonstrated intra- and inter-population genetic variability of *O. crenata* hosted by three different crops, which was expressed through different morphological characters. *O. crenata* plants collected from carrot fields were genetically slightly different from those collected from among legumes. Further DNA analyses of these populations to confirm the obtained results are under way.

MORFOLOŠKA OPREDELITEV VRSTE *OROBANCHE CRENATA* PRI KORENJU IN STROČNICAH (BOB IN ČIČERIKA): POKAZATELJI MOŽNE GENETSKE DIFERENCIACIJE PROTI GOSTITELJSKIM RASTLINAM

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POVZETEK

Korenje je pomembna kultura v Maroku. Pred kratkim so ugotovili, da ga napada zajedavska rastlina Orobanche crenata*, ki je sicer znana, da napada stročnice. Namen te raziskave je narediti morfološko primerjavo med rastlinami korenja, boba in čičerike, ki jih je napadla vrsta* O. crenata *na podlagi kvalitativnih in kvantitativnih parametrov. Avtorji so opazili veliko genetsko variabilnost v kvalitativnih znakih zajedavskih rastlin na intra- in inter-gostiteljskem nivoju. Opazili so razlike v steblu, listih, venčnih in cvetnih listih, čaši, osrednji brakteji cvetov, brazdi in prašnikih. V nasprotju so bile razlike na nivoju kvantitativnih znakov majhne. Variacije med zajedavskimi rastlinami glede na tip gostitelja so bile značilne le na nivoju obsega ogrlice in sesalnih korenin. Izsledki te študije bodo verjetno nadalje razloženi s specifičnimi odnosi med zajedavcem in gostiteljem ter prilagoditvami.*

Ključne besede: korenje, čičerika, bob, genetska variabilnost, morfološka primerjava, *Orobanche crenata*

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OCENE IN POROČILA

RECENSIONI E RELAZIONI

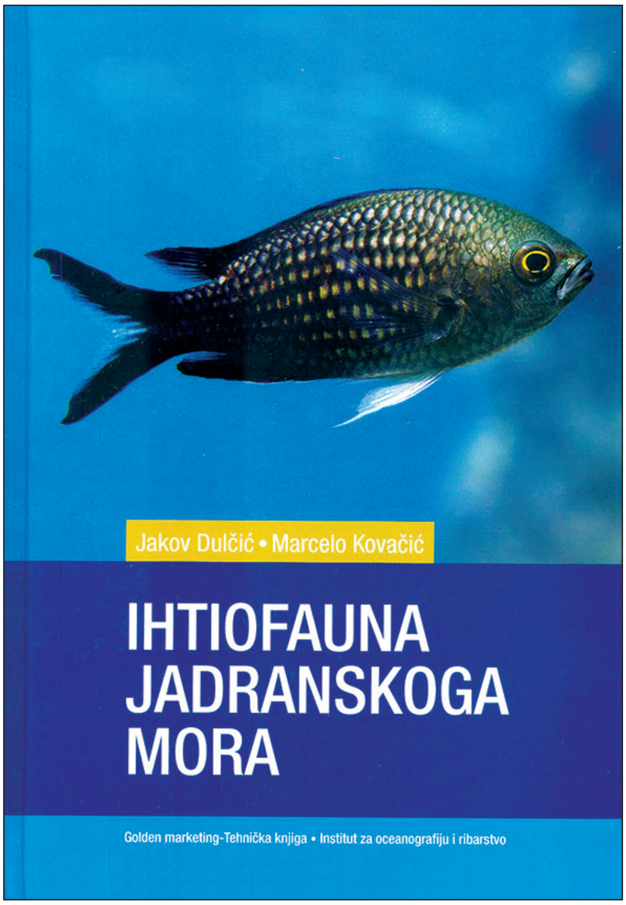
REVIEWS AND REPORTS

Book review:
ICHTHYOFAUNA OF THE ADRIATIC SEA

Authors: Jakov Dulčić & Marcelo Kovačić
Editor: Golden marketing, Tehnička knjiga,
Institut za oceanografiju i ribarstvo Split.
680 pp.

The Adriatic Sea is the cradle of marine biological and oceanographic sciences. The first research dealing with marine biodiversity was carried out in the 16th century, and continuous research of the Adriatic has been ongoing for the last two hundred years. This is also true for fish fauna, which in the Adriatic Sea has a longer research tradition than in other seas. Nevertheless, knowledge of fish fauna is far from being complete, as many species previously unknown to the Adriatic Sea are commonly recorded, while others are rapidly disappearing. In addition, modern methods, including those involving the aid of SCUBA diving equipment, have confirmed the existence of rare and little-known species of fish that standard ichthyological methods failed to detect. Despite the relatively enviable tradition of exploring life in the Adriatic, there have been surprisingly few monographs devoted to the richness of fish species in this sea. Among the most famous is the monograph by Dr. Tonko Šoljan *Fish of the Adriatic Sea*, an outstanding work in Croatian that was first printed in 1948 and has since appeared in many new editions and been translated into the Italian language as well. The second basic monograph on fish species entitled *Adriatic Ichthyofauna* (1996), again in Croatian, was written by Dr. Ivo Jardas.

This year, a new monograph was published by two renowned Croatian ichthyologists, Dr. Jakov Dulčić and Dr. Marcelo Kovačić. The former outstanding ichthyologist, like Šoljan and Jardas, comes from the Split Institute of Fisheries and Oceanography. Marcelo Kovačić is a curator at the Rijeka Museum of Natural History and a world-renowned expert on the fishes of the family Gobiidae. The book is entitled *Ichthyofauna of the Adriatic Sea* and was written in Croatian. Presenting an updated overview of the fish fauna of the Adriatic Sea, it is, unlike the first two monographs, richly adorned with photographs and drawings making it more suitable for a wider circle of readers. After a short introduction, the authors undertake a historical overview of fish research in the Adriatic and the Mediterranean and a review of biodiversity with special emphasis on fish fauna. They also provide basic information on how to use the book. This chapter is very important, as it presents the basic concepts and highlights the most important criteria for fish identification as well as anatomical and morphological features to pay attention to when trying to determine the identity of a specimen under investigation. The most extensive chapter, the third, supplies a key for determining the fish families of the Adriatic Sea, simplified and equipped with pictorial material that makes it easier to identify key characters. This chapter presents all the species so far confirmed in the Adriatic Sea. For each species a Croatian, Latin, and English name is provided, as well as its Latin synonyms. The authors then state the total size and in some cases the body weight, describe the species in terms of coloration, ecological and biological characteristics, distribution, importance to humans, status (regarding endangerment), protection measures, and lists key literature related to the species in the Adriatic. Each fish species is presented with a colour photograph – the vast majority stored in formalin or alcohol samples. The order of presentation of the species follows the modern systematics of fish, with the authors providing the key to identifying species within a family (if it consists of more than one species). This is followed by



a glossary of technical terms and abbreviations, and source materials. The book concludes with a factual index of Latin and Croatian names and terms and a brief description of both authors. The book was co-financed by the Croatian Ministry of Science and Education.

This monograph is a modern overview of the Adriatic fish fauna, which takes into account all the new records on the emergence of alien species and those associated with the northward spread of thermophilic species, which have been discovered and described in recent years. In his monograph, Šoljan presented 365 species, Jardas almost fifty years later 407 species; Dulčić and Kovačić describe as many as 444 species of fish in the Adriatic Sea. The key for the determination of fish species is much clearer and more understandable than in the earlier two monographs, which in most cases promises a correct identification to every reader. The book is a 680-page hard cover.

The cost of the book is 320 Croatian kunas (just over 40 euros), making it accessible to the general public as well as experts, all who are interested in exploring the richness of the Adriatic fish fauna, offering good prospects that readers will be able to recognise every species they find in their hands.

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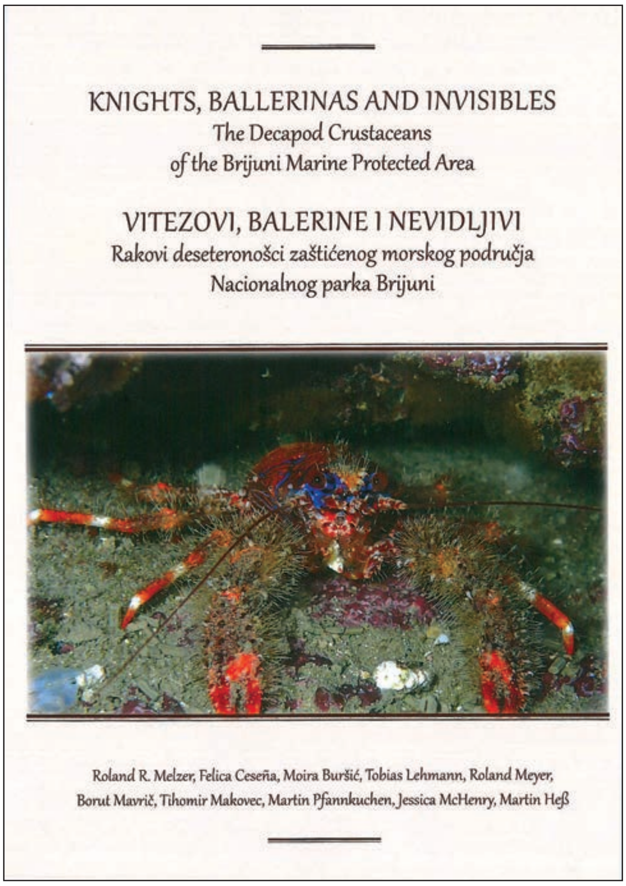
Book review:
KNIGHTS, BALLERINAS AND INVISIBLES: THE DECAPOD CRUSTACEANS OF THE BRIJUNI MARINE PROTECTED AREA

Authors: Roland Melzer, Felica Ceseña, Moira Buršić, Tobias Lehmann, Roland Mayer, Borut Mavrič, Tihomir Makovec, Martin Pfannkuchen, Jessica McHenry & Martin Heß
Editor: Javna ustanova Nacionalni park Brijuni, Schwarzprint, 123 pp., 2019.
The book can be purchased for 20 euros by sending mail to: infombp@nib.si


KNIGHTS, BALLERINAS AND INVISIBLES
The Decapod Crustaceans
of the Brijuni Marine Protected Area
VITEZOVI, BALERINE I NEVIDLJIVI
Rakovi deseteronošci zaštićenog morskog područja
Nacionalnog parka Brijuni

Roland R. Melzer, Felica Ceseña, Moira Buršić, Tobias Lehmann, Roland Meyer,
Borut Mavrič, Tihomir Makovec, Martin Pfannkuchen, Jessica McHenry, Martin Heß

At the end of last year, a monographic work with the poetic title *Knights, Ballerinas and Invisibles – The Decapod Crustaceans of the Brijuni Marine Protected Area* was published by ten researchers: from Germany, Croatia, Austria, Slovenia, and the USA, led by Prof. Roland Melzer. The international research group had been conducting studies on various aspects of marine biodiversity of the Brijuni National Park (NW Croatia) for many years. The book, which dedicates particular interest to decapods (Crustacea: Decapoda), has 123 pages and is enriched with quality photographs of shrimps, crabs, and other members of this taxonomic group. The way in which the authors present individual groups of decapod crabs is also interesting: we read about knights with strong armours, ballerinas, and ghosts - masters of disguise. The ballerinas are the shrimps, which the authors saw as dancing on the seabed, lobsters are squires, and crabs are dark knights.

The introductory chapter with the definition of decapod crustaceans, description of their body structure, and an evolutionary and systematic review, is followed by an extensive presentation of the species found in Brijuni, which covers the largest part of the publication. In addition to the lavish photographic material (213 colour images), the book is furnished with elegant and extremely elaborate illustrations of the external anatomical features of decapod crustaceans (28 BW and colour images). Higher taxonomical groups are presented in subchapters, each opening with a presentation of the typical characteristic of the higher taxon, and continuing with a basic description of each species, stating the morphological features useful for its distinction from similar species, and providing information on its habitat preferences and typical biological and ecological characteristics. The photographs of the species in their typical natural environments are also very helpful.

The monograph is an excellent identification tool for many decapod crustaceans. Although dealing with the decapod fauna present in the Brijuni archipelago, it will also be handy in identifying shrimps and crabs in the Slovenian coastal sea and broader northern Adriatic. I am confident that it will be of great use to researchers, biology students, underwater photographers, divers, and amateur naturalists alike.

I congratulate the authors on publishing the monograph, and the administration of the Brijuni National Park on their valuable support in the publishing process. Two Slovenian researchers from the Marine Biology Station of the National Institute of Biology (Piran), Borut Mavrič and Tihomir Makovec, both skilled divers, also contributed.

This scientific monograph includes all the information expected by students in the field, but also uses imagination to perhaps retrieve the wonder that humans who first came upon various aquatic (and terrestrial) animals surely were suffused with.

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Book review:
BIODIVERZITETA BIOGENIH FORMACIJ. ZAKLADNICA NARAVE SLOVENSKEGA MORJA

Authors: Lovrenc Lipej, Martina Orlando-Bonaca, Valentina Pitacco, Borut Mavrič
Založnik: Nacionalni inštitut za biologijo, Morska biološka postaja Piran, 2020, 230 str.

Pred nami je knjiga, ki bo razveselila vse, ki bi radi izvedeli več o življenju v našem morju. Slovenci smo veliki ljubitelji morja, v hladnem in deževnem vremenu pogosto sanjamo o počitnicah na morskih obalah. Nekateri radi pokukajo pod morsko gladino in želijo bolje spoznati pestrost živih bitij, a pogosto podcenjujejo bogastvo življenja v našem delu Jadranskega morja. Nekatere značilnosti in posebnosti tega najsevernejšega dela Sredozemskega morja nam razkrivajo raziskovalci Morske biološke postaje Nacionalnega inštituta za biologijo v pričujoči knjigi. Razveseljivo je, da se s tem množijo spoznanja o biotski pestrosti našega morja, nove vsebine pa bogatijo tudi slovenski jezik.

Avtorji nam najprej predstavijo različne biogene formacije in opozarjajo na pomen teh skalnatih osamelcev (v sicer prevladujoče muljastem in peščenem življenjskem okolju severnega Jadrana) za biotsko raznovrstnost. Osnovne podatke o biogenih formacijah v slovenskem morju so podali v zelo informativni preglednici, nato pa kratko opisali okolja, v katerih se pojavljajo. Zatem se posvetijo podrobnemu opisu posameznih vrst biogenih formacij. Tako spoznamo gruče, grebene cevkarjev, "trezze" in "tegnùe", slednje so posebnost tudi v Sredozemskem morju. Posebna pozornost avtorjev je namenjena grebenom sredozemske kamene korale (*Cladocora caespitosa*) in koraligenim algam, ki so ključni biogradniki sekundarnega trdnega dna v našem morju. Podrobno so predstavili predele s kameno koralo in z njimi povezane organizme. Zanimiv je prikaz odnosa med številom vrst nevretenčarjev in rib ter velikostjo kolonij kamene korale. V slovenskem morju sta dve večji biogeni formaciji, in sicer pred rtom Ronek in pred Debelim rtičem. Obe sta povezani s kameno koralo, saj ju v veliki meri tvorijo njeni odmrli koraliti; pomemben gradnik so tudi koraligene alge, med njimi predvsem rdeče alge (Rhodophyta).

V naslednjih treh sklopih vsebin so se avtorji posvetili ključnim biološkim procesom, ki vplivajo na dinamiko biogenih formacij. Opisali so zaraščanje trdnih struktur, naseljevanje planktonskih ličink in privabljanje drugih organizmov; ti procesi prispevajo k nastajanju novih bivalnih niš. Z biogenimi formacijami so povezani različni rastlinojedi in plenilski organizmi. Avtorji ob tem zgoščeno razložijo tudi različne življenjske strategije od prikrivanja do sobivanja. Opozorili so tudi na kriptobentoške habitate in zaenkrat še ne dovolj znane kriptobentoške organizme, med katerimi so posebej predstavljene ribe.

Osrednji in najobširnejši del knjige zavzemajo predstavitve rastlinskih in živalskih vrst, ki so na različne načine povezane z biogenimi formacijami. Predstavljeni organizmi so združeni po širših taksonomskih skupinah, opisane so njihove značilnosti in življenjska okolja, ki jih ti organizmi naseljujejo. Dodani so tudi podatki o pogostosti pojavljanja in o ogroženosti vrst. Med 130 opisanimi vrstami je 18 vrst alg, med njimi največ rdečih, po 14 vrst spužev, mnogoščetincev in rakov, po 10 vrst polžev, školjk, iglokožcev in plaščarjev. Z manj vrstami so zastopani ožigalkarji (6), mahovnjaki (6), sipunkulidi (1) in podkovnjaki (1); največ (22) pa je opisanih vrst rib. Vsaka vrsta je predstavljena z latinskim in slovenskim imenom, barvno fotografijo, ki jasno kaže opisane značilnosti, in ličnim grafičnim simbolom biogenega habitata. Iskanje podatkov olajšajo zelo uporabna seznama slovenskih in latinskih imen vrst ter popis literature, ki knjigo zaključujejo.

Z veseljem lahko zapišem, da smo dobili zanimivo, bogato opremljeno in v iskrivem jeziku napisano knjigo, ki širi znanje o našem delu Jadranskega morja. Knjiga bo pritegnila tako laike, ki želijo izvedeti več o življenju v morju, kot tudi strokovnjake, ki se ukvarjajo z različnimi vidiki biotske pestrosti. Njena odlika so gotovo tudi številne barvne fotografije, ki nazorno prikažejo pestrost biogenih tvorb in z njimi povezanih organizmov v najsevernejšem delu Jadranskega morja. Omenim naj tudi preglednice in lične slike oz. sheme, ki olajšajo razumevanje teksta. Zaradi nazornih in jasnih opisov organizmov in bioloških procesov bo knjiga dragocen in priročen učbenik, ki ga lahko s pridom uporabljamo na vseh ravneh izobraževanja.

Človeštvo se sooča z velikimi izzivi, povezanimi s spremembami na našem planetu, za katere smo v marsičem odgovorni sami. Intenzivnejši vremenski pojavi, višanje temperature v ozračju in vodah ter zmanjševanje biotske pestrosti so le nekateri zelo očitni opozorilni znaki. Priobalno morje in odprti oceani so izpostavljeni mnogim pritiskom zaradi dejavnosti ljudi. Spoznanje o ogroženosti velikega dela našega planeta in o nujnosti sprememb je vodilo Združene narode pri tem, da so prihodnje desetletje (2021–2030) razglasili za desetletje oceanografije za trajnostni razvoj. Med cilji tega velikega svetovnega programa je tudi "navdihujoče morje" – z željo, da bi ljudje bolje spoznali, razumeli in cenili pomen morja za dobrobit človeštva. Knjiga *Biodiverziteta biogenih formacij. Zakladnica narave slovenskega morja* predstavlja kamenček v mozaiku dejavnosti za doseganje tega cilja.

Alenka Malej
nekdanja vodja Morske biološke postaje Piran
(NIB)

POPRAVKI IN DOPOLNILA

ERRATA CORRIGE

ERRATA & CORRIGENDA

Corrigendum to "Capture of a Large Great White Shark, *Carcharodon carcharias* (Lamnidae) from the Tunisian Coast (Central Mediterranean Sea): a Historical and Ichthyological Event", Annales, Series Historia Naturalis, 2020, 30(1), 9-14
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Authors: Jeanne ZAOUALI, Sihem RAFRAFI-NOUIRA, Khadija OUNIFI-BEN AMOR, Mohamed MOURAD BEN AMOR & Christian CAPAPÉ

On page 10, in the legend of Figure 2, the correct scale bar is **100 mm**, and not 1000 mm.

KAZALO K SLIKAM NA OVITKU

SLIKA NA NASLOVNICI: Veliki beli morski volk (*Carcharodon carcharias*) je bil še pred sto leti v Sredozemskem morju znatno bolj pogost, kot je danes. Zato je vsak zapis o njegovem pojavljanju pomemben prispevek k poznavanju in ohranjanju te vrste. (Foto: Borut Furlan)

Slika 1: Za nekatere morske pse, kot sta navadna morska lisica (*Alopias vulpinus*) in sinji morski pes (*Prionace glauca*), je plitvo območje severnega Jadrana eno izmed maloštevilnih območij, kjer se razmnožujejo. Na sliki je radoveden primerek sinjega morskega psa. (Foto: Borut Furlan)
Slika 2: Vsako leto se v Sredozemskem morju pojavijo nove vrste rib, ki vanj prihajajo prek Sueškega prekopa in jim pravimo lesepske selivke. Ena takih je tudi modroprogasta papagajevka (*Scarus ghobban*), ki se počasi širi po Sredozemlju. (Foto: Borut Furlan)
Slika 3: Med glavači, ki so po številu vrst ena izmed najbolj bogatih družin, je mnogo vrst, ki so si po videzu zelo podobne. Bledega glavača (*Gobius fallax*) težko ločimo od nekaterih drugih sorodnih vrst s podobnim črtkanim vzorcem. (Foto: Borut Furlan)
Slika 4: Albinizem pri ribah hrustančnicah ni pogost pojav. Zaradi pomanjkanje pigmenta so albino živali ogrožene, saj so manj zaščitene pred plenilci. Na fotografiji sta dva identična albino primerka marogastega električnega skata (*Torpedo marmorata*). (Foto: Lovrenc Lipej)
Slika 5: Štiristo milijonov let so morski psi vladali morjem in oceanom, danes pa so mnogi med njimi na seznamu ogroženih vrst. V Sredozemskem morju se več kot polovica vrst morskih psov in njihovih sorodnikov skatov sooča z neposredno nevarnostjo izumrtja. (Foto: Borut Furlan)
Slika 6: Kalifornijski mak (*Eschscholzia californica*) je v Italiji okrasna rastlina, ki pa se zaseje sama in pobegne v naravo. (Foto: Mitja Kaligarič)
Slika 7: Poljski mak (*Papaver rhoeas*) je arheofit, ki je prišel v Evropo kot žitni plevel. Je tudi simbol spomina na prvo svetovno vojno. (Foto: Mitja Kaligarič)
Slika 8: Vrsta *Cistanche phelypaea* je sorodna vrstam iz rodu pojalnikov (*Orobanche*), saj so jo nekoč uvrščali v ta rod. Je popoln parazit, ki zajeda vrste iz rodu brškinov (*Cistus*). Posnetek je nastal na atlantski obali Maroka. (Foto: Mitja Kaligarič)

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FRONT COVER: The great white shark (*Carcharodon carcharias*) was significantly more common in the Mediterranean a hundred years ago than it is today. Any record of its occurrence is therefore an important contribution to the knowledge and conservation of this species. (Photo: Borut Furlan)

Figure 1: For some sharks such as the common thresher (*Alopias vulpinus*) and the blue shark (*Prionace glauca*), the shallow area of the northern Adriatic is one of the few reproductive areas. The photograph is a close-up of a curious specimen of the blue shark. (Photo: Borut Furlan)
Figure 2: Every year, new species of fish known as Lessepsian migrants enter the Mediterranean Sea through the Suez Canal. A case in point is the blue-barred parrotfish (*Scarus ghobban*), which is slowly spreading across the Mediterranean. (Photo: Borut Furlan)
Figure 3: Among the gobies, one of the largest families in terms of species number, there are many species that are very similar in appearance. Sarato's goby (*Gobius fallax*) is difficult to distinguish from some other closely related species due to their similar dashed patterns. (Photo: Borut Furlan)
Figure 4: Albinism in cartilaginous fish is an uncommon phenomenon. Due to the lack of pigment, albinos are endangered as they are more vulnerable to predators. In the photo, two identical albino specimens of marbled electric skate (*Torpedo marmorata*). (Photo: Lovrenc Lipej)
Figure 5: For four hundred million years, sharks were rulers of the seas and oceans, yet today many of them are on the endangered species list. In the Mediterranean, more than half of the shark species and their skate and rays relatives are facing an imminent threat of extinction. (Photo: Borut Furlan)
Figure 6: The California poppy (*Eschscholzia californica*) is grown as an ornamental plant in Italy, but it reseeds itself freely and has been known to escape into the wild. (Photo: Mitja Kaligarič)
Fig. 7: The common poppy (*Papaver rhoeas*) is an archaeophyte that arrived to Europe as a cereal weed. It is also an enduring symbol of remembrance of the First World War. (Photo: Mitja Kaligarič)
Figure 8: The species *Cistanche phelypaea* is related to species from the genus *Orobanche* and used to be categorised as such. It is a holoparasite infecting species of the genus *Cistus*. The photograph was taken on the Atlantic coast of Morocco. (Photo: Mitja Kaligarič)

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