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ADDITIONAL RECORDS OF SPINETAIL DEVILRAY *MOBULA JAPANICA* (CHONDRICHTHYES: MOBULIDAE) FROM THE TUNISIAN COAST (CENTRAL MEDITERRANEAN)

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ABSTRACT

The authors report on the capture of two specimens of spinetail devilray Mobula japanica *(Müller & Henle, 1841) off the northeastern Tunisian coast: two females measuring 190 cm and 270 cm in disc width and weighing 90 kg and 110 kg, respectively. The captures, considered as Herculean immigrants from the eastern tropical Atlantic, confirm the occurrence of the species in the mentioned area. The article discusses and comments on the establishment of a sustainable population in the area and further in the Mediterranean Sea.*

Key words: Mobulidae, *Mobula japanica*, Mediterranean Sea, Tunisian waters, abnormality

NUOVE SEGNALAZIONI DELLA PRESENZA DEL DIAVOLO DI MARE *MOBULA JAPANICA* (CHONDRICHTHYES: MOBULIDAE) LUNGO LA COSTA TUNISINA (MEDITERRANEO CENTRALE)

SINTESI

Nella presente nota gli autori segnalano la cattura di due esemplari di una delle specie di diavoli di mare, Mobula japanica *(Müller & Henle, 1841), al largo della costa tunisina nord-orientale. Si tratta di due femmine, la prima con 190 cm di larghezza del disco e 90 kg di peso, la seconda con 270 cm di larghezza e 110 kg di peso. Tali catture confermano la presenza nell'area studiata di questa specie, che arriva dall'Atlantico orientale tropicale ed entra nel Mediterraneo dallo stretto di Gibilterra (considerata pertanto fra i migrati di Ercole). Gli autori discutono e commentano la possibilità di stabilizzazione di una popolazione sostenibile nell'area e nella più ampia regione mediterranea.*

Parole chiave: Mobulidae, *Mobula japanica*, mare Mediterraneo, acque tunisine, anomalia

INTRODUCTION

Spinetail devilray *Mobula japanica* (Müller & Henle, 1841) is widely distributed in tropical to warm temperate waters of the Atlantic, Pacific and Indian Oceans (Townsend & Kyne, 2010; Bustamante *et al*., 2012). Off the eastern Atlantic coasts, *M. japanica* was reported as *M. rancureli* Cadenat, 1959 from the Ivory Coast (Cadenat, 1959) and the Gulf of Guinea (Blache *et al*., 1970). *M. rancureli* was afterwards considered as a junior synonym of *M. japanica*, which hence occurs off the western coast of Africa (Louisy, 2002). Additionally, investigations regularly conducted off the Tunisian coasts allowed Capapé *et al*. (2015a) to report the captures of 11 specimens of *M. japanica* from northern areas, which constitute the first Mediterranean records of the species.

Our actions to assess the status of *M. japanica* in Tunisian waters were supported by local fishermen, who contributed by reporting sightings and captures of specimens. Within this cooperation, we were informed that two specimens had been caught by fishermen off the northern Tunisian coast. The aim of this paper is to describe these captures with respect to the possible establishment of this species in the mentioned area, as well as in other regions of the Mediterranean Sea.

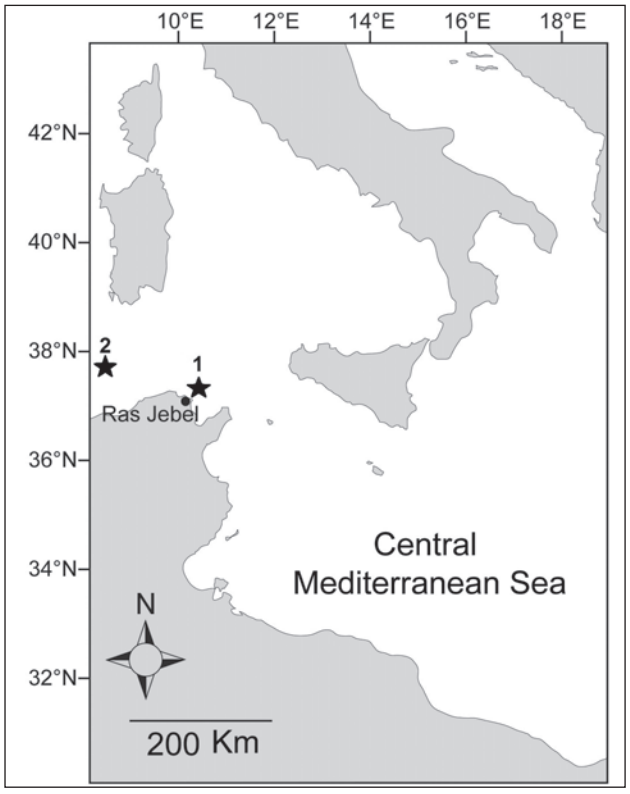

Fig. 1: Map of Central Mediterranean showing the capture sites of the Tunisian specimens of *Mobula japanica* ***off the Tunisian coast. Legend: black star 1 records published in Capapé*** *et al.* ***(2015a); black star 2 records from this study.***
Sl. 1: Zemljevid osrednjega Sredozemskega morja z lokalitetami, kjer so bili ujeti primerki vrste *Mobula japanica* ***ob tunizijski obali. Legenda: zvezdica s št. 1 – podatki, objavljeni v prispevku Capapé*** *et al.* ***(2015a); zvezdica s št. 2 – podatki iz pričujoče raziskave.***

MATERIAL AND METHODS

Two specimens of *Mobula japanica* were captured on 14th and 15th May 2015 at night, during commercial light-fishing targeting European pilchard *Sardina pilchardus* (Walbaum, 1792) and mackerel *Scomber* spp., at an approximate depth of 120-130 m, by means of gillnets (mesh opening 18 mm), off the north-eastern coast of Tunisia (37° 36′ N, 8° 54′ E; Fig. 1). The fishing was carried out in that zone based on information provided by experienced fishermen. Both specimens were carefully examined, photographed, weighed to the nearest kilogram and measured to the nearest centimetre, following Capapé *et al*. (2015a); the results are summarised in Table 1.

As the two specimens were dressed out, cut into pieces by retailers and sold rapidly, only their heads were recovered and delivered to the laboratory for further examinations. The heads were preserved in 10 % buffered formalin and deposited in the Ichthyological Collection of the Faculté des Sciences de Bizerte, under catalogue numbers: FSB-Mob-jap-06 and FSB-Mob-jap-07.

RESULTS AND DISCUSSION

The Tunisian *Mobula japanica* specimens were females measuring 190 cm and 270 cm in disc width (DW), respectively, and weighing 90 kg and 110 kg in total body mass, respectively (Tab. 1).

They were identified by the following combinations of characteristics (Fig. 2): disc broad, anterior margins of the pectoral slightly convex, posterior margins concave, angles acute and rounded at the apex; head very short, rostral margin rather straight; elliptical spiracles located above the level of pectoral fins, oval-based stinging spine at the base of the tail; origin of the dorsal fin a little in advance of the beginning of pelvic fins, gill-filter plates not fused with 18-28 lateral lobes, terminal lobe leaf-shaped with longitudinal ridges, mouth on undersurface of head, teeth minute and not arranged in rows, but spaced from each other, tooth height larger than crown width, dorsal surface dark blue with occasional lighter shoulder patches, characteristic white tip on dorsal fin (Fig. 3), belly whitish with dark patches, no dark margin anteriorly. The anterior margin of the smaller specimen (FSB-Mob-jap-06) was not straight due to an evident unusual wide indentation on the left side (Fig. 4). This morphological abnormality may either be a teratology or denote a wound despite the fact that

Tab. 1: Morphometric measurements expressed in centimetres and percentages of disc width (% DW) related to the Tunisian specimens of *Mobula japanica* ***(FSB-Mob-jap-06 and FSB-Mob-jap-07).***
Tab. 1: Morfometrične meritve dveh tunizijskih primerkov vrste *Mobula japanica* ***(kataloški oznaki FSB-Mob-jap-06 in FSB-Mob-jap-07), izražene v centimetrih in v deležu širine diska (% DW)***

Reference	**FSB-Mob-jap-06**		**FSB-Mob-jap-07**	
Sex	**Female**		**Female**	
Measurements	**cm**	**% DW**	**cm**	**% DW**
Disc length	85	44.7	128	47.4
Disc width (DW)	190	100.0	270	100.0
Cephalic fin length	17	8.9	31	11.5
Diameter of eye ball	2.5	1.3	5	1.9
Cranial width	39	20.5	42	15.6
Preoral length	8.5	4.5	10	3.7
Mouth width	25	13.2	31	11.5
Internarial distance	20	10.5	24	8.9
Cephalic fin width	11	5.8	16	5.9
Space between first gill slit	22	11.6	28	10.4
Space between second gill slit	21	11.1	27	10.0
Space between third gill slit	21	11.1	31	11.5
Space between fourth gill slit	21	11.1	30.5	11.3
Space between fifth gill slit	21.5	11.3	31	11.5
Pre-first gill slit length	32.5	17.1	43.5	16.1
Pre-second gill slit length	37.5	19.7	49.5	18.3
Pre-third gill slit length	43.5	22.9	55.5	20.6
Pre-fourth gill slit length	48	25.3	62.5	23.1
Pre-fifth gill slit length	54	28.4	67.5	25.0
Rostrum to 1st gill openings	19	10.0	27.5	10.2
Rostrum to 5th gill openings	39	20.5	48	17.8
Distance between cephalic fins tips	26	13.7	33	12.2
Distance between cephalic fins	21	11.1	38	14.1
Distance between eyes	31.5	16.6	48	17.8
Interspiracular width	34	17.9	38	14.1
Dorsal fin base length	9	4.7	11	4.1
Total body mass (kg)	90		110	

no healed scar was visible. Similarly patterned injuries generally occur during competition events with carnivorous species, so the possibility that this might also be the case for the specimen herein described cannot be totally excluded (see Capapé *et al*., 2015b).

All observations about morphology, colour, morphometric measurements and head proportions are consistent with those provided by Notarbartolo Di Sciara (1987), Townsend & Kyne (2010), Bustamante *et al.* (2012) and Capapé *et al.* (2015a). The overall disc width of specimens captured in Tunisian waters (see Capapé *et al*., 2015a) ranged between 190 and 270 cm, so according to White *et al.* (2006), who noted that *M. japanica* reaches a maximum DW of 310 cm, but usually measures less than 250 cm in DW, the specimens can be considered large. Generally, large elasmobranch species have the ability to perform long migrations (Capapé, 1989), and the present captures of *M. japanica* off the Tunisian coast corroborate the previous opinion expressed by Capapé *et al.* (2015a). It can be deduced that all

Fig. 2: *Mobula japanica****, specimen FSB-Mob-jap-06, showing the white tip of dorsal fin (scale bar = 20 cm).***
Sl. 2: *Mobula japanica****, primerek v zbirki z oznako FSB-Mob-jap-06, z belo obrobljeno konico hrbtne plavuti (merilo = 20 cm)***

M. japanica specimens caught in Tunisian waters had come from the eastern tropical Atlantic and entered the Mediterranean Sea through the Strait of Gibraltar, which constitutes a Herculean migration (*sensu* Quignard & Tomasini, 2000).

Is this species at present definitively established in the Mediterranean Sea? Could it be that several previous records of the closely related *M. mobular* were indeed of *M. japanica*, which fact, if adequately supported, corroborates the above reported hypothesis? Despite the fact that all females caught in the area were probably adults (the size at sexual maturity is about 207 cm DW in the Gulf of California according to White *et al.*, 2006), such hypothesis cannot be totally ruled out. However, further

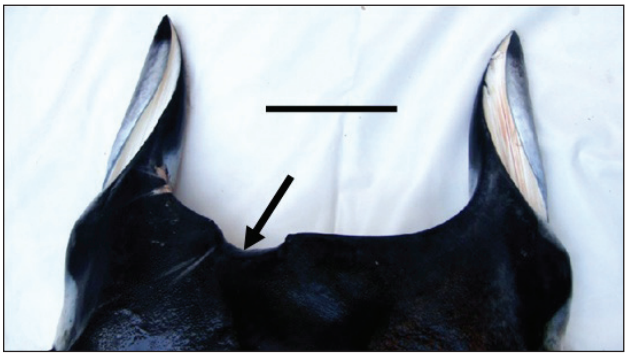

Fig. 4: The anterior margin of *Mobula japanica****, specimen FSB-Mob-jap-06 showing the broad indentation (black arrow), with scale bar = 10 cm.***
Sl. 4: Sprednji rob primerka vrste *Mobula japanica* ***s kataloško oznako FSB-Mob-jap-06 s široko zajedo (črna puščica) (merilo = 10 cm)***

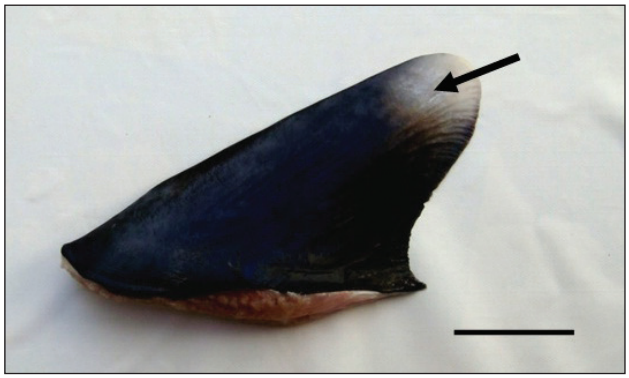

Fig. 3: Dorsal fin showing white tip in *Mobula japanica****, specimen FSB-Mob-jap-07, with scale bar = 3 cm.***
Sl. 3: Belo obrobljena konica hrbtne plavuti pri primerku vrste *Mobula japanica* ***s kataloško oznako FSB-Mob-jap-07 (merilo = 3 cm)***

records are needed to confirm the successful establishment of a population of *M. japanica* in the western Mediterranean Sea. Unfortunately, as is the case of other elasmobranch species, *M. japanica* is highly vulnerable due to its *k*-selected characteristics, and therefore it is at present considered as a threatened species (White *et al.*, 2006). The recent increase of spinetail devilray catches in Tunisian waters requires urgent local conservation measures and fishing management to avoid a possible extinction of this species in the area.

NOV ZAPIS O POJAVLJANJU MANTE VRSTE *MOBULA JAPANICA* (CHONDRICHTHYES: MOBULIDAE) VZDOLŽ TUNIZIJSKE OBALE (OSREDNJE SREDOZEMLJE)

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POVZETEK

V pričujočem zapisu avtorji poročajo o ulovu dveh primerkov mante vrste Mobula japanica *(Müller & Henle, 1841)ob severovzhodni tunizijski obali. Obe sta bili samici, pri čemer je prva merila 190 cm v premeru diska in tehtala 90 kg, druga pa 270 cm in 110 kg. Ta ulov, pri katerem gre za priselitev Herkulovih selivk iz vzhodnega tropskega Atlantika, potrjuje pojavljanje vrste v obravnavanem območju. Avtorji nadalje razpravljajo o morebitni ustalitvi populacije te vrste na obravnavnem območju in širšem Sredozemlju.*

Ključne besede: Mobulidae, *Mobula japanica*, Sredozemsko morje, tunizijske vode, anomalije

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ADDITIONAL RECORDS OF TWO LESSEPSIAN FISH, *SIGANUS LURIDUS* AND *CHAMPSODON VORAX* FROM IZMIR BAY (AEGEAN SEA, TURKEY)

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ABSTRACT

Two Lessepsian fish species, Siganus luridus *(Siganidae) and* Champsodon vorax *(Champsodontidae) were reported for the second time from the Bay of Izmir, NE Aegean Sea and some morphometric and meristic characteristics of the specimens were also given.*

Keywords: Lessepsian fish, new record, measurement, dispersion

NUOVE SEGNALAZIONI DI DUE PESCI LESSEPSIANI, *SIGANUS LURIDUS* E *CHAMPSODON VORAX,* DALLA BAIA DI SMIRNE (MAR EGEO, TURCHIA)

SINTESI

La presenza di due specie di pesci lessepsiani, Siganus luridus *(Siganidae) e* Champsodon vorax *(Champsodontidae), è stata segnalata per la seconda volta nella baia di Smirne (Izmir), nel Mar Egeo nord-orientale. L'articolo riporta alcune caratteristiche morfometriche e meristiche dei due pesci.*

Parole chiave: pesci lessepsiani, nuove segnalazioni, misurazioni, dispersione.

INTRODUCTION

The opening of the Suez Canal in 1869 linked the Mediterranean with the tropical Red Sea and this connection has led to a massive influx of Red Sea biota into the Mediterranean, including fish species (Golani *et al.,* 2006). The invasion of Red Sea organisms through the Suez Canal is known as the "Lessepsian migration" (after Ferdinand de Lesseps, who supervised the canal's construction).

On the Turkish coasts, Çınar *et al*. (2011) chronologically listed a total of 400 alien species, including 58 fish, with 27 Lessepsian fish species reported from the Aegean Sea. Recently, Ergüden & Özdemir (2015) updated to a total number of 64 the Indo-Pacific fish species in Turkish marine waters, of which 61 species in the Southern coasts of Turkey, 38 in the Aegean Sea, 3 in the Sea of Marmara and one in the Black Sea. It is evident that a rapid range expansion of alien fish occurred along the coasts of the Aegean Sea in recent years.

Izmir Bay is a very important nursery and fishing area in the North-eastern Aegean Sea. About 276 fish species has been recorded from the bay (Geldiay, 1969) and nowadays, increasing the Lessepsian fish diversity in the area must be probably enhanced due to the warming of the sea (Raitsos *et al.*, 2010). Various Lessepsian fish, such as *Saurida undosquamis* (Richardson, 1848), *Lagocephalus sceleratus* (Gmelin, 1788), *Siganus luridus* (Rüppell, 1829), *S. rivulatus* Forsskål, 1775, *Champsodon vorax* Günther, 1867 and *Stephanolepis diaspros* Fraser-Brunner, 1940 were consecutively reported from the bay in the last decade (Akyol & Kara, 2003; Bilecenoğlu *et al*., 2006; Kara & Akyol, 2011; Gurbet & Kara, 2013; Akyol & Özgül, 2015; Aydin & Akyol, 2015). Recently, *Etrumeus teres* was also found in the bay (O. Akyol, *unpubl. data*).

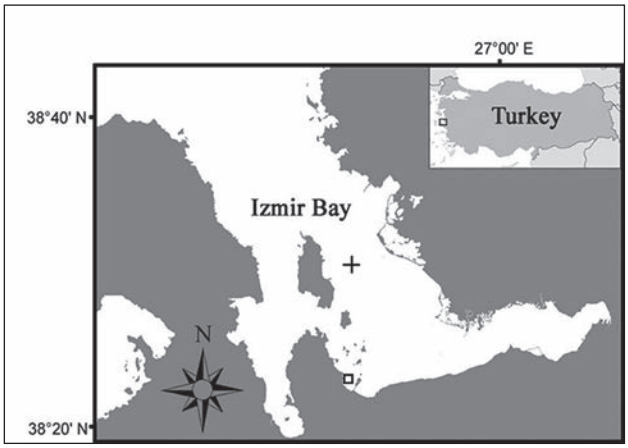

Fig. 1: Sampling locations of the specimens: *Champsodon vorax* ***(+) and*** *Siganus luridus* ***(□).***
Sl. 1: Vzorčevalni lokaliteti, kjer sta bila ujeta primerka vrst *Champsodon vorax* ***(+) in*** *Siganus luridus* ***(□)***

Additional records of alien species in a certain area, accompanied by biological observations, improve knowledge on their establishment success. Thus, this paper documents the occurrence of two Lessepsian fish, *S. luridus* and *C. vorax* caught in the Izmir Bay for the second time while some biological data of collected specimens are presented.

MATERIAL AND METHODS

During investigations, conducted in 2013 and 2015 in the Turkish Aegean Sea and focusing on the Lessepsian fish distribution one specimen of *Siganus luridus* and one specimen of *Champsodon vorax* were collected from Izmir Bay (Fig. 1). After measurements to the nearest millimeter and counts, both specimens were fixed with 5 % formaldehyde solution and deposited in the fish collection of the Faculty of Fisheries, Ege University (ESFM-PIS).

RESULTS AND DISCUSSION

***Siganus luridus* (Rüppell, 1829)**

The specimen of *Siganus luridus* (197 mm of total length, ESFM-PIS/2013-004) (Fig. 2) was captured on 2 October 2013 at Urla coast of Izmir Bay (38° 30′ 14″ N, 26° 47′ 00″ E), with trammel net (72 mm stretched mesh size) at a depth of 8 m on sandy bottom with *Posidonia* meadows.

Morphometric characteristics, meristic counts, selected body proportions (Tab. 1) and color pattern were in accordance with the description of Ben-Tuvia (1986), Golani *et al*. (2006) and Kara & Akyol (2011).

***Champsodon vorax* Günther, 1867**

The specimen of *Champsodon vorax* (125 mm of total length, ESFM-PIS/2015-002) (Fig. 3), was caught on 10 March 2015 with bottom trawl net (44 mm mesh size), east of Uzunada Island, Izmir Bay (38° 22′ 21″ N, 26° 45′ 54″ E), on muddy bottom at a depth of 50 m.

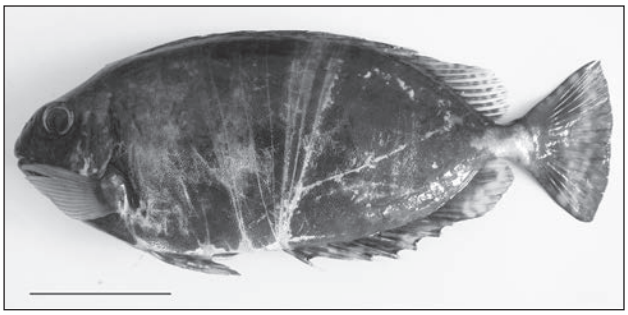

Fig. 2: *Siganus luridus* ***(ref. ESFM-PIS/2013-004), captured in Izmir Bay (scale bar = 50 mm). (Photo: O. Akyol)***
Sl. 2: Primerek vrste *Siganus luridus* ***(ref. ESFM-PIS/2013-004), ujet v Izmirskemu zalivu (merilo = 50 mm). (Foto: O. Akyol)***

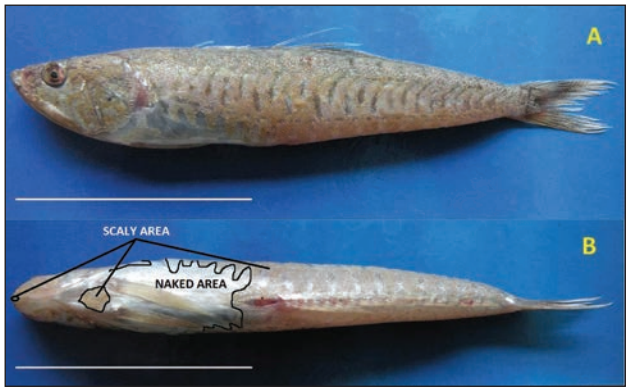

Fig. 3: *Champsodon vorax* ***(ref. ESFM-PIS/2015-002), captured in Izmir Bay: (A) lateral view, (B) ventral view (scale bar = 50 mm). (Photo: O. Akyol)***
Sl. 3: Primerek vrste *Champsodon vorax* ***(ref. ESFM-PIS/2015-002), ujet v Izmirskemu zalivu: (A) pogled s strani, (B) pogled od spodaj (merilo = 50 mm). (Foto: O. Akyol)***

All measurements, counts, selected body proportions (Tab. 1) and color patterns were in accordance with previous descriptions of Aydin & Akyol (2015 and references therein).

S. luridus has been a well-known colonizer of the southern Aegean Sea waters for a long time. In recent years, it has reached the northernmost latitude both in southern Chios Island (Katsanevakis & Tsiamis, 2009) and Sigri Bay, Lesvos Island, Greece (Evagelopoulos *et al*., 2015) and Edremit Bay, coast of Assos, Turkey (Işmen *et al*., 2015). After the first record of the species in Izmir Bay (17 individuals) given by Kara & Akyol (2011), the second one reported here may indicate that the species is establishing in the area.

The second record of *C. vorax* in Izmir Bay, firstly reported in the area by Aydin & Akyol (2015), documents a tendency to rapid expand towards the northern latitudes of the Aegean, since Gökova Bay record in 2014, SE Aegean Sea (Yapıcı *et al.,* 2015).

The findings reported in this ichthyological note further highlight that Izmir Bay, located in northern latitudes of the Mediterranean, is becoming step by step an area suitable to Lessepsian fish introduction and establishment, linked to the effects of global warming.

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Tab. 1: Morphometric measurements, ratios and counts of *Siganus luridus* ***and*** *Champsodon vorax****, captured from Urla coast, Izmir Bay.***
Tab. 1: Morfometrične meritve in meristični podatki za primerka vrst *Siganus luridus* ***in*** *Champsodon vorax****, ujetih na obrežju Urla v Izmirskem zalivu***

Species	***Siganus luridus***		***Champsodon vorax***	
Measurements	**Size (mm)**	**Proportion**	**Size (mm)**	**Proportion**
Total length (TL)	197		125	
Standard length (SL)	166	84.3 %TL	108	86.4 %TL
Maximum body depth	70	35.5 %TL	18	14.4 %TL
Predorsal fin length	42	21.3 %TL	36	28.8 %TL
Prepectoral fin length	34	17.3 %TL	30	24.0 %TL
Pre-anal fin length	87	44.2 %TL	54	43.2 %TL
Head length (HL)	38	19.3 %TL	29	23.2 %TL
Eye diameter	10	26.3 %HL	5.6	19.3 %HL
Preorbitary length	14	36.8 %HL	8.5	29.3 %HL
Counts				
1st Dorsal fin rays	XIV+10		V	
2nd Dorsal fin rays	-		20	
Anal fin rays	VII+9		18	
Pectoral fin rays	16		12	
Weight (g)	147		16	

DODATNI ZAPISI O POJAVLJANJU DVEH VRST LESEPSKIH RIBJIH SELIVK, *SIGANUS LURIDUS* IN *CHAMPSODON VORAX*, IZ IZMIRSKEGA ZALIVA (EGEJSKO MORJE, TURČIJA)

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POVZETEK

Dve vrsti lespeskih ribjih selivk, Siganus luridus *(družina Siganidae) in* Champsodon vorax *(družina Champsodontidae), sta bili drugič potrjeni v Izmirskem zalivu v severovzhodnem delu Egejskega morja. Avtorja podajata morfometrične in meristične podatke primerkov obeh vrst.*

Ključne besede: lesepske ribe, novi zapis, meritve, razširjanje

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"Without sharks, you take away the apex predator of the ocean,
and you destroy the entire food chain."
Peter Benchley

SHARK ATTACKS AGAINST HUMANS AND BOATS IN TURKEY'S WATERS IN THE TWENTIETH CENTURY

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ABSTRACT

Thirteen shark attacks were recorded in Turkey's waters between 1931 and 1983. Ten out of the 13 attacks (76.9 %) occurred in the Sea of Marmara, and were followed by 2 attacks recorded in the Mediterranean and 1 attack in the Aegean Sea. In 7 attacks (53.8 %) targets were the fishing boats, of which 6 of them were boats of tuna handliners, while 6 attacks (46.2 %) were directly against humans. In 3 incidents (23.1 %) skin or scuba divers, who caught fish with a harpoon were attacked, while 3 attacks were against swimmers. Two attacks (15.3 %) were fatal. Large predatory sharks have been occurring in the vicinity of aquaculture cages, which are located along Turkey's Aegean and Mediterranean coasts, as seen in the Güllük Bay incident; however, threats to public safety caused by the predator aggregations close to shorelines is still unknown.

Keywords: shark attack, Turkey, fishery, aquaculture, public safety

ATTACCHI DI SQUALI A UOMINI E BARCHE IN ACQUE TURCHE NEL VENTESIMO SECOLO

SINTESI

Tredici attacchi di squali sono stati registrati nelle acque della Turchia tra il 1931 e il 1983. Dieci dei 13 attacchi (il 76,9 %) si sono verificati nel Mar di Marmara, due attacchi nel Mediterraneo e un attacco nel mar Egeo. Sette volte (ossia nel 53,8 % dei casi) sono state attaccate barche da pesca, di cui sei erano barche per la pesca del tonno con le lenze. I bersagli dei restanti sei attacchi (pari al 46,2% dei casi) erano umani. In tre casi (23,1 %) sono stati attaccati apneisti o subacquei che pescavano con un arpione, mentre per tre volte gli squali hanno attaccato nuotatori. Due attacchi (15,3 %) sono stati fatali. I grandi squali predatori sono stati avvistati in prossimità delle gabbie per l'acquacoltura che si trovano lungo le coste turche dell'Egeo e del Mediterraneo, come nel caso dell'incidente nella baia di Güllük. Tuttavia, le conseguenze delle minacce alla sicurezza pubblica relative ai raggruppamenti di predatori vicino alle linee costiere restano sconosciute.

Parole chiave: attacco dello squalo, Turchia, pesca, acquacoltura, sicurezza pubblica

INTRODUCTION

The term shark attack has been considered to be any forceful or injurious exchange between man and any shark (Baldridge, 1988). This frightening incident has always been one of the more thoroughly examined issues of the challenge between man and shark. Because of their feeding mechanisms, including sharp teeth and powerful jaws, and since they could attain very large sizes (*i.e.*, >4 m, in case of white or tiger sharks; Ebert & Stehmann, 2013), sharks are considered to be the top predators of the marine world, and as Baldridge (1988) stated, regardless of its size, any shark having both opportunity and physical capacity for injuring humans can be considered dangerous. In an aquatic environment where most humans can at best keep their heads above the water, the physical and predatory capabilities of these top predators render land-based humans easy prey in such forceful encounters (Caldicott *et al.*, 2001). In the early days of shark attack science, the opinion was that sharks, being cowardly scavengers, reserved their attention solely for the wounded and the dead. Most of the scientists of that era also believed that they did not attack live human beings, without being provoked (Baldridge, 1988). However, recent case studies have shown that sharks can attack live and active human beings due to a multiplicity of motivations (see Clua & Reid, 2013; Clua *et al.*, 2014; Levine *et al.*, 2014).

Of more than 5700 cases recorded in the Global Shark Attack File (GSAF), 160 have occurred in the Mediterranean Sea. According to the GSAF, only 2 attacks occurred in Turkey's waters in the 1930's. Until the last quarter of twentieth century, our knowledge on sharks occurring in Turkey's waters had many gaps. Nowadays, one of the major questions to be answered is, whether the knowledge on shark attacks allegedly occurring in Turkey's waters, reflects the real situation or not? Following several studies carried by the Ichthyological Research Society (IRS), a non-governmental and non-profit institution, dedicated for the research of sharks since 2000, authors acquired more data on several shark attacks that occurred in Turkey's waters during the twentieth century. Some preliminary data has been published previously (Kabasakal, 2014, 2015a).

In the present article, authors analyse the details of several fatal and non-fatal shark attacks against humans and boats that occurred in Turkey's waters, in the light of available data. Furthermore, a brief discussion on predatory aggregations around aquaculture cages and the possible consequences in terms of public safety in coastal waters is also made.

MATERIAL AND METHODS

Data on shark attacks in Turkey's waters were obtained from the following sources: (1) news that has appeared in printed and internet media; (2) GSAF data base which is accessible via the following link: www.sharkattackfile.net; (3) interviews with fishermen, especially old tuna handliners, who actively fished in Bosphoric waters

Tab. 1: Chronological list of shark attacks occurred in Turkish waters. Numbers in the No column are same as the numbers in Figure 1. AE - Aegean Sea, MS - Mediterranean Sea, SM - Sea of Marmara.
Tab. 1. Kronološki pregled napadov morskihpsov v turških vodah. Številke v stolpcih se ujemajo s številkami na zemljevidu obravnavanega območja na sliki 1. AE: Egejsko morje, MS: Sredozemsko morje, SM: Marmarsko morje.

No	Date	Region	Locality	Activity	Fatality	Reference
1	1930	SM	Yeşilköy	Handlining	No	De Maddalena & Heim (2012)
2	17 Mar 1931	SM	Bakırköy	Handlining	No	Unpubl. data
3	8 Feb 1934	SM	Haydarpaşa	Handlining	No	Unpubl. data
4	16 Aug 1937	SM	İstanbul	Swimming	No	GSAF (2015)
5	17 Sept 1948	MS	Yumurtalık	Swimming	Yes	Unpubl. data
6	1958	SM	Ahırkapı	Handlining	No	Kabasakal (2014, 2015a)
7	1958	SM	Ahırkapı	Handlining	No	Kabasakal (2014, 2015a)
8	25 Dec 1958	SM	Ahırkapı	Handlining	No	Kabasakal (2014, 2015a)
9	1966	SM	Sivriada	Scuba diving and spearfishing	No	Unpubl. data
10	7 July 1967	SM	Tuzla	Scuba diving and spearfishing	Yes	Unpubl. data
11	1970	MS	Antalya	Swimming	No	Unpubl. data
12	1970	AE	İzmir	Handlining	No	Unpubl. data
13	1983	SM	Dilovası	Spearfishing	No	Unpubl. data

between the 1930's and 1990's; and (4) available scientific literature. The selection of specific newspapers, magazines and websites for this study depended on their availability. The news were gathered through the use of library archives for the years prior to their inclusion in online newspaper databases, screening the daily issues of newspapers, and through an internet search. Approximate locality of each shark attack was plotted on the map (Fig. 1). Voice records of interviews with fishermen, screened newspaper pages and internet articles saved as pdf files are kept in the archives of IRS and available for inspection upon request.

RESULTS AND DISCUSSION

Analysis of the mentioned data sources revealed 13 shark attacks occurred in Turkey's waters between 1931 and 1983. Ten out of the 13 attacks (76.9 %) occurred in the Sea of Marmara, and were followed by 2 attacks (15.3 %) recorded in the Mediterranean and 1 attack (7.7 %) in the Aegean sea. Four attacks (30.7 %) occurred during late spring (May), summer (July and August) and early autumn (September) months, when sea surface temperatures were > 20 ºC, while 3 attacks (23.1 %) occurred during winter (December and February) and early spring (March) months, when sea surface temperatures were < 20 ºC (Tab. 1). In 7 attacks (53.8 %) targets were the fishing boats, of which 6 of them were boats of tuna handliners, while 6 attacks (46.2 %) were directed against humans. In 3 incidents (23.1 %) skin or scuba divers, who were harpooning fish, were attacked. Additional 3 attacks were against swimmers. Two attacks (15.3 %) were fatal.

The story of shark attacks in Turkey's waters started in 1930. In that year, two British citizens went to sea aboard a small fishing boat off Santo Stefano (Yeşilköy, Sea of Marmara; Fig. 1, Tab. 1), and were attacked by a large shark (De Maddalena & Heim, 2012). The species of the shark was assumed to be a great white shark (*Carcharodon carcharias*), although this assumption has

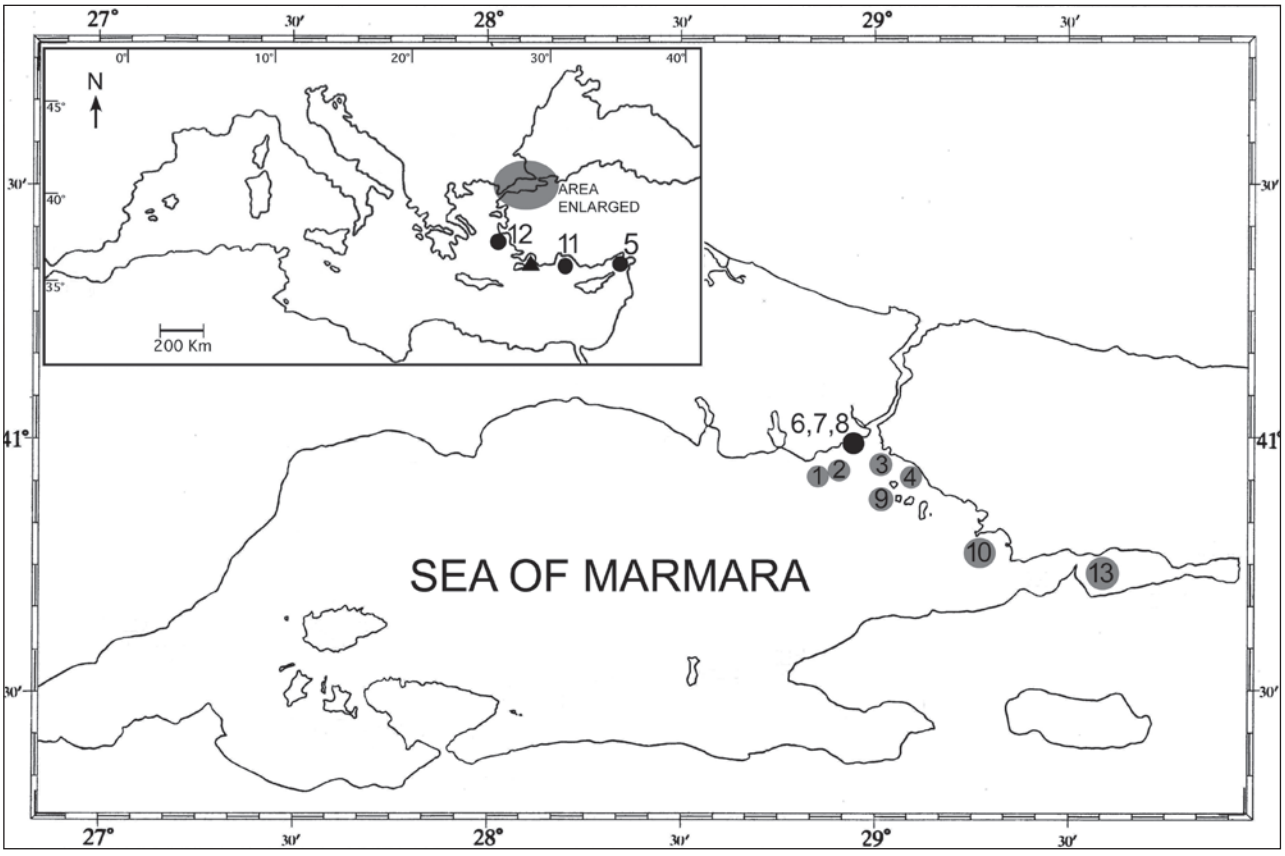
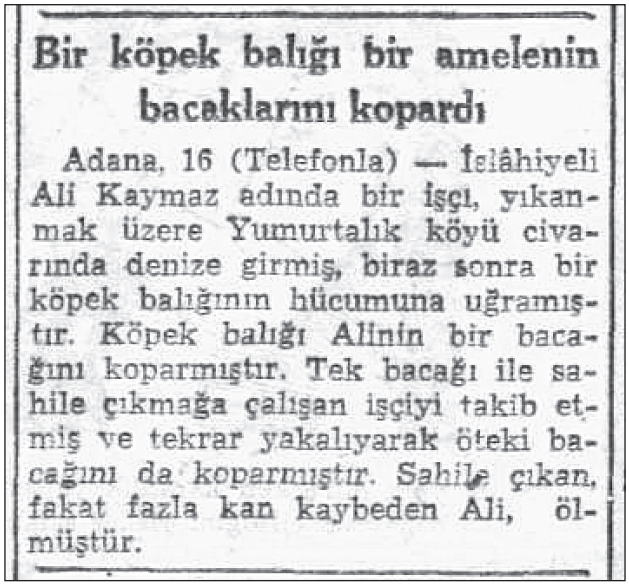


Fig. 1: Map showing the localities of shark attacks occurred in Turkey's waters. (▲) In the small map showing the approximate locality, where a spearfishing skindiver encountered a great white shark off Marmaris coast on 28 September 2011. Numbers on the map are same as the numbers in Table 1.
Sl.1: Zemljevid obravnavanega območja z lokalitetami, kjer so se zgodili napadi moskih psov v turških vodah. Trikotnik (▲) na manjšem zemljevidu označuje približno lokaliteto, kjer je ribič s podvodno puško srečal belega morskega volka blizu marmarske obale 28 septembra 2011. Številke na zemljevidu se ujemajo s številkami v tabeli 1.

never been confirmed (De Maddalena & Heim, 2012). Following the Santo Stefano incident, a second shark attack on a tuna handliner's boat occurred on 17 March 1931, in close vicinity to Bakırköy (Sea of Marmara; Fig. 1, Tab. 1). According to the newspaper report, on that date three fishermen went to sea for handlining tuna and their boat was attacked by a large shark. The fishermen hit the shark with paddles to fend it off, but the predatory shark continued attacking the boat and eventually broke it up. Once overboard the fishermen spent almost 2 hours in water with shark, but fortunately none of them were harmed and all were rescued alive. Three years later, another tuna handliner's boat was attacked by a large shark on 8 February 1934 off Haydarpaşa (Sea of Marmara; Fig. 1, Tab. 1). Following the shark attack the fishing boat was damaged and sunk, and the wounded fishermen were saved. On 16 August 1937, a non-fatal attack to a swimmer occurred off the Istanbul coast (Sea of Marmara; Fig. 1, Tab. 1) (GSAF, 2015). The species of the shark which attacked the boats and a swimmer in 1930's remained unknown.



Bir köpek balığı bir amelenin bacaklarını kopardı

Adana, 16 (Telefonla) — İslâhiyeli Ali Kaymaz adında bir işçi, yıkanmak üzere Yumurtalık köyü civarında denize girmiş, biraz sonra bir köpek balığının hücumuna uğramıştır. Köpek balığı Alinin bir bacağını koparmıştır. Tek bacağı ile sahile çıkmağa çalışan işçiyi takib etmiş ve tekrar yakalıyarak öteki bacağını da koparmıştır. Sahile çıkan, fakat fazla kan kaybeden Ali, ölmüştür.

Fig. 2: Newspaper clip reporting the fatal shark attack occurred of Yumurtalık coast on 17 September 1948 (case No 5 in Table 1). Translation of the newspaper clip reads: "Adana (interview via phone call) - A construction worker, Mr. Ali Kaymaz from village of İslahiye, has been attacked by a shark, while he was swimming off Yumurtalık coast near Adana city. At first strike shark severed one of his legs, then he struggled to leave the water but the shark attacked again and severed the other leg. The worker died because of severe bleeding."
Slika 2: Časopisni prispevek o napadu morskega psa na človeka s smrtnim izzidom ob obali Yumurtalık 17 septembra 1948 (primer št. 5 v tabeli 1). Prevod prispevka se glasi: "Adana (intervju po telefonu) – Gradbenega delavca, gospoda Ali Kaymaz iz vasi İslahiye, je napadel morski pes, medtem ko je plaval ob obali Yumurtalık blikzu mesta Adana. V prvem napadu mu je morski pes odtrgal nogo, v drugem pa, medtem ko je Ali poskušal zbežati iz vode, še drugo nogo. Gradbeni delavec je kasneje umrl zaradi prehude izgube krvi."

On 17 September 1948, a non-provoked fatal shark attack occurred off Yumurtalık (NE Mediterranean Sea; Fig. 1, Tab. 1). According to the newspaper report, a migrant worker was attacked by a shark while swimming off Yumurtalık. In the first strike the shark severed one of his legs, and then as the victim struggled to leave the water, the shark made a second attack, which resulted in severing his other leg. The victim died a very short time later due to hemorrhaging. The Yumurtalık incident is considered the first confirmed fatal shark attack to have occurred in Turkey's waters, which was proved by the newspaper report (Fig. 2). The species of the shark remains unknown.

Ten years later, 3 shark attacks occurred against fishing boats in Bosphoric waters. In 1958, two fishing boats of tuna handliners were attacked by great white sharks, which were attempting to prey on hooked tunas off Ahırkapı (Sea of Marmara; Fig. 1, Tab. 1). According to the interview with Mr. İrfan Yürür, one of the few surviving legendary tuna handliners, who was active in the Bosporus Strait waters between the 1930's and 1980's, in one instance, a nearly 6 m long great white shark attacked his fellow fishing boat. The shark was hooked while it was attempting to feed on the captured tuna and attacked the boat (Kabasakal, 2015a).

The great white shark struggled to get off the hook and attacked another boat upon getting free. Two of the many triangular and serrated edged teeth got stuck in the lagging of the boat, Mr. Yürür reported in the interview. Following these two incidents, on 25 December 1958, a third attack by a great white shark on a tuna handliners fishing boat occurred off Ahırkapı (Fig. 1, Tab. 1; Kabasakal, 2014). According to the newspaper report of the same date, the boat had been bitten several times by the great white shark and several teeth got stuck in boat's hull, which are visible in the photograph accompanying the report.

In 1966, an Istanbul based SCUBA diver Mr. Zareh Magar was spearfishing off Sivriada (Sea of Marmara; Fig. 1, Tab. 1). While he was searching fish in the caverns, he suddenly noticed that a huge shark was approaching him. According to the report by Mr. Magar, which was published in Hayat magazine on 12 May 1966, the shark attacked the diver, but he left the water as soon as possible without injuries (Magar, 1966). According to Mr. Magar's statement, dozens of tuna jumped out of the sea just a short time following his ascent.

On 7 July 1967, another Istanbul based Scuba diver Mr. Güngör Güven dived off Tuzla coast (Sea of Marmara; Fig. 1, Tab. 1). According to the newspaper report of the same date, Mr. Güven was spearfishing only 200

m off the coast at a depth of 10 m. Suddenly the water turned red and Mr. Güven never ascended to the surface. Just a few minutes later a large dorsal fin appeared at the surface, where Mr. Güven had been spearfishing. Search and rescue divers could only find the right hand, a finger bearing teeth marks, the Scuba tank and the torn diving suit of the victim. Before 1970, a non-fatal shark attack occurred against a fishing boat off Kilizman near the city of Izmir (Aegean Sea; Fig. 1, Tab. 1), while a fisherman was hauling a drop-line set for red sea bream (*Pagrus* spp.). According to a newspaper report a 200 kg weighted shark attacked the hooked fish, meanwhile the fisherman attempted to harpoon the shark. Following the response of the fisherman the shark attacked the boat and caused severe damage.

Following the Kilizman incident, a shark attack against a swimmer occurred off Antalya near Konyaaltı beach (Mediterranean Sea; Fig. 1, Tab. 1) in the early 1970's. During that time, there had been a slaughterhouse built along the seaside, which dumped its' waste directly into the sea. Finally, in 1983 a non-fatal shark attack against a diver who was spearfishing, occurred off Dilovası (Sea of Marmara; Fig. 1, Tab. 1). Although a great white shark is assumed to be responsible for this attack, this assertion is considered doubtful.

The sea temperatures above 20 ºC have been assumed to be a triggering factor for a shark attack (Springer & Gold, 1989). The extent of humans' use of the sea and therefore their availability for attack was suggested by Baldridge (1988) to be certainly closely related to temperature. However, despite this environmental fact, significant numbers of attacks have also been reported in the areas where water temperatures were below this assumed critical limit (Baldridge, 1988; Springer & Gold, 1989; GSAF, 2015). Based on the dates of attacks, 30.7 % of the attacks occurred in the periods of the year where the temperature is above 20 ºC and 23.1 % of attacks occurred in cold seasons (< 20 ºC sea surface temperature). Chronological data of the attacks with confirmed dates show that the shark attacks in Turkey's waters have occurred throughout the year (Tab. 1).

Ten (76.9 %) out of 13 shark attacks mentioned appear to be motivated by handlining or spearfishing (Tab. 1). Furthermore, the motivation of 1 attack (7.6 %; case 11, Tab. 1) was the waste from a slaughterhouse which was operating along the seaside. Thus, based on the present results, motivation of 11 (84.6 %) out of 13 shark attacks which occurred in Turkey's waters had anthropogenic factors such as fishing or waste dumping. Only 1 incident (7.6 %; case no 5, Tab. 1) was a non-provoked fatal shark attack on a swimmer. According to Baldridge (1988), shark attacks can occur due to several motivations and 50 to 75 % of attacks against humans might have been triggered by non-feeding factors. Nevertheless, feeding might very well be the primary motivation for attacks, as Baldridge (1988) suggested, and regarding the sharks as opportunistic feeders, a hooked tuna or a speared fish can provide an easy feeding opportunity for the predator. The fact that 83 % of all documented shark attacks in Turkey's waters occurred during fishing activities emphasize the relationship between the attacks and the opportunistic feeding behaviour of sharks.

According to Springer & Gold (1989) the length of the sharks which have been known to attack people varies from 2 to 8 m; however, Caldicott *et al*. (2001) stated that the lower limit of this scale might be as short as 45 cm. In general, any shark that can grow larger than 1.8-2.0 m is potentially lethal to a human (Baldridge & Williams, 1969; *op cit* Caldicott *et al*., 2001). Juveniles of some of the prominent man eaters, (*e.g.* the great white shark, *C. carcharias*, and the tiger shark, *Galeocerdo cuvieri*; Compagno, 1984), can make fatal attacks against humans (Clua & Reid, 2013; Clua *et al*., 2014). On 26 March 2009, a non-provoked fatal shark attack on a 19 year old male surfer occurred in waters off the western coast of New Caledonia (Clua & Reid, 2013). The information provided by a witness and the analysis of a partial bite on the right calf allowed the authors to identify a juvenile great white shark with an estimated total length of 2.7 m. Similarly, on 21 May 2011, a 15 year old male died following an attack by a juvenile tiger shark with an estimated total length of 2.8 m, in New Caledonia's waters (Clua *et al*., 2014).

Tricas & McCosker (1984) postulated that an ontogenetic development in dentition of *C. carcharias* at approximately 3.0 m in total length, may account for the shift in preferences of prey types and predatory behaviour. Young and juvenile great white sharks less than 3.0 m in total length are known to feed on squid, small teleosts and cartilaginous fishes, while larger sharks feed on more energetic prey, like marine mammals and bluefin tuna (Fergusson *et al*., 2000; Kabasakal, 2009, 2015a; De Maddalena & Heim, 2012). Furthermore, McCosker (1985) suggested that young great white sharks (≥ 2.5 m total length) can feed on pinnipeds and other marine mammals. Thus, attacks of juvenile great white sharks against humans can be the consequence of a learning phase, in which a young shark is improving its predatory abilities as a top predator (Clua & Reid, 2013). According to Guttridge *et al*. (2009), sharks can learn in an associative or non-associative means by which they can counteract the behavioural plasticity of their prey, fine tuning foraging tactics and capture.

Since the 1990's a total of 14 great white sharks were either sighted or captured in coastal waters of Turkey's Aegean Sea (Kabasakal, 2014; Kabasakal & Kabasakal, 2015). Total lengths of 5 out of 14 specimens were ≥ 4.5 m; sizes of 3 out of 14 varied from 1.8 to 3.0 m, and the remaining 6 specimens which include new-borns had total lengths which were ≤ 1.4 m. On 28 September 2011, the great white shark with an estimated total length of 5.0 m approached a skin diver who was spearfishing off Marmaris (Fig. 1) at a depth of 15 m (Kabasakal, 2014). The shark circled around the diver a

few times before it moved away. Based on the data provided by Kabasakal (2014) and Kabasakal & Kabasakal (2015), it is obvious that juvenile and adult specimens of *C. carcharias* are occurring in coastal waters of Turkey's Aegean Sea from February to late September. *C. carcharias* is the only species occurring in Turkey's waters, which is categorized as very dangerous by Compagno (1984) and responsible for many sharks attacks which have occurred over the entire Mediterranean Sea (De Maddalena & Heim, 2012).

Besides the great white shark, the shortfin mako (*Isurus oxyrinchus*) and blue sharks (*Prionace glauca*), which are categorized as dangerous sharks by Compagno (1984), are known to occur in the coastal waters of Turkey's Aegean and Mediterranean seas (Kabasakal, 2010, 2015b). On 16 August 2009 a female blue shark (3.5 m total length) was caught off Ayvacık (NE Aegean Sea; Kabasakal, 2010), while another specimen (≥ 2 m total length) was observed near aquaculture cages in Güllük Bay (SE Aegean Sea; G. Balkan, *pers. comm.*). In 2 out of the 5 shark attacks that occurred in Sharm El Sheikh (Red Sea) in 2010, shortfin mako sharks were the causal species, and the attacks occurred at most 40 m off the coast (Levine *et al.*, 2014). Authors suggested that the dumping of sheep carcasses off the resort areas and the hand-feeding of sharks were likely triggers for the incidents. A similar shark attack outbreak due to anthropogenic waste was observed off Recife (Brazil) over the 1992-2006 period (Hazin *et al.*, 2008), which was also the causal factor of the shark attack that occurred off Antalya coast in 1970 (case no 11, Tab. 1).

Based on GSAF (2015) data base, 54 shark attacks occurred in the Eastern Mediterranean to date, of which 34 of them were the incidents recorded in adjacent waters of Turkey. However, with the addition of present results these numbers are increased to 65 and 45 respectively. The most recent shark attack in adjacent waters to Turkey occurred on 29 September 2013 off Ashod (Israel; GSAF, 2015).

CONCLUSIONS

Chronological analyses of the shark attacks that have occurred in Turkey's waters show that the incidents cover almost the entire 20th century (Tab. 1). The majority (84.6 %) of these attacks occurred during fishery operations (handlining or spearfishing). Moreover, the causal factor of one of these shark attacks was the dumping of waste, as was the case for the attacks that occurred in Sharm El Sheikh and Recife. Therefore, it should be kept in mind that anthropogenic waste dumping from slaughterhouses or similar facilities can create sensorial stimulus for sharks to come closer to coastal areas. From this point of view, aquaculture cages set too close to shore lines or offshore transport cages of pelagic fish like bluefin tuna can also create a stimulus for the attraction of predatory sharks (Galaz & De Maddalena, 2004; Papastamatiou *et al.*, 2010; Kabasakal, 2014). Galaz & De Maddalena (2004) and Kabasakal (2014) reported on two cases from Mediterranean waters, in which the great white sharks followed and entered the tow cages of bluefin tuna. Historically, the coexistence of great white sharks and bluefin tuna in Mediterranean Sea is a very well known phenomenon (De Maddalena & Heim, 2012). According to Papastamatiou *et al.* (2010), predatory sharks exhibit site fidelity around aquaculture cages in Hawaiian waters. As in the case of Güllük Bay incident, large predatory sharks can occur in the vicinity of aquaculture farms set along Turkey's coast, occasionally. Although, for the moment, threats to public safety of these aggregating top-predators is unknown, aquaculture farm planners should bear in mind that such marine cages can create sensorial stimulus of easy source of prey for sharks, a predator capable of learning.

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NAPADI MORSKIH PSOV NA LJUDI IN PLOVILA V TURŠKIH VODAH V DVAJSETEM STOLETJU

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POVZETEK

Med letoma 1931 in 1983 so v turških vodah zabeležili trinajst napadov morskih psov. Deset od teh (76,9 %) se je zgodilo v Marmarskem morju, nadaljnja dva napada v sredozemskih vodah in eden v Egejskem morju. V sedmih primerih (53,8 %) so morski psi napadli plovila, med katerimi je bilo 6, s katerih so lovili tune na trnek. V ostalih šestih primerih pa je morski pes napadel človeka. V treh primerih (23,1 %) je morski pes napadel potapljača na dah oziroma potapljača z jeklenko, v drugih treh pa plavalce. Velike plenilske morske pse so pogosto opazovali ob kletkah ribogojnic, ki se nahajajo vzdolž turške egejske in sredozemske obale, npr. v zalivu Güllük. Kakorkoli že, o morebitni nevarnosti za varnost ljudi zaradi zbiranja morskih psov za zdaj ni nobenih podatkov.

Ključne besede: napadi morskih psov, Turčija, ribištvo, akvakultura, varnost ljudi

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PHOTOGRAPHIC RECORD OF THE SPINNER SHARK, *CARCHARHINUS BREVIPINNA* (MÜLLER & HENLE, 1839), IN GÖKOVA BAY (SOUTH AEGEAN SEA, TURKEY)

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ABSTRACT

In August 1998, a picture of a spinner shark, Carcharhinus brevipinna *(Müller & Henle, 1839) was taken by an amateur group of divers at a depth of 3 m in Boncuk Bay (Gökova Bay, south Aegean Sea). Photographic evidence of this shark in Boncuk Bay contributes to our knowledge about the historical distribution of the species in Turkish waters.* C. brevipinna *is considered a very rare shark species in Turkish seas and needs immediate protection in Turkish territorial waters. The sighting of the spinner shark in the vicinity of a well-documented nursery ground of the sandbar shark,* C. plumbeus*, does not necessarily indicate a breeding ground for* C. brevipinna *in the studied area, as well; however, the possibility of a hypothetical nursery for the spinner shark in the Boncuk Bay area should be investigated in the future.*

Key words: spinner shark, *Carcharhinus brevipinna*, occurrence, distribution, Aegean Sea

AVVISTAMENTO FOTOGRAFICO DELLO SQUALO TISSITORE, *CARCHARHINUS BREVIPINNA* (MÜLLER & HENLE, 1839), NEL GOLFO DI GÖKOVA (MAR EGEO MERIDIONALE, TURCHIA)

SINTESI

Nell'agosto del 1998 uno squalo tissitore, Carcharhinus brevipinna *(Müller & Henle, 1839), è stato ripreso da un gruppo amatoriale di subacquei ad una profondità di 3 metri nella baia di Boncuk (golfo di Gökova, mar Egeo meridionale). Le prove fotografiche della presenza di questo squalo nella baia di Boncuk contribuiscono alla conoscenza sulla distribuzione storica delle specie in acque turche.* C. brevipinna *è considerato quale specie molto rara di squali nei mari della Turchia e ha pertanto bisogno di una protezione immediata nelle acque territoriali turche. L'avvistamento dello squalo tissitore in prossimità di una ben documentata zona di crescita dello squalo grigio,* C. plumbeus*, non indica necessariamente una zona di riproduzione per* C. brevipinna *nell'area studiata. Tuttavia, la possibilità di un'ipotetica zona di crescita per lo squalo tissitore nella baia di Boncuk dovrebbe venir verificata in un prossimo futuro.*

Parole chiave: squalo tissitore, *Carcharhinus brevipinna*, avvistamento, distribuzione, mar Egeo

INTRODUCTION

The spinner shark, *Carcharhinus brevipinna* (Müller & Henle, 1839), is a common coastal-pelagic, warm--temperate and tropical shark of the continental and insular shelves, commonly found in shallow waters less than 30 m deep, though it is occasionally reported from a depth of at least 75 m (Ebert & Stehmann, 2013). *C. brevipinna* is a rare-to-occasional species in the whole Mediterranean, where it is recorded as bycatch in deep--sea and pelagic longline fishing off the eastern Algerian and Tunisian coasts (Serena, 2005).

Although Akşıray (1987) and Mater & Meriç (1996) included spinner shark in their ichthyological inventories of the seas of Turkey, the occurrence and status of *C. brevipinna* in the mentioned region had been a point of debate until the 2000s. Kabasakal (2002) reported the presence of *C. brevipinna* in Turkish waters based on 3 specimens recorded off the Kuşadası and Marmaris coasts (Aegean Sea) and in İskenderun Bay (NE Mediterranean Sea).

In the present article, authors report a specimen of *C. brevipinna* photographed in Gökova Bay (SE Aegean Sea) in the late 1990s. The present article could be a significant contribution to our current knowledge on the historical occurrence of the spinner shark in Aegean waters.

MATERIAL AND METHODS

In August 1998, a carcharhinid shark was observed and photographed by an amateur group of divers in Boncuk Bay (approximate location 36° 58′ 42.0″ N, 28° 12′ 52.5″ E; Fig. 1) within the boundaries of the Gökova Special Environmental Protection Area (SEPA). The shark remained in close proximity to the divers for about 5 minutes at a depth of 3 m. Due to the absence of a nearby reference object during photographing it was not possible to estimate the size of the shark. The photograph was obtained from the archives of H. Lukas, F. Diestel and P. Rauhut by the first author in 2012. The shark was subsequently identified by the authors as *Carcharhinus brevipinna*. The identification of the species is based on Grace (2001), Serena (2005) and Bariche (2012). The photographs of the present specimen are held in the personal archives of the both authors.

RESULTS AND DISCUSSION

The following description of the spinner shark is based on the specimen seen in Figure 2: a large, but slender shark with a long, sharply pointed snout, small eyes, long gill slits, and small pectoral fins. The body is robustly fusiform, with a wide caudal peduncle. The origin of the first dorsal fin is over the behind/ rear tip of the pectoral fin. Between the two dorsal fins there is no interdorsal ridge. The tips of the fins are dark. A white band is visible on flanks.

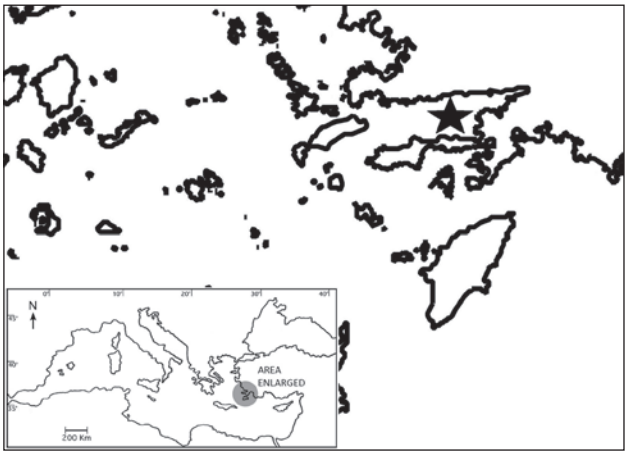

Fig. 1: Map showing approximate location (★) of sighting of present spinner shark, *C. brevipinna****, in Gökova Bay.***

Sl. 1: Zemljevid z označeno lokaliteto (★), kjer so fotografirali kratkoplavutega morskega psa, *C. brevipinna****, v zalivu Gökova***

Carcharhinus brevipinna, like many of the large shark species, poses a particular dilemma, as it is yet unknown whether it is rare in the Mediterranean and adjacent waters, or just rarely caught and reported (Cavanagh & Gibson, 2007). For example, Branstetter (1984) reports *C. brevipinna* being present throughout the Mediterranean, even in the Adriatic; however, according to Lipej *et al*. (2004), there have been no confirmed records of spinner shark occurrence in the Adriatic Sea. In a recent comprehensive study on the occurrences of large sharks in the open waters of the SE Mediterranean Sea, Damalas & Megalofonou (2012) recorded 249 specimens representing 10 species, captured by Greek and Cypriot longline fishing vessels between 1998 and 2005. Although the authors observed 4 carcharhinid taxa (*C. plumbeus*, *Carcharhinus* spp., *Prionace glauca* and *Rhizoprionodon acutus*) in the investigated area, their catch data did not include *C. brevipinna*. To date, 11 carcharhinid species have been reported from Mediterranean waters (Serena, 2005). However, *Carcharhinus* is one of the largest and most important genera of sharks, and the discrimination between the species in the field is sometimes rather difficult, due to a strong resemblance between the black-tipped *Carcharhinus* species (*brevipinna* and *limbatus*), which occur sympatrically in the Mediterranean Sea (Serena, 2005) and could possibly cause misidentifications. Indeed, the first record of the spinner shark in the Mediterranean was provided by Tortonese (1963) (as *Aprionodon brevipinna*), and was based on an earlier misidentification as *C. limbatus* by Tortonese (1938) (R. Fricke, *pers. comm*.).

Based on the information obtained from available literature, the occurrence of the spinner shark in the eastern Levant dates back to the mid-20th century, when a shark specimen (total length 55 cm) was hooked in Haifa Bay (Israeli coast of the E Mediterranean) on 23rd November 1958, and was later identified as *A. brevipinna* (Ben-Tuvia, 1966). According to Ben-Tuvia's report (Ben-Tuvia, 1966), the identification of the Haifa specimen was later confirmed by world-renowned shark experts J. Garrick and V. G. Springer. Following the first Haifa specimen, another spinner shark (total length 110 cm) was hooked in the same area on 27th May 1964. Later, Ben-Tuvia (1971) reported on the capture of a third spinner shark (length 29 cm) without giving detailed information about the specimen or the fishing locality. Before the observation of the present specimen in Boncuk Bay, Kabasakal (2002) reported on the capture of 3 spinner sharks off the coast of Turkey (2 in Aegean waters and 1 in the eastern Mediterranean). Since the field survey of Kabasakal's study was carried out between 1995 and 1999 (Kabasakal, 2002), the capture of these 3 spinner sharks does not necessarily confirm the contemporary occurrence of *C. brevipinna* in Turkish waters, nor does the present specimen observed in 1998.

Therefore, the current presence of *C. brevipinna* in the seas of Turkey requires clarification. On this same note, a record of *C. brevipinna* can indeed be found in the updated checklist of the marine fishes of Turkey (Bilecenoğlu *et al.*, 2014), however, it is based on the distributional data given by Branstetter (1984). Similarly, Hadjichristophorou (2006) includes *C. brevipinna* in the list of Cypriot sharks, but his record is based on the distributional information of spinner shark provided quite some time ago by Compagno (1984); whereas a recent list of sharks recorded off the Syrian coast (E Mediterranean; Saad *et al.*, 2006) does not include *C. brevipinna* at all. Although Ben-Tuvia (1966, 1971) and Golani (2006) conclude that *C. brevipinna* is a common or prevalent shark in the Mediterranean waters of Israel, Bariche (2012) suggests that it is a rare-to-occasional shark in the region. Supporting Bariche's suggestion (Bariche, 2012), Serena (2005) also considers *C. brevipinna* as a rare-to-occasional shark throughout the Mediterranean, contrasting with the alleged commonness of the spinner shark off the Israeli coast (Ben-Tuvia, 1966, 1971; Golani, 2006).

The origin of *C. brevipinna* in the eastern Mediterranean waters has been a constant point of debate since Ben-Tuvia's milestone study on the Red Sea fishes found in the Mediterranean (Ben-Tuvia, 1966). In one of his classical studies of Lessepsian fish in the Levantine Basin, based on the supposition that no records of *C. brevipinna* from the western Mediterranean existed at that time, Ben-Tuvia (1966) assumed a Red Sea origin for the spinner shark. In contrast to his assumption (Ben-Tuvia, 1966), there are now numerous records of *C. brevipinna* in western Mediterranean waters available (see Hemida

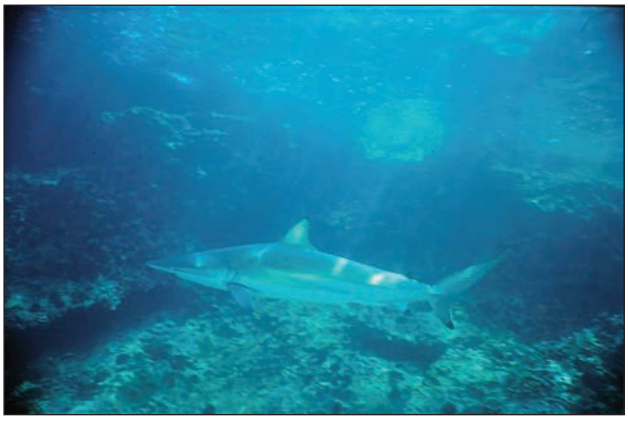

Fig. 2: Spinner shark, *C. brevipinna****, sighted in Gökova Bay, in August 1998.***
Sl. 2: Kratkoplavuti morski pes, *C. brevipinna****, posnet v zalivu Gökova v avgustu 1998***

et al., 2002; Bradaï *et al.*, 2006; Psomadakis *et al.*, 2012; Sperone *et al.*, 2012).

Our current knowledge on the species of the *Carcharhinus* genera occurring in the seas of Turkey consists of rudimentary data (Başusta *et al.*, 1998; Kabasakal, 2015). Earlier accounts of the occurrence of spinner shark in Turkish waters were based on reports of general ichthyological inventory studies carried out in the mentioned region (*e.g.* Mater & Meric, 1996; Başusta *et al.*, 1998; Fricke *et al.*, 2007; Bilecenoğlu *et al.*, 2014), in which the occurrence data for *C. brevipinna* is based on Branstetter (1984), Akşıray (1987) and Fischer *et al.* (1987). Even Akşıray's record of *C. brevipinna* from Turkish waters fails to provide information on where the examined specimens had been caught or stored (Akşıray, 1987). Kabasakal (2002) provided the first reliable report on the presence of *C. brevipinna*, based on the three specimens he had collected from Kuşadası, Marmaris and İskenderun Bays, respectively.

This historical photographic evidence of the spinner shark is also the first record for Gökova Bay. Since Gökova Bay is a SEPA, the monitoring of the status and of the possible changes in biodiversity is therefore an important issue. So far, 15 studies have been carried out in Gökova SEPA in order to assess the fish fauna occurring in the area (*e.g.* Öğretmen *et al.*, 2005; Öziç & Yılmaz, 2006), but none of them included *C. brevipinna* in their inventories of the recorded fish species. Since Boncuk Bay, which is located on the eastern coast of Gökova SEPA, provides a nursery area for sandbar shark (*C. plumbeus*), annual monitoring studies have been conducted there since 2006, but the spinner shark has never been observed or otherwise recorded in these studies (Bilecenoğlu, 2008; Akça, 2010; Filiz *et al.*, 2012).

Today, the conservation status of *C. brevipinna* in the Mediterranean Sea is estimated as data deficient – DD

(Cavanagh & Gibson, 2007), and endangered (EN) in Turkish seas (Fricke *et al.*, 2007). In the Northwest Atlantic, *C. brevipinna* is considered a vulnerable shark by IUCN (Serena, 2005). The scarcity of records about *C. brevipinna* in the studied area could be explained as a consequence of a rapid decline of this shark (Ferretti *et al.*, 2008). Occurrence of the spinner shark in the vicinity of a well-documented nursery ground of the sandbar shark does not necessarily indicate a possible breeding ground for *C. brevipinna* in the studied area, though this possibility should be in the future investigated in the Boncuk Bay area.

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FOTOGRAFSKI ZAPIS O KRATKOPLAVUTEM MORSKEM PSU, *CARCHARHINUS BREVIPINNA* (MÜLLER & HENLE, 1839), V ZALIVU GÖKOVA BAY (JUŽNO EGEJSKO MORJE, TURČIJA)

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POVZETEK

Avgusta 1998 so amaterski potapljači posneli kratkoplavutega morskega psa, Carcharhinus brevipinna *(Müller & Henle, 1839), na globini 3 m v zalivu Boncuk (zaliv Gökova, južno Egejsko morje). Fotografija te vrste, posneta v zalivu Boncuk, je nov doprinos k poznavanju zgodovinske razširjenosti kratkoplavutega morskega psa v turških morjih. Vrsta* C. brevipinna *je opredeljena kot zelo redka vrsta v turških morjih in kot taka potrebna takojšnjega varovanja na območju turških ozemeljskih voda. Opažanje kratkoplavutega morskega psa v bližini znanega razmnoževalnega območja sivega morskega psa,* C. plumbeus*, še ne pomeni, da se tudi ta vrsta v tem okolju razmnožuje, vsekakor pa bi bilo to smiselno preveriti na območju zaliva Boncuk v bližnji prihodnosti.*

Ključne besede: kratkoplavuti morski pes, *Carcharhinus brevipinna*, pojavljanje, razširjenost, Egejsko morje

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OBSERVATIONS ON THE THINLIP CONGER *GNATHOPHIS MYSTAX* (OSTEICHTHYES: CONGRIDAE) FROM THE TUNISIAN COAST (CENTRAL MEDITERRANEAN)

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ABSTRACT

The paper reports on some aspects of morphology, morphometric measurements, meristic counts and colour of all Gnathophis mystax *found in northern Tunisian waters. Some measurements, such as pre-dorsal length, pre-anal length, pectoral length and pre-pectoral length are in correlation with size; however, the b < 3 values display negative allometry. The relationship between total length (TL) and the hepatosomatic index (HSI) is linked to size. Similar observations were recorded between TL and the gonadosomatic index (GSI), and between TL and condition (K). Of the 48 stomachs examined for contents, 29 were empty. A total of 19 items were found in the stomach contents, although partially digested.*

Key words: *Gnathophis mystax*, morphology, meristic counts, hepatosomatic index, gonadosomatic index, feeding habits

OSSERVAZIONI SUL GRONGO NASUTO *GNATHOPHIS MYSTAX* (OSTEICHTHYES: CONGRIDAE) LUNGO LA COSTA TUNISINA (MEDITERRANEO CENTRALE)

SINTESI

Gli autori riportano alcuni aspetti che si riferiscono a morfologia, misurazioni morfometriche, conte meristiche e colorazione di tutti gli individui di Gnathophis mystax *ritrovati nelle acque tunisine settentrionali. Alcune misurazioni, quali la lunghezza pre-dorsale, lunghezza pre-anale, lunghezza pettorale e la lunghezza pre-pettorale, sono correlate con le dimensioni degli individui. Tuttavia, i valori di b sono risultati minori a 3, indicando allometrie negative. Il rapporto tra la lunghezza totale (TL) e l'indice epatosomatico (HSI) è legato alle dimensioni. Osservazioni simili sono state registrate tra la TL e l'indice gonadosomatico (GSI), e tra la TL e la condizione (K). Dei 48 contenuti di stomaco esaminati, 29 erano vuoti. In totale, 19 pezzi sono stati trovati nei contenuti di stomaco, tuttavia già parzialmente digeriti.*

Parole chiave: *Gnathophis mystax*, morfologia, conte meristiche, indice epatosomatico, indice gonadosomatico, abitudini alimentari

INTRODUCTION

Thinlip conger *Gnathophis mystax* (Delaroche, 1809) is known to be commonly found off the eastern Atlantic coast extending from the south of Portugal to Morocco, southwardly the occurrence of the species remains doubtful and needs confirmation (Blache & Bauchot, 1972; Blache, 1977); it is replaced off the South African coast by southern Atlantic conger *Gnathophis capensis* (Kaup, 1856), following Smith (1990). In the Atlantic, the species is also reported off Madeira and the Canary Islands (Rucabado *et al*., 1978). *G. mystax* is well-known throughout the Mediterranean Sea and the Black Sea (Rucabado *et al*., 1978; Bauchot & Saldanha, 1986). The species has been reported as rather common off the northern Tunisian coast (Bradaï *et al*., 2004) and rare southwardly, where Bradaï (2000) recorded 2 specimens measuring 335 mm and 448 mm in total length, respectively.

G. mystax is a benthic species inhabiting muddy and sandy bottoms, dwelling at depths between 80 and 800 m (Bauchot & Saldanha, 1986). Little is known about the biology of *G. mystax*; Bauchot & Saldanha (1986) noted that spawning occurred in warm season, August to October in the Mediterranean Sea, with the egg averaging 2.5–3.0 mm in diameter, and probably referred to Blache (1977) when adding that leptocephali are characterized by long larval life, 12 months in tropical Atlantic. On the other hand, three papers focused on the diet and feeding habits of *G. mystax* specimens from the coast of Spain (Rucabado *et al*., 1978; Casadevall & Matallanas, 1990) and the Tyrrhenian Sea (Carpentieri *et al*., 2007).

The capture of specimens in northern Tunisian waters has allowed us to confirm the occurrence of the species in this area, as well as presenting herein some data about its morphometry, reproductive biology, diet and feeding habits. Such data constitute a first step to expanding the knowledge about the species in this area and to improving, if nothing else, its ecological role in it, as was the case with the Mediterranean moray eel *Muraena helena* Linnaeus, 1758 (Sallami *et al*., 2014).

MATERIALS AND METHODS

A total of 48 blacktail conger, *Gnathophis mystax*, were obtained between January 2010 and December 2011 at the fish markets of Zarzouna near Bizerte in northern Tunisia, and Kelibia, in the northern Cape Bon. All the specimens had been captured off the northern and north-eastern Tunisian coasts, including the Gulf of Tunis (Fig. 1). According to the information provided by experienced fishermen who are well-acquainted with the local fishing grounds, they were caught by commercial fishing vessels using trawl over sandy/muddy bottoms and longlines on rocky bottoms, at depths ranging from 50 to 200 m. All fresh specimens were measured

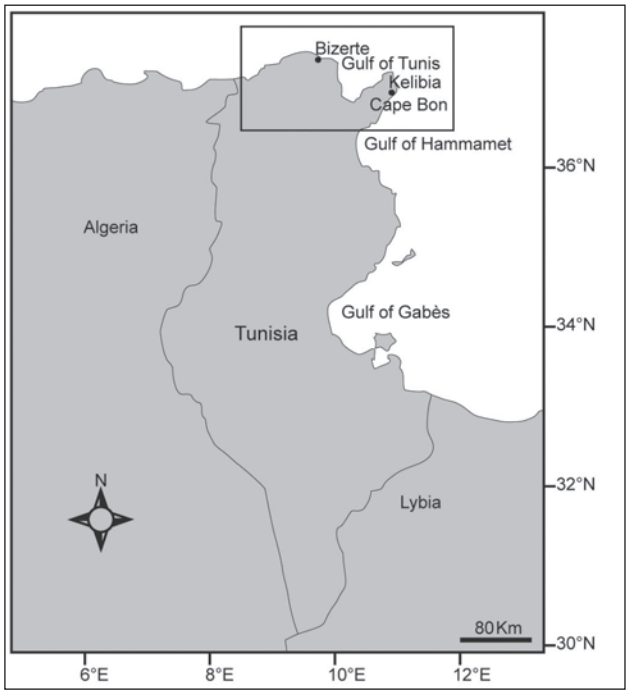

Fig. 1: Map of Tunisia showing the area of capture (rectangle) of** Gnathophis mystax**.
Sl. 1: Zemljevid Tunizije z označenim območjem ulova (pravokotnik) dolgonosega ugorja

in situ for total length (TL) to the nearest millimetre, and each specimen was weighed for total body weight (TBW) to the nearest gram. The specimens were then delivered to the laboratory, and the morphometric measurements recorded there in each specimen are plotted in Figure 2; relationships between total length and each measurement are expressed in logarithmic co-ordinates. We studied two meristic counts: vertebral number and number of pores in *linea lateralis*. In order to clearly expose the vertebral column, we kept the specimens in warm water prior to removing their flesh; following Bauchot & Saldanha (1986), we counted the numbers of abdominal vertebrae, caudal vertebrae and total vertebrae, and with special regard to *linea lateralis* we counted the pre-pectoral and pre-anal pores.

Once removed, the gonads, the liver, and the stomach contents were weighed to the nearest decigram. Additionally, the stomach contents were sorted out and identified to the lowest taxonomic level (or species level, where possible) using taxonomic keys and field guides (Perrier, 1964, 1975; Riedl, 1991; Louisy, 2002; Quéro *et al*., 2003). Prey items were counted and weighed to the nearest decigram, after surface water had been blotted off them with tissue paper. Whenever the prey recovered from the stomach was incomplete, its count was based on the number of different typical parts, such as beaks for cephalopods, claws and legs for various crus-

taceans, carapaces for decapod crabs, shell and foot for bivalves, operculum and shell for gastropods, and a whole vertebral column and otoliths for teleost species. Unidentified prey was preserved in 10% buffered formalin to be examined later by specialists.

The sample was evaluated for normality by means of the Shapiro-Wilk's test (W), with $P < 0.05$. The chi-square (χ^2) test was used to determine significance ($P < 0.05$). The relation between total length (TL) and total body weight (TBW) was used as a complement to feeding studies following Froese *et al.* (2011). Linear regression was expressed in decimal logarithmic coordinates and correlations were assessed by least-squares regression. Comparison of means was carried out by ANOVA. These two latter tests were performed via STAT VIEW 5.0 logistic model.

The analyses of food composition and feeding habits of *G. mystax* were studied by using indices suggested by Hureau (1970), Hyslop (1980) and Rosecchi & Nouaze (1985-86), such as:

- vacuity index, VI = (number of empty stomachs / total number of stomachs) × 100,
- mean number of preys per stomachs, MN = total number of prey ingested / total number of full stomachs,
- percentage of numerical abundance, %N = (number of prey items *i* / total number of preys) × 100,
- weight percentage, %W = (weight of prey *i* / total weight of all prey items) × 100,
- frequency of occurrence percentage, %F = (number of stomachs containing prey items *i* / total number of full stomachs) × 100.

The main food items were identified using the index of relative importance (IRI) of Pinkas *et al.* (1971), as modified by Hacunda (1981):

$$\mathrm{IRI} = \%\mathrm{F} \times (\%\mathrm{N} + \%\mathrm{W})$$

This index was expressed as:

$$\%\mathrm{IRI} = \frac{\mathrm{IRI}}{\Sigma \mathrm{IRI}} \times 100$$

All the indices listed above contributed to a better understanding of the importance of individual prey items in the feeding habits of the fish species under study.

The trophic level for any consumer species *i* is:

$$\mathrm{TROPH} = 1 + \sum_{j-1}^{\mathrm{G}} \mathrm{DC}_{ij} \times \mathrm{TROPH}_j$$

where TROPH_j is the fractional trophic level of prey *j*, DC_{ij} represents the fraction of *j* in the diet of *i* and G is the total number of prey species (Pauly *et al.*, 1998; Pauly & Christensen, 2000; Pauly & Palomares, 2000).

The TROPH and standard errors (SE) of *G. mystax* in the study area were calculated using TrophLab (Pauly *et al.*, 2000), a stand-alone Microsoft Access routine for estimating trophic levels, downloadable from FishBase (Froese & Pauly, 2014). Statistical differences ($P < 0.05$) in the basic diet composition as a function of size and season were established by applying a χ^2 test (Sokal & Rohlf, 1987).

Hepatosomatic index (HSI), gonadosomatic index (GSI) and condition factor (K) were calculated as:

$$\mathrm{HSI} = \frac{\mathrm{LM}}{\mathrm{TBW}} \times 100$$

$$\mathrm{GSI} = \frac{\mathrm{GM}}{\mathrm{TBW}} \times 100$$

$$\mathrm{K} = \frac{\mathrm{TBW}}{\mathrm{TL}^3} \times 100$$

with TL = total length, LM = liver mass, GM = gonad mass, and TBW = total body weight. Variations in HSI and GSI related to size were considered in all categories of specimens. Tests for significance ($P < 0.05$) were performed by using ANOVA and a χ^2 test, with special regard to variations in HSI and GSI related to size.

RESULTS

Sample description

The distribution of the sampled *Gnathophis mystax* is presented in Figure 2 (Shapiro-Wilk test, W= 0.98; $P < 0.001$); that allows us to state that the studied sample came from a normally distributed population. Of the 48 specimens collected, 31 were females and significantly outnumbered the males ($\chi^2 = 19$, df = 1, $P < 0.05$). The smallest specimen measured 170 mm in total length and weighed 8.3 g, whereas the largest specimen measured 363 mm and weighed 61.4 g.

Morphological measurements and meristic counts

The specimens of *G. mystax* were identified as follows: snake-like body, scaleless, rounded in anterior half, rather compressed behind anus, snout prominent, pointed and slender, eye large and oval, interorbital space narrow, mouth moderately large, labial flange narrow on upper lip, broader on lower lip, anterior nostril opening in a flexible tube at snout near to premaxillary teeth, posterior nostril a horizontal slit with a slightly crenulate edge, opening before and near eye. Colour brownish, rather darker dorsally, belly lighter, posterior edges of dorsal and anal fins blackish, distal end of caudal fin black.

Three *G. mystax* are preserved in the Ichthyological Collection of the Faculté des Sciences of Tunis and the

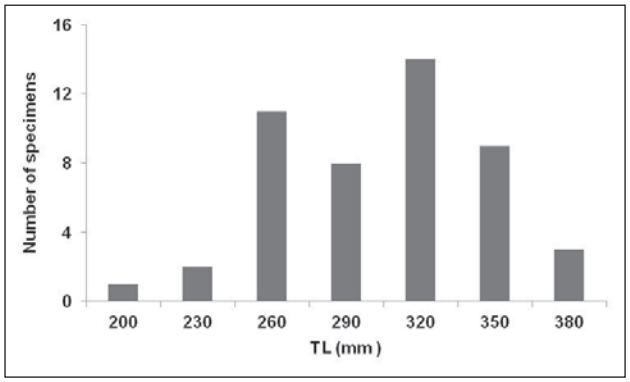

Fig. 2: Size distribution of studied specimens of *G. mystax*.
Sl. 2: Velikostna porazdelitev obravnavanih osebkov

Faculté des Sciences of Bizerte and registered under the following catalogue numbers: FSB-Gna-mys 01, FST-Gna-mys 02 and FST-Gna-mys 03, respectively; some measurements (Fig. 3) were carried out on these three specimens and summarized in Table 1.

Additionally, the relationships between total length (TL) and some measurements such as pre-dorsal length (Pre Dors length), pre-anal length (Pre Anal length), pectoral length (Pect length) and pre-pectoral length (Pre

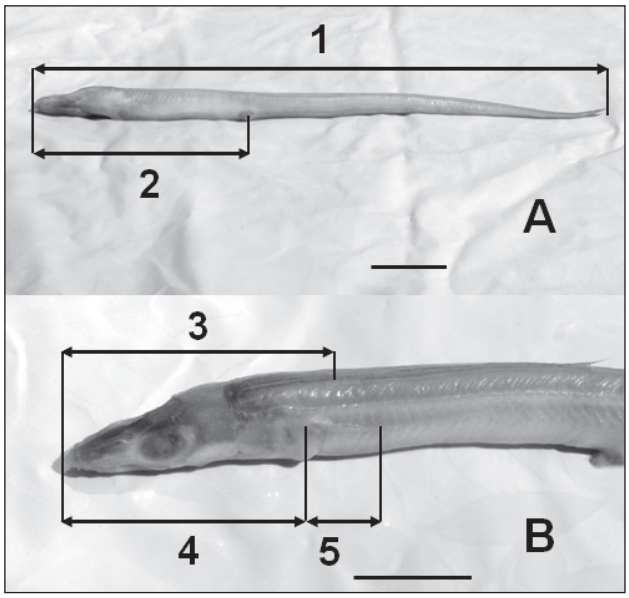

Fig. 3: Measurements recorded in *G. mystax*: ***(A) 1 - total length, 2 - Pre-anal length; (B) 3 - Pre-dorsal length, 4 - Pre-pectoral length, 5 - Pectoral length.***
Sl. 3: Meritve, opravljene na primerkih dolgonosih ugorjev: (A) 1 - celotna dolžina, 2 - dolžina do zadnjične plavuti; (B) 3 - razdalja do hrbtne plavuti, 4 - razdalja do prsne plavuti, 5 - razdalja do trebušne plavuti.

Tab. 1: Morphometric measurements, meristic counts and weights carried out in three specimens of *Gnathophis mystax* ***caught off the northern Tunisian coast.***
Tab. 1: Morfometrične meritve, meristika in masa pri treh primerkih dolgonosega ugorja, ujetih v severnotunizijskih vodah

Specimen	FST-Gna-mys 01		FST-Gna-mys 02		FST-Gna-mys 03	
Measurements	mm	%TL	mm	%TL	mm	%TL
Total length (TL)	248	100	309	100	370	100
Pre anal length	92	37.23	117	37.86	140	37.83
Pre dorsal length	46	18.00	56	18.14	68	18.37
Pre pectoral length	39	16.73	48	15.60	63	17.02
Pectoral length	12	4.36	15	4.85	20	5.13
Counts						
Abdominal vertebrae	43		43		43	
Caudal vertebrae	89		91		91	
Total vertebrae	132		134		134	
Pre pectoral pores	5		5		6	
Pre anal pores	32		32		32	
Weights (g)						
Total body weight	16.8		31.3		70.7	
Eviscerated body weight	15.2		27.5		65.2	
Liver weight	0.2		0.4		1.3	
Gonad weight	0.2		0.3		1.1	

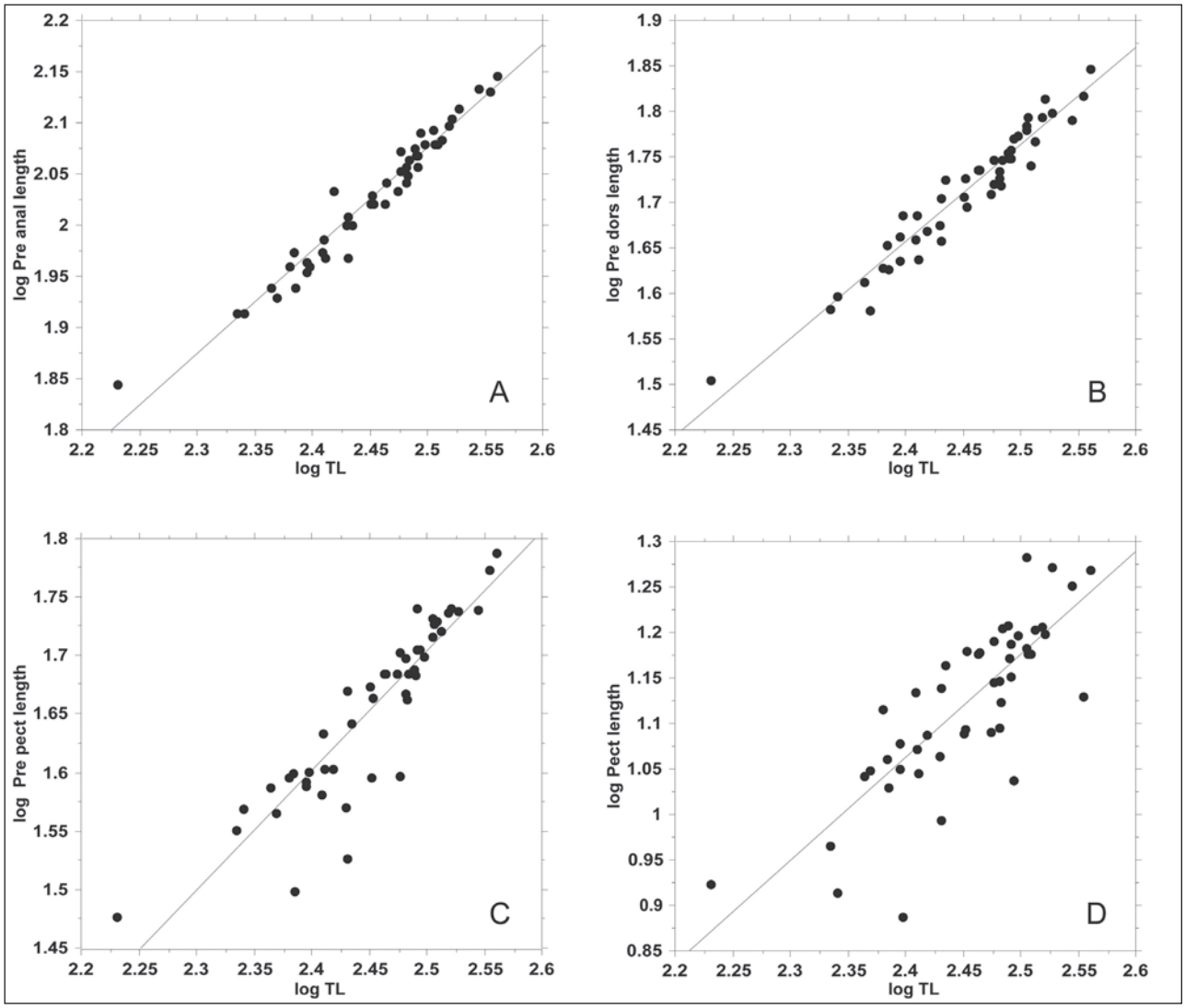

Fig. 4: Relationship expressed in logarithmic co-ordinates: total length (TL)** vs. **(A) Pre-anal length, (B) Pre-dorsal length, (C) Pre-pectoral length, (D) Pectoral length, for the studied sample of** G. mystax**.
Sl. 4: Premosorazmerni odnosi med logaritemsko izraženimi parametri, in sicer celotna dolžina (TL) proti (A) razdalji do zadnjične plavuti, (B) razdalji do hrbtne plavuti, (C) razdalji do prsne plavuti in (D) dolžini prsne plavuti pri vzorcu dolgonosih ugorjev.

Pect length) are plotted in Figure 4, as follows:

(A) log Pre Anal length = 1.01 × log TL - 0.436 (r = 0.97, $P < 0.001$)

(B) log Pre Dors length = 1.07 × log TL - 0.90 (r = 0.97, $P < 0.001$)

(C) log Pre Pect length = 1.024 × log TL - 0.856 (r = 0.90, $P < 0.01$)

(D) log Pect length = 1.14 × log TL - 1.66 (r = 0.81, $P < 0.001$)

Vertebral counts were carried out in 39 specimens: the number of abdominal vertebrae ranged between 38 and 44, with 43 as the modal value and a mean of 41.90 ± 1.41; they were outnumbered by caudal vertebrae, which ranged between 88 and 98, with 90 as the modal value and a mean of 90.55 ± 12.20. The total number of vertebrae ranged between 130 and 142, with 133 and 134 as the modal values and a mean of 131.02 ± 16.5. The results are similar to those recorded in the Mediterranean (Tab. 2). Pores were counted in 48 specimens; 5 pre-pectoral pores were recorded in 32 specimens, and 6 in 16 specimens, and were outnumbered by pre-anal pores, which ranged between 30 and 33, with 33 as the modal value and a mean of 32.10 ± 1.13.

Biological observations

The relationship between total length and the hepato-somatic index (HSI) is plotted in Figure 5, and it appears

Tab. 2: Number of vertebrae counted in** G. mystax **caught off the northern Tunisian coast, compared to those recorded in the Mediterranean.
Tab. 2: Število preštetih vretenc v raziskanem vzorcu s severnotunizijske obale v primerjavi s podatki iz Sredozemlja

Number of vertebrae			Area	Authors
Abdominal	Caudal	Total		
43-47	-	134-141	Mediterranean Sea	Bauchot & Saldanha (1986)
43-47	91-94	134-141	Mediterranean Sea	Aboussouan (1994)
38-44	88-98	134-141	Tunisian coast	This study

that HSI values increase with size. The highest values were recorded in the largest specimens and were significantly different (t-test = 13.41, df = 47, $P < 0.01$), similar observations were recorded between TL and the gonadosomatic index, GSI (Fig. 6), and between TL and condition, K (Fig. 7), with t-test = 7.37, df = 47, $P < 0.05$ for the former, and t-test = 67.71, df = 47, $P < 0.05$ for the latter.

Additionally, the relationship between TL and total body weight (TBW) was:

$\log TBW = 3.09 \times \log TL - 5.88$ ($r = 0.96$, $n = 48$) (Fig. 8).

Diet

Of the 48 stomach examined for contents, 29 were empty, and the assessed vacuity index (VI) was relatively high, reaching 60.41 %. 19 items in all were found in the stomach contents. They were already partially digested, therefore the species-level identification was difficult; nevertheless, remains of crustaceans and osteichthyans were observed (Tab. 3).

Crustaceans were the preferential prey with %IRI = 98.85, osteichthyans were secondary with %IRI = 1.14. Additionally, crustaceans constituted the most important prey items in term of abundance (%N = 89.47), frequency of occurrence (%F = 89.47) and biomass (%W = 92.64). The TROPH value calculated for *G. mystax* was 3.51 ± 0.6.

DISCUSSION

The morphology, morphometric measurements, meristic counts and colour of all available *Gnathophis mystax* found in northern Tunisian waters were in total agreement with Albuquerque (1954-1956), Saldanha (1967), Bauchot & Saldanha (1986), Aboussouan (1994), Louisy (2002) and Quéro *et al.* (2003). Such records confirm the occurrence of the species in the study area. Also, some measurements, such as pre-dorsal length, pre-anal length, pectoral length and pre-pectoral length, are correlated with size; b values, however, were < 3, displaying negative allometries. Since the species lives burrowed into muddy bottoms, it is less prone to long-distance migrations, its snake-like morphology allows it to move covered by mucous around its habitat, and the use of fins is not fundamental.

G. mystax inhabits deep marine areas (Bauchot & Saldanha, 1986; Casadevall & Matallanas, 1990), as are those close to the shore of the northern Tunisian coast (Castany, 1955; Ben Mustapha, 1966). The Gulf of Gabès in the south, on the other hand, is a very shallow basin with an underwater depth of less than 50 m extending as far as 110 km off the coast, and the 200 m isobath runs at a distance of 250-400 km away from the coast (Seurat, 1934; Ben Othman, 1971). Such ecological parameters could explain why *G. mystax* is more frequently caught off the northern Tunisian coast (Bradai *et al.*, 2004). Additionally, according to the information given by Tunisian fishermen, the species is discarded at sea due to its low commercial value and thus rarely found in local fishery landing sites or fish markets, as confirmed by the sample studied in the present paper, which only comprised 48 specimens. For the time being, the species is not considered as threatened and, following Papaconstantinou et al. (2011), is probably still present in all the areas where it has been previously recorded, including Tunisian waters.

Tab. 3: Diet composition for total sample of** G. mystax **caught off the northern Tunisian coast. Legend: %N - percentage by number, %W - percentage by weight, %F - percentage by occurrence, %IRI - index of relative importance.
Tab. 3: Sestava prehrane dolgonosih ugorjev, ujetih ob severnotunizijski obali. Legenda: %N - delež števila primerkov plena, %W - delež mase, %F - frekvenca pojavljanja, %IRI - indeks relativne pomembnosti plena.

Prey items	%N	%W	%F	%IRI
Crustaceans	89.47	92.64	89.47	98.85
Osteichthyans	10.52	7.35	10.52	1.14

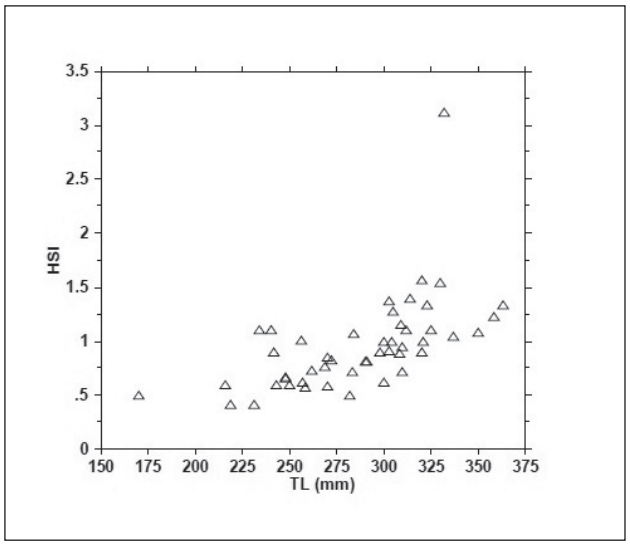

Fig. 5: Total length (TL)** vs. **hepatosomatic index (HSI) for the studied sample of** G. mystax**.
Sl. 5: Odnos med celotno dolžino (TL) in hepatosomatičnim indeksom (HSI) pri vzorcu dolgonosih ugorjev

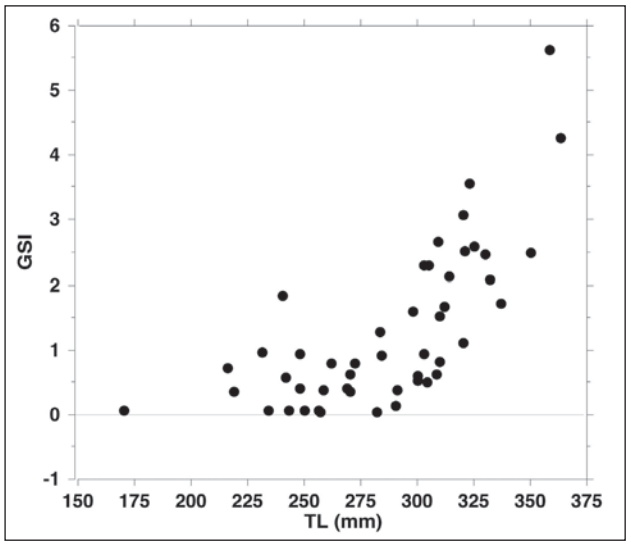

Fig. 6: Total length (TL)** vs. **gonadosomatic index (GSI) for the studied sample of** G. mystax**.
Sl. 6: Odnos med celotno dolžino (TL) in gonadosomatičnim indeksom (HSI) pri vzorcu dolgonosih ugorjev

The values of HSI, GSI and K of G. mystax increased with size; the well-correlated growths suggest that the species had sufficient food available in its life area to develop (Froese *et al.*, 2011). Additionally, a larger liver may allow both males and females to maximize gonadal production, as shown by the concomitant increase of GSI values in larger specimens. The high values of K and the positive allometry calculated from the total length vs. to-

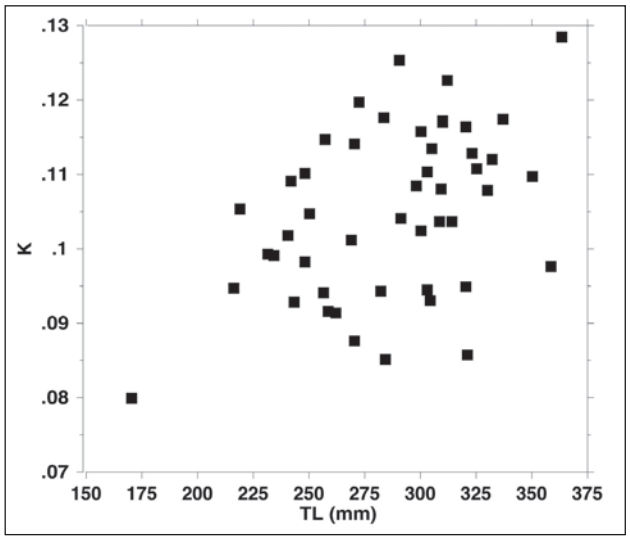

Fig. 7: Total length (TL)** vs. **condition factor (K) for the studied sample of** G. mystax**.
Sl. 7: Odnos med celotno dolžino (TL) in indeksom kondicije (K) pri dolgonosih ugorjih

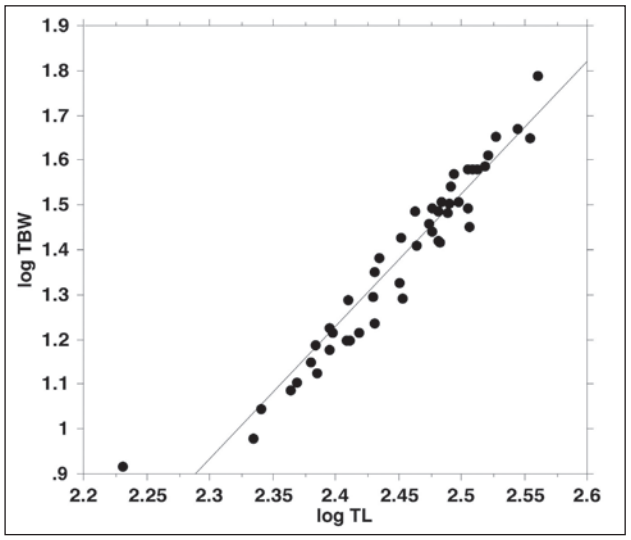

Fig. 8: Relationship between total length (TL) and total body weight (TBW) expressed in logarithmic co-ordinates for the studied sample of** G. mystax**.
Sl. 8: Odnos med celotno dolžino (TL) in celokupno maso (TBW) (izražen v logaritemskih vrednostih) pri dolgonosih ugorjih

tal body weight relationship could confirm such pattern.

Conversely, VI displayed a high value in total accordance with Casadevall & Matallanas (1990), which could be accounted for by the manner of sampling, by the type of biological environment, by the fact that the preys were unavailable in both bottom and in the water column, and fishing methods cannot be ruled out either. All the specimens sampled off the northern Tunisian coast were caught by trawling and generally spent quite some time in the nets before being landed; the prey they had consumed had thus been completely digested and their stomachs were found empty when analysed. This hypothesis was corroborated by the unidentifiable remains of digested prey items found inside the stomachs. Two zoological groups were recorded in the stomach contents, crustaceans and osteichthyans, confirming observations of previous studies carried out in other marine areas. However, Rucabado *et al*. (1978), Casadevall & Matallanas (1990) and Carpentieri *et al*. (2007) discovered other preys, such as annelids, bivalves, cephalopods and echinoderms, probably because their sample was larger than ours; furthermore, ontogenic changes are probably related to the biological environment and therefore prey availability.

The TROPH value of the sampled *G. mystax* was 3.51 ±0.6, close to that estimated by Stergiou & Karpouzi (2002), which ranged between 3.42 and 3.62. It follows that *G. mystax* is a carnivorous species playing a major role in the regulation of marine ecosystems; it is a top predator just like the elasmobranch species and many marine mammals with a TROPH ranging between 3.10 and 4.74 (Cortés, 1999) and 3.20 and 4.50 (Pauly *et al*., 1998), respectively. *G. mystax* exploits similar resources as other high-level marine consumers of the area, but since it dwells at greater depths, the pressure of competition for food is probably avoided, especially since its closely related species of conger eel (*Conger conger)*, which forages the same prey items, inhabits shallow coastal waters with a rocky bottom and a depth ranging from 0 to 100 m (Bauchot & Saldanha, 1986).

OPAZOVANJA DOLGONOSEGA UGORJA *GNATHOPHIS MYSTAX* (OSTEICHTHYES: CONGRIDAE) OB TUNIZIJSKI OBALI (OSREDNJE SREDOZEMLJE)

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POVZETEK

*Avtorji poročajo o nekaterih morfoloških vidikih, morfometričnih in merističnih meritvah ter barvnem vzorcu razpoložljivih primerkov dolgonosega ugorja (*Gnathophis mystax*) v severnotunizijskih vodah. Nekatere meritve, kot npr. razdalja do hrbtne plavuti, razdalja do zadnjične plavuti, razdalja do prsne plavuti in razdalja do trebušne plavuti, so povezane z velikostjo, vendar kaže vrednost b < 3 na negativno alometrično rast. Avtorji so ugotovili premosorazmerno korelacijo med hepatosomatičnim indeksom (HIS) in celotno dolžino telesa. Podobno povezanost so ugotovili med gonadosomatičnim indeksom (GSI) in dolžino telesa ter kondicijskim indeksom (K). Pregledali so tudi 48 želodcev, od katerih je bilo 29 praznih. V želodcih so našli 19 različnih skupin plena, ki pa je bil že delno prebavljen.*

Ključne besede: *Gnathophis mystax*, morfologija, meristika, hepatosomatični indeks, gonadosomatični indeks, prehrana

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RECENT RECORD OF THE SERPENT EEL *OPHISURUS SERPENS* (PISCES: OPHICHTHIDAE) IN THE GULF OF TRIESTE (NORTHERN ADRIATIC SEA)

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ABSTRACT

On 19th November 2015 one specimen of serpent eel Ophisurus serpens *(Linnaeus, 1758) (Ophichthidae) was caught by fishermen in the Gulf of Trieste. This species could be considered as exceptionally rare in the northernmost area of the Adriatic Sea, because it was recorded only once in the last hundred years.*

Keywords: serpent eel, *Ophisurus serpens*, Gulf of Trieste, northern Adriatic Sea.

RECENTE SEGNALAZIONE DEL PESCE SERPENTE *OPHISURUS SERPENS* (OPHICHTHIDAE) NEL GOLFO DI TRIESTE (ALTO ADRIATICO)

SINTESI

Il 19 novembre 2015 un esemplare di pesce serpente Ophisurus serpens *(Linnaeus, 1758) (Ophichthidae) è stato catturato dai pescatori nel Golfo di Trieste. Questa specie può essere considerata eccezionalmente rara nell'area più settentrionale del Mare Adriatico, in quanto è stata segnalata solamente una volta nell'arco di un secolo.*

Parole chiave: pesce serpente, *Ophisurus serpens*, Golfo di Trieste, Alto Adriatico

INTRODUCTION

The serpent eel *Ophisurus serpens* (Linnaeus, 1758) (family Ophichthidae) is a marine, brackish, reef-associated and benthic species living from shallow waters to depths of 300 m (Bauchot, 1986). The serpent eel buries its body and exposes only the head in sandy or muddy bottoms, feeding mainly on benthic invertebrates and fish (Bauchot, 1986; Froese & Pauly, 2015). It is a cosmopolitan species, widely distributed in the Atlantic Ocean (northern coast of Iberian peninsula to South Africa, and also Madeira) and the Indo-Pacific Ocean (southern Mozambique to South Africa; north to Japan, south to Australasia) (Bauchot, 1986).

In the Mediterranean Sea, *O. serpens* has been reported from Greece, western Aegean Sea (Stergiou *et al*., 1997); the Tuscan and Latium coasts of Italy (Biagi *et al*., 2002); the Alboran Sea (Abad *et al*., 2007); the Ligurian Sea (Relini *et al*., 2007); the Tunis Southern Lagoon (Ben Amor *et al*., 2009); and the northwestern Ionian Sea (Maiorano *et al*., 2010). Moreover, Borges *et al*. (2003) recorded 6 specimens of *O. serpens* from the Algarve coast (southern Portugal), near the Gibraltar Strait.

This species is very rare in the Adriatic Sea, where it lives between 30 and 400 m depth on sandy and sandy-muddy bottom (Jardas, 1996). The last record was dated to 2005, when 18 specimens were caught in the eastern central Adriatic (Dulčić *et al*., 2005).

After Perugia (1866), who reported on this species in the harbor of Trieste in 1866, the present paper represents the most recent record of this species for the Gulf of Trieste, the northernmost area of the Adriatic Sea.

MATERIAL AND METHODS

One specimen of *Ophisurus serpens* was caught on 19th November 2015, using a hydraulic dredge for the harvesting of the bivalve *Ensis minor* (Chenu, 1843). The fishermen photographed the specimen by a mobile phone (Fig. 1) and subsequently released it alive. *O. serpens* can be easily distinguished from all other Mediterranean snake eels by its very long snout, its slender and elongate jaws that are incapable of closing completely in adults, the presence of temporal, post-orbital and interorbital pores, and the absence of a caudal fin with a hard caudal tip (McCosker, 1977; Smith & McCosker, 2008). These characteristics, in particular the presence of pores, were immediately observed by fishermen on board, thus confirming the species identification of the specimen.

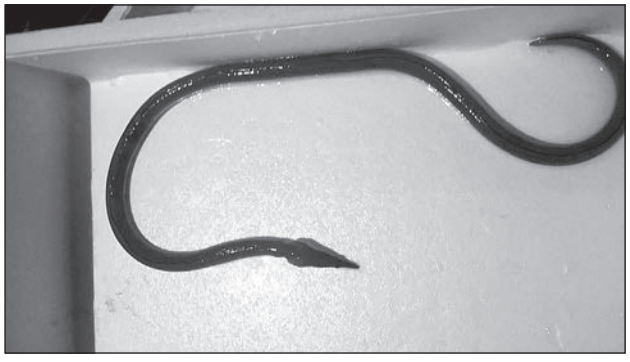

Fig. 1: Ophisurus serpens caught in the Gulf of Trieste (Photo: L. Lian).
Sl. 1: Primerek zobate jegulje iz Tržaškega zaliva (Foto: L. Lian).

RESULTS AND DISCUSSION

The capture site of *Ophisurus serpens* was located in front of Sant'Andrea Island (Fig. 2) at a depth of approximately 3 m, on sandy bottom. Due to the release of the specimen, it was not possible to get the main morphometric data. We can only estimate a total length of about 50 cm from Fig. 1, because the expanded polystyrene box used for fish packaging is 50 cm in length. McCoster & Castle (1986) reported that maximum length for this species is 250 cm (as total length TL), whereas Jardas (1996) noted a maximum TL of 240 cm, although usual TL in catch ranged between 50 and 150 cm.

The serpent eel could be considered as a relatively rare species in the Adriatic Sea, but fishing gear for providing target species must be taken into account when considering their rarity (Dulčić *et al*., 2005). Most of

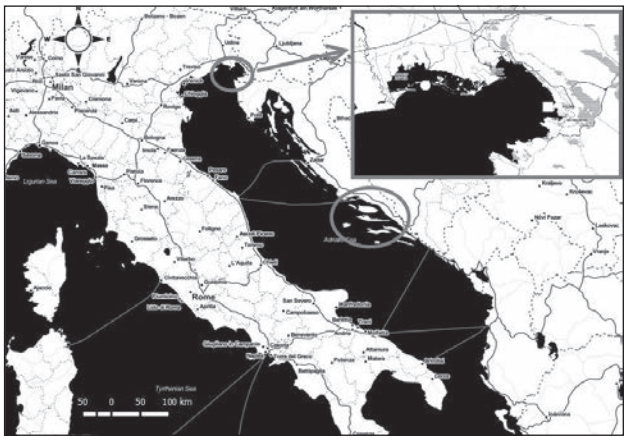

Fig. 2: Records of O. serpens in the Adriatic Sea: ○ present record in the Gulf of Trieste, □ record of Perugia (1866) in the harbour of Trieste. Data in the eastern Adriatic are also presented. See Dulčić et al. (2005) for the details of localities.
Sl. 2: Podatki o pojavljanju zobate jegulje v Jadranskem morju: ○ novi podatek za Tržaški zaliv, □ podatek o najdbi, ki jo navaja Perugia (1866) v tržaškem pristanišču. Označeni so tudi podatki o pojavljanju zobate jegulje v vzhodnem Jadranu. Podatke o natančnih lokalitetah navajajo Dulčić s sodelavci (2005).

the fishing gear could be inappropriate to catch a species living buried with only its head exposed. In fact all catches in the eastern Adriatic were done only by long line (Dulčić *et al*., 2005). The present specimen was caught by an hydraulic dredge able to eject water under pressure (1.2–2.5 bar), easing the advancement of the gear and the harvesting of buried species (Romanelli *et al*., 2009), such as in the case of *O. serpens*. The present record is the first official for the northern sector of the Adriatic Sea after the historical record of Perugia (1866), who reported on a specimen caught in the harbor of Trieste and deposited in the museum -"Civico Museo Ferdinando Massimiliano" in Trieste. Following the definitions for degrees of rarity suggested by Morović (1973), this species could be considered as exceptionally rare in the Gulf of Trieste, because this fish was recorded only once in the last hundred years (Bello *et al*., 2014). In addition, the present record represents the northernmost one for the Mediterranean, and the most recent for this basin are those of Ulaș & Akiol (2015) and Filiz *et al*. (2015) in the Turkish waters of the Aegean Sea. This record of *O. serpens* in the Gulf of Trieste confirms the precious collaboration with fishermen, who are daily involved in the marine environment, and often are the first to meet rare and/or alien species, especially fish and crabs. Without their contribution a lot of occurrences would have passed unnoticed (Azzurro *et al*., 2013).

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NOV ZAPIS O POJAVLJANJU ZOBATE JEGULJE *OPHISURUS SERPENS* (PISCES: OPHICHTHIDAE) V TRŽAŠKEM ZALIVU (SEVERNI JADRAN)

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Devetnajstega novembra 2015 so ribiči v Tržaškem zalivu ujeli primerek zobate jegulje Ophisurus serpens *(Linnaeus, 1758) (Ophichthidae). Ta vrsta je v najsevernejšemu delu Jadrana izjemno redka, saj je bila pred tem v zadnjih sto letih samo enkrat ulovljena.*

Ključne besede: zobata jegulja, *Ophisurus serpens*, Tržaški zaliv, severni Jadran.

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ADDITIONAL RECORD OF COMMON BREAM *ABRAMIS BRAMA* (CYPRINIDAE) IN THE ADRIATIC DRAINAGE SYSTEM (NORIN RIVER, CROATIA)

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ABSTRACT

On 14 March 2015 an adult specimen of common bream Abramis brama *was caught with fish trap in Norin River (right bank tributary of the Neretva River, Adriatic drainage system, near settlement Vid, Croatia). This represents the second record of this species for the Adriatic drainage system in Croatia.*

Key words: Cyprinidae, *Abramis brama*, Adriatic drainage system, Croatia

NUOVE SEGNALAZIONI DELL'ABRAMIDE COMUNE *ABRAMIS BRAMA* (CYPRINIDAE) NEL SISTEMA DI DRENAGGIO ADRIATICO (FIUME NORIN, CROAZIA)

SINTESI

*Il 14 marzo 2015 un esemplare adulto dell'abramide comune (*Abramis brama*) è stato catturato con una nassa nel fiume Norin (affluente della riva destra del fiume Neretva, sistema di drenaggio dell'Adriatico, vicino al villaggio di Vid, in Croazia). Questa cattura rappresenta la seconda segnalazione della specie nel sistema di drenaggio adriatico in Croazia.*

Parole chiave: Cyprinidae, *Abramis brama*, sistema di drenaggio dell'Adriatico, Croazia

INTRODUCTION

The common bream, *Abramis brama* (Linnaeus, 1758) (Cyprinidae), inhabits most European drainages from Adour (France) to Pechora (White Sea basin); Aegean Sea basin, in Lake Volvi and Struma and Maritza drainages (Kottelat & Freyhof, 2007). It is not native to Iberian Peninsula, Adriatic basin, Italy, Scotland, and Scandinavia north of Bergen (Norway) and 67 °N (Finland). It is locally introduced in Ireland, Spain, north-eastern Italy, from Marmara basin (Turkey) and eastward to Aral basin, in Lake Baikal and upper Ob and Yenisei drainages (Kottelat & Freyhof, 2007). In Croatia, this species is found only in the waters of the Black Sea drainage system (Glamuzina *et al*., 2013).

MATERIAL AND METHODS

On 14 March 2015 an adult specimen (Fig. 1) of common bream was caught with fish trap in Norin River (right bank tributary of the Neretva River, Adriatic drainage system, near settlement Vid, Croatia) (43.081644 °N, 17.629486 °E). This represents the second record of this species for the Adriatic drainage system in Croatia.

RESULTS AND DISCUSSION

The first record of the common bream for the Adriatic drainage system (Mala Neretva River, wider area of Neretva River estuary, Croatia) was on 17 April 2010 (male, total length = 43.8 cm, weight = 1047 g) (Bartulović *et al*., 2010).

One question could arise after this additional record in the wider area of Neretva River estuary: "Has this species established a population?" Although there is still no evidence of a permanent population in the study area (not enough available reports confirmed on a scientific basis), the capture described here might be an indication of that since some fishermen have signalled the species in some parts of Neretva river delta during 2015 (Dugandžić, *pers. comm*.). The only possible explanation for such record is a not sufficiently controlled introduction (in this case of a non-native species).

The common bream has been introduced to the Neretva River and now represents a potential threat to the natural equilibrium of their community. This species may develop stunted high density populations becoming locally abundant, with potential negative consequences both within and beyond the local fish community due to competition for food resources or hybridization (Bartulović *et al*., 2010). Furthermore, common bream often has a pronounced migratory behaviour and may consequently perform considerable distances to lakes within a river system (Volta *et al*, 2013). Successful non-native species are often characterized by high physiological tolerance and functional characteristics different from those of the members of invaded communities and have been reported to affect the functional diversity of communities with possible strong impacts on food webs and ecosystem functioning (see Bartulović *et al*., 2010). These features make the common bream a potentially effective and highly undesirable invader of southern European waters (see Volta *et al*, 2013).

It is quite clear that non-native species can have significant effects on the composition of entire communities by displacement of local species with similar trophic level, by altering the behaviour or habitat selection of prey, resulting in a significant disturbance of the local communities interactions (Cucherousset & Olden, 2011). However, at this point it is not known to what

Fig. 1: (Left) *Abramis brama* ***caught in Norin River (Croatian coast, Adriatic drainage system); (right) male, with nuptial tubercles on the head. (Photo: B. Markota)***
Sl. 1: Ploščič (*Abramis brama****), ujet v reki Norin (hrvaška obala, jadransko povodje) (levo); samec, dobro vidni paritveni grebenčki na glavi (desno). (Foto: B. Markota)***

extent the occurrence of the common bream in the Neretva watershed is related to environmental quality and to natural biodiversity. Therefore it is evident that understanding on all aspects of the invasion process, from introduction to the establishment, spread and impacts is still required.

Prevention measures should be taken by the administration to avoid the spreading of this species to other reservoirs and river basins. Eradication of introduced fish is practically impossible in large freshwater ecosystems, so prevention of further introductions and translocations is of primary concern.

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NOVI PODATEK O POJAVLJANJU PLOŠČIČA (*ABRAMIS BRAMA,* CYPRINIDAE) V JADRANSKEM POVODJU (REKA NORIN, HRVAŠKA)

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POVZETEK

*14. marca 2015 je bil v ribiško mrežo ujet odrasel primerek ploščiča (*Abramis brama*) v reki Norin (jadransko povodje, desni pritok reke Neretve pri naselju Vid, Hrvaška). Gre za drugi primer pojavljanja te vrste v jadranskem povodju na Hrvaškem.*

Ključne besede: Cyprinidae, *Abramis brama*, jadransko povodje, Hrvaška

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FAVNA

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CONTRIBUTION TO THE FAUNA OF SCARABAEOIDEA (COLEOPTERA) OF CRES ISLAND, CROATIA

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ABSTRACT

The first recent overview of the Scarabaeoidea of the Croatian island of Cres is presented. The material for this survey was collected during several field trips organized between 2011 and 2014. A total of 44 species were recorded, 21 of which represent first records for the area. With the records of 10 additional species found in the literature, the number of species known to occur on Cres is 54.

Key words: dung beetles, diversity, *Osmoderma eremita, Lucanus cervus*

CONTRIBUTO ALLA CONOSCENZA DELLA FAUNA DEGLI SCARABAEOIDEA (COLEOPTERA) SULL'ISOLA DI CHERSO, CROAZIA

SINTESI

L'articolo presenta una prima panoramica recente della fauna degli Scarabaeoidea sull'isola croata di Cherso. Per l'indagine il materiale è stato raccolto nel corso di diversi lavori sul campo organizzati tra il 2011 e il 2014. In totale sono state trovate 44 specie, di cui 21 sono state registrate per la prima volta in quest'area. Durante l'analisi della letteratura disponibile sul tema, gli autori hanno trovato le segnalazioni di 10 altre specie, pertanto il numero totale di specie confermate per l'isola di Cherso è al momento pari a 54.

Parole chiave: scarabei stercorari, diversità, *Osmoderma eremita*, *Lucanus cervus*

INTRODUCTION

The Scarabaeoidea (formerly known as Lamellicornia) is a superfamily of beetles belonging to the suborder Polyphaga. This diverse superfamily consists of more than 35 000 species described to date, distributed in all continents except Antarctica. The Scarabaeoidea can be easily recognized by the presence of clubbed antennae, the apical segments of which are in the form of lamellae of variable size (Ballerio *et al*., 2010).

A large part of this superfamily consists of dung beetles. Traditionally, dung beetles are defined as coprophagous members of the Coleopteran families Aphodiidae, Scarabaeidae and Geotrupidae (Halffter & Matthews, 1966). Most species consume dung as a primary source of food and utilize it as a nesting resource, and as such, they are key providers of several ecological services such as waste removal, secondary seed dispersal and vertebrate parasite suppression (Mathison & Ditrich, 1999; Andresen & Feer, 2005; Horgan, 2005). Feeding on vertebrate dung makes dung beetles likely to be influenced by changes in mammal communities, *e.g.* the abandonment of pastures has a big influence on communities of dung beetles (Estrada *et al*., 1999). Furthermore, veterinary treatments have one of the most harmful effects on dung beetle communities that feed on dung, especially the anti-parasitic compounds in the faeces of domestic livestock. In particular, Ivermectin, a broad-spectrum veterinary drug, reduces species diversity and increases the dominance of certain species (Wall & Strong, 1987; Lumaret *et al*., 1993; Lumaret*,* 1994; Krüger & Scholtz, 1996). Because of their ecology, dung beetles are useful as bioindicators for investigating the anthropogenic impact on ecosystems (Halffter & Matthews, 1966; Halffter & Edmonds, 1982; Hanski & Cambefort, 1991).

The beetle fauna of the Adriatic islands has been investigated as early as the beginning of the 19th century; however, most records were collected sporadically, and unsystematically. The best source of information for all the Adriatic islands is probably the masterwork of Petar Novak (Novak, 1952, 1964) who compiled all available published and unpublished references and manuscripts till the middle of the 20th century, along with a great number of data from his entomological collection, and the collections of his contemporaries. More than 60 years since then, his book still remains the richest source of information for most of the Adriatic islands (Novak, 1952). In the last few decades, new data about island beetle fauna have been published for only a few islands: Kornati and Murter (Vujčić-Karlo *et al*., 1995) and Kornat, Lavsa and Žut (Koren *et al*., 2010).

Here we present the results of the first recent survey of the superfamily Scarabaeoidea on the northern Adriatic island of Cres. Our goal is to: (i) present the results of the recent survey of the area, (ii) create a checklist of the Scarabaeoidea of the area and (iii) discuss new records of interesting or rare species. Overall, the main goal is to contribute to the knowledge of the superfamily Scarabaeoidea of Croatia.

MATERIAL AND METHODS

Study area

Cres is located in the northern part of the Adriatic Sea, and is the largest island in the Adriatic (405.70 km^2) (Duplančić *et al*., 2004). It is about 66 km long and 12 km wide at the widest part. The island is influenced by both the Mediterranean and continental climate (Stražičić, 1981). The northern part of Cres has a submediterranean climate, while the central and southern parts have the true Mediterranean climate, where hot, dry summers and wet winters prevail (Stražičić, 1981).

Geologically, Cres represents the unsubmerged part of the Mt. Učka mountain range, which decreases in altitude from the northern to the southern part of the island. The highest peak on the island is Gorice (648 m a.s.l.). In the central part of Cres, there is a freshwater lake known as Vransko jezero, which is the biggest freshwater lake in the Adriatic archipelago. The main geological basal rocks on the island consist of Cretaceous limestone and dolomites (Stražičić, 1981).

As regards vegetation composition, Cres can be divided into three parts. The northern part is covered by mixed deciduous forests of *Quercus pubescens*, *Carpinus orientalis* and *Ostrya carpinifolia* (Klepac *et al*., 1993). The largest forest on the island is named Tramuntana and is located in the northern part of Cres, from the village of Križić to cape Jablanac (Stražičić, 1981). In the central part, only forest fragments remain, and the habitat includes mostly karst and stony pastures. The southern part of the island is covered by Eu-Mediterranean evergreen forests and karst grasslands and pastures (Stražičić, 1981). Forests are the most common habitat type and cover 38% of the island's surface area. Pastures are grazed mostly by sheep, while horses and donkeys are also present on the island. Many large wild vertebrate species are present on the island, including the wild boar (*Sus scrofa*), roe deer (*Capreolus capreolus*), fallow deer (*Dama dama*) and muflons (*Ovis musimon*), most of which have been introduced on the island.

Scarabaeoidea survey

This field work took place throughout the island, particularly in the northern and central parts. We visited 16 sample sites between 2011 and 2014 (Fig. 1). Dung beetles were collected manually from vertebrate dung. Other scarabs were collected mostly unsystematically using hand and net collecting from flowers, trees, tree trunks and tree hollows. To collect additional species, pyramid light traps were used at several localities. Scarabaeid beetles that could not be identified in the field were sacrificed and later identified at the laboratory

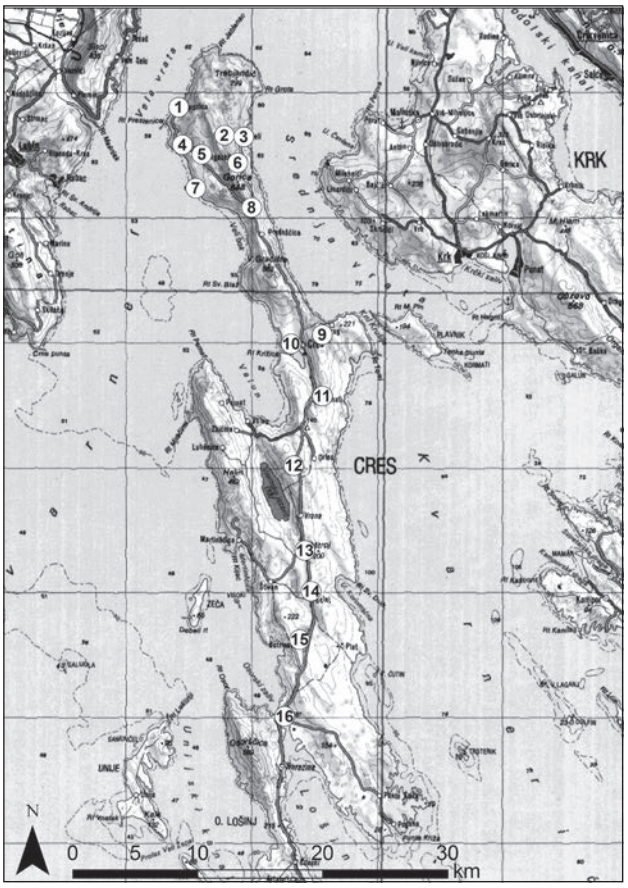

Fig.1: Map of surveyed localities on Cres Island.
Sl. 1: Zemljevid vzorčenih lokalitet na otoku Cres.

using standard identification keys (Mikšić, 1958; Baraud, 1992 and Ballerio *et al*., 2010). All the collected beetles are stored in the private insect collections of the authors. The nomenclature follows Ballerio *et al*. (2010), while zoogeographic affiliation is according to Brelih *et al*. (2010). Additional data about the Scarabaeoidea fauna of Cres was found in several papers (Müller, 1923; Novak, 1952, 1964; Pittino, 1991; Ranius *et al*., 2005; Harvey *et al*., 2011).

RESULTS AND DISCUSSION

During this survey we recorded a total of 44 species belonging to the superfamily Scarabaeoidea, of which 31 species belong to dung beetles (Scarabaeidae: Aphodiinae, Scarabaeinae and Geotrupidae). With the records of additional species found in the literature, the known number of species is 54 (Tab. 2). Most recorded species have a Turanic-European (8), Palearctic (7) or Asian-European (6) distribution. As many as 22 recorded species have some kind of Mediterranean distribution patterns (*e.g.* strictly Mediterranean, east Mediterranean etc.).

The recorded number of species represents about 25% of the known members of the superfamily Scarabaeoidea known from Croatia (Mikšić, 1970). With this in mind, more species records are to be expected, but with no complete overview of the Scarabaeoidea of the Adriatic islands, it is impossible to guess how many species on average inhabit each island. How poorly Cres was surveyed in the past is revealed by the fact that 21 species recorded during this survey represent first records for the island. What is necessary to emphasize is that during this survey we concentrated mostly on the dung beetle fauna and all other species were collected only occasionally and unsystematically; and this is visible in the results as some of the common species (*e.g. Amphimallon solstitiale* (Linnaeus, 1758)) were not recorded during this study. However, we found that the inclusion of additional records from the family Scarabaeoidea would be beneficial, and give a more comprehensive picture about the beetle fauna of the island. With only limited literature data about the Scarabaeoidea of Cres (Müller, 1923) any meaningful comparison with the historical data is not plausible. For some species, this area represents their northern distribution border, and they are accordingly rarer (*e.g. Bubas bison* (Linnaeus, 1767), *Scarabaeus* (*Scarabaeus*) *typhon* (Fischer von Waldheim, 1823). One such species, *S. typhon*, was recorded only once during this survey, and the record was based on a dead individual. This is one of the largest species of the genus *Scarabaeus* in Croatia. It is primarily coprophagous, but occasionally also necrophagous (Ballerio *et al*., 2010). Adults are active from early spring to autumn. We searched for this species in the same locality several times, at different vegetation seasons but we were unsuccessful. In Croatia, it is distributed from the southern part of Istria, across the Adriatic islands to the southernmost parts of Dalmatia (Mikšić, 1970). Based on our experience, this species is presently very local and rare in Croatia, but can also be relatively common in some localities (*e.g.* the surroundings of river Zrmanja or on the island of Pag). For any meaningful conclusions, the current knowledge about the distribution of the genus *Scarabaeus* in Croatia needs updating, as many species records are based on a very small number of observations (see Mikšić, 1958, 1970), most of which are not confirmed.

Based on our results, it appears that the dung beetle fauna of Cres is very diverse. The major food source for the scarab beetles on the island is sheep dung. Since sheep dung is usually very small in surface area, it is greatly influenced by high temperatures. As a result, sheep dung dries rapidly. This prevents most of the dung beetles from feeding on sheep dung. This is most obvious during the summer months (June-August), when we visited many locations, but were unable to find any dung beetles due to the fact that all the excrements were dry. As a result, in summer months we were able to collect at only three of more than ten visited locations. And since sheep are the

Tab. 1: List of surveyed localities.
Tab. 1: Seznam vzorčenih lokalitet.

No.	Locality	Habitat	Dung type	Dates of findings	Lat. (N)	Long. (E)
1.	Porozine harbour	xerotermophilous slopes and forest edge	/	21.5.2011	45.132588	14.288063
2.	Beli, Tramuntana forest	grassland surrounded by mixed forest, with occasional bushes	sheep	17.4.2011, 21.4.2011, 15.6.2011, 7.7.2011, 14.4.2012, 17.4.2013, 30.8.2013, 3.10.2013, 21.11.2013	45.112663	14.334926
3.	Beli village surroundings	rocky pasture with bushes	sheep	17.4.2011, 19.4.2011, 15.6.2011, 14.4.2012	45.111634	14.354582
4.	Filozići village	stony karst grassland with small patches of trees	sheep	19.3.2014	45.105544	14.292301
5.	Dragozetići village	karstic pasture	sheep	19.3.2014	45.098815	14.312048
6.	Sv. Petar village	forest path with small grassland clearings	sheep	21.5.2011	45.092853	14.348487
7.	Predošćica village	karst grassland	sheep	9.5.2012	45.074421	14.306250
8.	Road to Beli, near the clifs	rocky pasture with bushes	sheep	21.11.2013	45.060790	14.363079
9.	Merag, 1,5 km SW of the harbour	karstic pasture	sheep, horse	17.4.2013, 11.5.2013	44.969600	14.435610
10.	Cres city surroundings	olive grows with grassy undergrowth	sheep	21.5.2011, 19.3.2014	44.962874	14.404268
11.	Loznati, 200 m E of the village	rocky karstic pasture	sheep	11.5.2013, 19.3.2014	44.925439	14.436275
12.	Zbišina, 1 km N of the village	karstic pasture	sheep	20.6.2013	44.875213	14.407711
13.	Hrasta village	karstic pasture	sheep	19.3.2014	44.814127	14.419507
14.	Belej village surroundings	karstic pasture	sheep	20.3.2014	44.784898	14.426039
15.	Ustrine village	karstic pasture	sheep	20.3.2014	44.750044	14.414820
16.	Osor, near the village	dry karstic pasture, bushy vegetation	donkey	20.3.2014	44.694649	14.400351

main source of dung on the island, this could present a problem for the survival of dung beetles.

In the past, other livestock such as cows, donkeys and horses were more common on Cres, as well as on other Adriatic islands, but are now rapidly disappearing. The only exceptions are the islands offering significant tourism services, where such animals are still kept for meat or cheese production. Also, on some islands, horses are becoming more common, again because of tourism. These practices may indeed conserve dung beetle populations on the Adriatic islands, but for the populations on some of the smaller islands (*e.g. Šćedro*, *Čiovo*) the livestock has almost completely disappeared. On the other hand, the situation on the island of Cres there is even more interesting, due to the several large herbivores that were introduced to the island (mentioned in the introduction). These species, along with the present livestock, should allow for the survival of dung beetles on the islands.

Negative practices that are becoming common in Dalmatia (*e.g.* destruction of entire karst pastures and grasslands and converting them into arable land or vineyards) were not observed on Cres.

Apart from the dung beetles, two other interesting members of the Scarabaeoidea superfamily were recorded during this survey; both were previously recorded for the island (Ranius *et al.*, 2005; Polak, 2006; Harvey *et al.*, 2011). These two species are of a particular in-

Tab. 2: Species recorded on the island of Cres (* Species recorded in the area for the first time; **Numbers of localities correspond to those given in Tab. 1.).
Tab. 2: Zabeležene vrste na otoku Cres (* prvič zabeležene vrste na raziskanem območju; ** število lokalitet ustreza številom v Tab. 1.).

No.	List of species	Locality numbers**	Literature records	Biogeography
GEOTRUPIDAE Latreille, 1802				
1.	*Anoplotrupes stercorosus* (Scriba, 1791)*	2, 14	/	European-Siberian
2.	*Geotrupes* (*Geotrupes*) *mutator* (Marsham, 1802)	/	Müller (1923), Novak (1952)	Turanic-European
3.	*Geotrupes* (*Geotrupes*) *puncticollis* Malinowsky 1811	2, 11	Novak (1964)	Turanic-European
4.	*Jekelius* (*Jekelius*) *brullei* (Jekel, 1866)	2, 4, 5, 14	Müller (1923), Novak (1952)	Mediterranean
5.	*Trypocopris* (*Trypocopris*) *vernalis* (Linnaeus, 1758)*	2, 3, 4, 5, 11	/	European species
SCARABAEIDAE Latreille, 1802				
SCARABAEINAE Latreille, 1802				
6.	*Bubas bison* (Linnaeus, 1767)	/	Müller (1923), Novak (1952)	West Mediterranean
7.	*Caccobius schreberi* (Linnaeus, 1758)	2	Müller (1923), Novak (1952)	Turanic-European-Mediterranean
8.	*Copris lunaris* (Linnaeus, 1758)	11	Müller (1923), Novak (1952)	Asian-European
9.	*Euonthophagus amyntas* (Olivier, 1789)	10, 11	Müller (1923), Novak (1952)	Asian-European
10.	*Euoniticellus fulvus* (Goeze, 1777)*	2, 4, 5, 6, 12, 14	/	Palearctic
11.	*Gymnopleurus geoffroyi* (Fuessly, 1775)*	11	/	European-Mediterranean
12.	*Onthophagus coenobita* (Herbst, 1783)	2, 9, 10, 11	Müller (1923), Novak (1952)	Turanic-European
13.	*Onthophagus fracticornis* (Preyssler, 1790)	2, 3, 4, 5, 9, 10, 11, 12, 15	Müller (1923), Novak (1952)	Siberian-Turanic-European
14.	*Onthophagus grossepunctatus* Reitter, 1905*	2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 13, 14, 15, 16	/	Southern and central European
15.	*Onthophagus lemur* (Fabricius, 1781)	2, 3, 4, 5, 6, 7, 9, 10, 11, 12, 13, 14, 15, 16	Müller (1923), Novak (1952)	Turanic-European
16.	*Onthophagus ruficapillus* Brullé, 1832*	6	/	Turanic-European
17.	*Onthophagus verticicornis* (Laicharting, 1781)*	2, 6, 7, 9, 11	/	Turanic-European
18.	*Onthophagus medius* Kugelan 1792*	10, 11, 13, 14	/	Asian-European
19.	*Onthophagus furcatus* (Fabricius, 1781)	2, 7, 9 ,11	Müller (1923), Novak (1952)	Turanic-European-Mediterranean
20.	*Onthophagus taurus* (Schreber, 1759)*	2, 3, 8, 11, 12	/	Palearctic
21.	*Scarabaeus variolosus* Fabricius, 1787	6, 9	Müller (1923), Novak (1952)	Mediterranean

22.	*Scarabaeus* (*Scarabaeus*) *typhon* (Fischer von Waldheim, 1823)*	6	/	Asian-southern European
23.	*Sisyphus schaefferi* (Linnaeus, 1758)	2, 6	Müller (1923), Novak (1952)	Turanic-European-Mediterranean
APHODIINAE Leach, 1815				
24.	*Acrossus luridus* (Fabricius, 1775)	2, 3, 4, 5, 7, 8, 9, 10, 11, 13, 14, 15, 16	Müller (1923), Novak (1952)	Palearctic
25.	*Amidorus thermicola* (Sturm, 1800)*	2, 5, 13, 15	/	Turanic-European
26.	*Aphodius fimetarius* (s.l.)	2, 9, 10	Müller (1923), Novak (1952)	Subcosmopolitan
27.	*Calamosternus granarius* (Linnaeus, 1767)	/	Müller (1923), Novak (1952)	Palearctic
28.	*Chilothorax paykulli* (Bedel, 1907)*	2, 5, 8, 11	/	European-Mediterranean
29.	*Colobopterus erraticus* (Linnaeus, 1758)	2, 4, 5, 6, 7, 9, 10, 11, 12, 13, 15, 16	Müller (1923), Novak (1952)	Asian-European-Mediterranean
30.	*Esymus merdarius* (Fabricius, 1775)	/	Müller (1923), Novak (1952)	Central Asian-European-Mediterranean
31.	*Eudolus quadriguttatus* (Herbst, 1783)*	2, 3, 7, 11	/	Palearctic
32.	*Melinopterus consputus* (Creutzer, 1799)*	2	/	Turanic-European-Mediterranean
33.	*Melinopterus prodromus* (Brahm, 1790)	2, 3, 9, 11, 12	Müller (1923), Novak (1952)	Asian-European-Mediterranean
34.	*Nimbus johnsoni* (Baraud, 1976)*	2, 5	/	South European
35.	*Volinus sticticus* (Panzer, 1798)*	2	/	Turanic-European
36.	*Oxyomus sylvestris* (Scopoli, 1763)	/	Müller (1923), Novak (1952)	Turanic-European-Mediterranean
DYNASTINAE MacLeay, 1819				
37.	*Pentodon bidens* (Pallas, 1771)	2	Müller (1923), Novak (1952)	Asian-European-Mediterranean
38.	*Oryctes nasicornis* (Linnaeus 1758)*	2	/	Palearctic
CETONIINAE Leach, 1815				
39.	*Tropinota hirta* (Poda, 1761)*	1 - 16	/	Asian-European-Mediterranean
40.	*Oxythyrea funesta* (Poda, 1761)	1 - 16	Müller (1923), Novak (1952)	European-Mediterranean
41.	*Cetonia aurata* (Linnaeus, 1761)	1 - 16	Müller (1923), Novak (1952)	Asian-European
42.	*Valgus hemipterus* (Linnaeus, 1758)*	2	/	Palearctic
43.	*Protaetia angustata* (Germar, 1817)	1, 11	Müller (1923), Novak (1952)	Mediterranean
44.	*Protaetia cuprea* (Fabricius, 1775)	2, 3	Müller (1923), Novak (1952)	Asian-European
45.	*Osmoderma eremita* (Scopoli, 1763)	2	Ranius *et al*. (2005); Polak (2006)	European

MELOLONTHINAE Leach in Samouelle, 1819				
46.	*Holochelus fraxinicola* (Hope, 1825)	/	Müller (1923), Novak (1952)	Eastern-European-Mediterranean
47.	*Amphimallon solstitiale* (Linnaeus, 1758)	/	Müller (1923), Novak (1952)	Asian-European
48.	*Haplidia transversa* (Fabricius, 1801)	2	Müller (1923), Novak (1952)	Eastern Mediterranean
RUTELINAE MacLeay, 1819				
49.	*Anisoplia flavipennis* (Brullé, 1832)	/	Müller (1923), Novak (1952)	Eastern European
50.	*Anisoplia monticola* (Erichson, 1848)	/	Müller (1923), Novak (1952)	Central-Mediterranean
LUCANIDAE Latreille, 1804				
51.	*Dorcus parallelipipedus* (Linnaeus, 1785)*	2	/	Turanic-European-Mediterranean
52.	*Lucanus cervus* (Linnaeus, 1758)	1, 2, 3	Harvey *et al*. (2011)	Turanic-European
TROGIDAE MacLeay, 1819				
53.	*Trox litoralis* Pittino, 1991	/	Pittino (1991)	Eastern Mediterranean
54.	*Trox scaber* (Linnaeus, 1767)*	2	/	Subcosmopolitan

terest as both are listed in the Annexes of the Habitat Directive; *O. eremita* is listed in both Annexes II and IV, while *L. cervus* is listed in Annex IV (COUNCIL DIRECTIVE 92/43/EEC). During this survey, we recorded *L. cervus* in great numbers at dusk across the Tramuntana forest during the summer months of each year. Also, a large number of dead as well as live individuals were recorded on tree barks and on the ground during the day. With many old trees, and an extensive forest area, the survival of this species is probably not threatened here. On the other hand, we recorded only a single adult specimen of *O. eremita* in the same forest, but this is probably due to lack of systematic surveying on our part. The larvae of this species use hollows in old trees. The Tramuntana forest is known for the large number of very old *Quercus* trees, and as such probably represents a suitable habitat for this species, which was also noted by Polak (2006) who recorded a large number of species in the forest. A more extensive survey of this species on the island is needed to access the current distribution, population structure and conservation status. Our record represents the second recent record of this species in Croatia (Koren *et al*., 2011).

The island of Cres is still rich in diverse habitats. Tramuntana forest in the north represents an ideal habitat for the development of saproxylic beetles such as *O. eremita* and *L. cervus*. On the other hand, pastures scattered across the island represent suitable habitats for many dung beetle species. While this survey contributed to the knowledge of dung beetles and other scarabs of the islands, the knowledge is far from complete and additional surveys are needed.

PRISPEVEK K POZNAVANJU FAVNE SCARABAEOIDEA (COLEOPTERA) OTOKA CRES, HRVAŠKA

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POVZETEK

Predstavljamo prvi recentni pregled favne Scarabaeoidea hrvaškega otoka Cres. Material za raziskavo smo zbrali v času *terenskega dela med letoma 2011 in 2014. Skupno smo zabeležili 44 vrst, od katerih jih je bilo 21 prvič zabeleženih za to območje. V literaturi najdemo podatke še za 10 vrst, ki pa jih v času raziskave nismo našli.* Število *znanih vrst za otok Cres se je tako dvignilo na 54.*

Ključne besede: koprofagni hrošči, pestrost, *Osmoderma eremita, Lucanus cervus*

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AN ATTEMPT TO DEMONSTRATE THE INFLUENCE OF MAUNDER MINIMUM CLIMATE ON SALT PRODUCTION AND IT'S PRICE IN THE SLOVENIAN ISTRIA (SEČOVLJE SALT-PANS)

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ABSTRACT

This paper investigates the harvest of sea salt in the former Pirano Commune from 1637 to 1744 under the rule of the Venetian Republic. The period from 1645 to 1715 coincides with the so called Maunder minimum when minimum solar activity was detected. As the indicator of solar activity the sunspot numbers were used. The paper reviews different historical climate records and presents the results of empirical analysis of possible relationship between solar activity during the Maunder minimum and salt production, as well as its price. The results imply a causal connection between solar activity and salt price series, but the problems with the unreliable and short time series and missing data compelled our research to use statistical methods that might produce inconsistent and spurious results.

Key words: Maunder minimum, sunspot number, solar activity, climate in pre-instrumental period, salt production, Sečovlje salt-pans

TENTATIVO DI DIMOSTRARE L'INFLUENZA DEL CLIMA DURANTE IL MINIMO DI MAUNDER SU PRODUZIONE E PREZZO DEL SALE NELL'ISTRIA SLOVENA (SALINE DI SICCIOLE)

SINTESI

L'articolo esamina la raccolta del sale marino nell'ex Comune di Pirano dal 1637 al 1744, sotto il dominio della Repubblica di Venezia. Il periodo 1645-1715 coincide con il cosiddetto minimo di Maunder, quando fu registrato il minimo dell'attività solare. Il numero di macchie solari è stato usato quale indicatore dell'attività solare. Diverse registrazioni climatiche storiche sono state esaminate e vengono presentati i risultati dell'analisi empirica della possibile relazione tra l'attività solare durante il minimo di Maunder e la produzione ed il prezzo del sale. I risultati implicano un nesso causale tra l'attività solare e la serie dei prezzi del sale, ma i problemi legati alle brevi e poco affidabili serie storiche nonché i dati mancanti hanno portato gli autori all'uso di metodi statistici che potrebbero aver prodotto risultati inconsistenti e fuorvianti.

Parole chiave: Minimo di Maunder, numero di macchie solari, attività solare, clima nel periodo pre-strumentale, produzione del sale, saline di Sicciole

INTRODUCTION

It is commonly known that salt production by solar evaporation of brine is highly dependent on the weather, mainly on solar irradiance (clouds), rainfall and wind. Rainfall during the salt harvesting season and extended winters, as well as lower summer temperatures can cut down the harvest of salt. In his model of solar brine evaporation, Akridge (2008) stresses the importance of high sunlight duration and its intensity, and low relative humidity and rainfall in traditional salt making procedures. The aim of this article is to search for possible connections between weather conditions during the Maunder minimum (hereafter referred to as the MM) and salt production in the Sečovlje salt-pans, as well as its price. During the time of the MM, the Slovenian Istria was part of the Venetian Republic. In the Venetian Republic, salt was one of the most important trading goods and consequently the reason for numerous wars. As one of the state monopolies, salt production and trade were carefully monitored and its prices were strictly regulated by the Salt Magistracy (Magistrato al Sale). The Piran salt-pans were the largest North Adriatic salt-pans, and after 1460 probably the most important in the entire Venetian Republic (Bonin, 2001; Darovec, 2001).

In 1636, the Salt Magistracy decided that the Piran Commune should harvest 5,200 modio yearly (1 modio = 801 kg). This quantity was the standard until 1749, when this limit was abolished. The Salt Magistracy also regulated the price of the harvested salt (Bonin, 2001). We would like to point to the fact that at the beginning of the MM salt price increased twice (1650, 1664) and remained high until the end of the MM when it decreased. Such price fluctuation could suggest a connection between salt price and low solar activity during the MM. The question arises as to whether it is possible that the Venetian Republic incorporated the natural cycles in the state policy, and how the MM influenced the salt harvesting in the Sečovlje salt-pans. In this paper we discuss the possible relationship between salt production and sunspot number, and between sunspot number and salt price. Moreover, the specific focus is on describing the weather conditions in the region during the MM, which might influence the salt production.

Connection between solar activity – climate and between solar activity – agricultural economics

The period from 1645 to 1715 coincides with the MM when minimum solar activity was detected. In history, different indicators have been employed as measures of solar activity. The basic indicator and also the most commonly used parameter is the number of sunspots visible on the solar disk. During the MM, the number of sunspots was the lowest recorded in history; the fact was first recognized by Spörer and later confirmed by other authors (Spörer, 1887; Maunder, 1922; Eddy, 1976; Lean *et al.*, 1995). With the modern era satellite observation, it has been established that the solar irradiance variations are correlated with sunspot number (Wilson & Hudson, 1988, 1991; Frohlich, 2000; Lean, 2001).

Many authors in the past showed a great interest in the reconstruction of the climate during the MM. Some studies rely on historical data (mostly annals, chronicles and historiographical records), while others use various proxies to reflect variations in air and sea temperature. The majority of studies have shown that the MM delineates a period with an increase in climatic variability over Europe and the coldest period of Little Ice Age (Pfister, 1999; Wanner *et al.*, 2000), with extremely cold winters (Pfister, 1994, 1999; Kington, 1995, 1997, 1999; Wanner *et al.*, 1995; Koslowski & Glaser, 1999; Luterbacher, 2000; Luterbacher *et al.*, 2000). The reduction of winter mean temperatures over wide areas of Europe is estimated to be of the order of 1–1.5 °C compared to present levels (Pfister, 1994, 1999; Xoplaki *et al.*, 2001). Estimates of the reduction of solar irradiance are in the order of 0.2 to 0.4 % relative to present levels (Lean & Rind, 1998, 1999).

Several studies reported that the climate during the MM in the eastern and western Mediterranean was generally slightly wetter, colder, and highly variable with severe and more frequent droughts and floods than in the previous century (Barriendos, 1997; Rodrigo *et al.*, 2000; Xoplaki *et al.*, 2001). Similar conclusions for the region of the Slovenian Istria can be drawn from the chronicles of severe weather and climate anomaly conditions, researched by Ogrin (1995). The period was not exceptional in all records context, except for the strong storms with hale and strong wind, which were more frequent during the MM. Ogrin (1995, 2005) also analysed the correlation between salt production in the Sečovlje salt-pans from 1926 to 1937 and from 1946 to 1959 and rainfall occurrence. He found strong inverse correlation ($r > 0.71$, $P < 0.01$) between rainfall occurrence (mm) during the salt harvesting season and salt production (kg/m^2).

In the past, many different authors analysed the correlation between the solar activity and the climate. However, the reported results are contradictive, from strong negative to strong positive correlation, sometimes also no correlation at all was found, depending on the location, the time interval and the analysis technique (Tsiropoula, 2003). The most commonly used meteorological parameters in Sun–weather correlation studies are temperature, rainfall and cloud cover, all very important in production of salt by brine evaporation. Several studies point to the fact that solar activity has a good correlation with the Earth's global climate and temperature (Eddy, 1977; Friis-Christensen & Lassen, 1991; Soon *et al.*, 1996; Baliunas & Soon, 1996; White *et al.*, 1997; Parker, 1999; Baker, 2000; Lean & Rind, 2001; Rozelot, 2001; Tsiropoula, 2003; Tan *et al.*, 2004; Georgieva

et al., 2005; Haigh, 2007), and with the Earth's cloud cover (Svensmark & Friis-Christensen, 1997; Svensmark, 1998; Marsh & Svensmark, 2000).

One of the first papers that directly discuss the Sun - climate correlation was published by Koppen (1914), who concluded that there is a negative correlation between the 11-year solar cycle and Earth's mean surface temperature. Similar results were later reported also by Labitzke & Van Loon (1988, 1992) who suggested a correlation between the 11-year solar cycle and a wide range of stratospheric parameters, and by Reid (1991) who found striking similarities between sea surface temperatures and sunspot number solar cycle. Different results were reported also for solar activity and rainfall association. Clayton (1923) determined that continental middle latitude winter precipitations are negatively correlated with solar activity, while summer precipitations are positively correlated with it. Xanthakis (1973) reported a strong positive or negative correlation between precipitation and the 11-year cycle depending on latitude and longitude bands. Different authors also report a moderate to strong correlation between solar activity and rainfall or the monsoon rainfall variability (Ananthakrishnan & Parthasarathy, 1984; Parthasarathy *et al.*, 1993; Jain & Tripathy, 1997; Rodrigo *et al.* 2000; Hiremath & Mandi, 2004; Hiremath, 2006).

The history of studying the possible influence of solar activity on the agricultural economics is rather long. In the past, researchers focused mostly on the influence of solar activity on wheat price (Jevons, 1884). Jevons (1884) studied the fluctuation of wheat prices over 140 years (1259-1400). He discovered a causal connection between the 11-year solar cycle and wheat price. Some more recent works (Pustilnik & Yom Din, 2004, 2009) have shown that a possible nonlinear causal connections between solar activity and wheat prices may exist, and that the influence is not homogenous, but varies with latitude (Pustilnik & Yom Din, 2009).

According to the reviewed literature, we could draw a conclusion that variability in solar activity somehow influences temperature, Earth's cloud cover and rainfall. Since salt production in traditional salt-pans is highly sensitive to weather conditions, especially summer rainfall and low temperatures, we can speculate about possible physical connection between sunspot number and salt production as well as its price during the period of the MM.

MATERIAL AND METHODS

The relevant data on salt production and its price was collected from original sources. The Piran Archive has been an important and reliable source of information regarding salt harvesting and salt price. The first record mentioning salt production is from 1637, while the recorded data can be found until 1685 with the exception of years 1657, 1658, 1663 and 1672, which were not recorded. In 1685, after the salt clerk Giorgio Giraldio finished his long career, the systematic record of these data also came to an end. During all this time, the salt workers of Piran were allowed to produce 5,200 modio per year or 26,000 modio every five years. If they did not produce the agreed quantity during a particular year, they were allowed to produce more in subsequent years to reach the agreed limit. During the period 1637 – 1646, the salt workers of Piran exceeded the agreed quantity by 3,453 modio. According to the data, they produced much less than agreed over the next three decades. Also in the decade 1730 – 1739, when they produced 42,497 modio of salt, they did not reach the allowed quantity of salt. The exceptionally bad harvests were in years 1649 (259 modio), 1650 (1,219 modio), 1652 (1,697 modio), 1675 (1,747 modio) and 1677 (1,530 modio). Not only the inclement weather conditions, but also the poor maintenance of the salt fields and protective dykes were reported as reasons for the bad harvest. On September 21st 1675, the salt workers Domenico and Bernardino Caldana asked the Salt Magistracy for a loan of 500 ducats in order to improve the salt fields. In their application they stated that salt seasons had been very poor, and that they also had low production of oil and wine. Despite overall bad decades for salt production during the MM, some exceptions were also recorded. The records of very good harvests can be found for years 1637 (10,078 modio), 1659 (10,155 modio), 1683 (10,522 modio) and 1685 (10,537 modio). In 1718 they produced as much as 12,000 modio. According to the economic policy of the Venetian Republic, the salt production was strictly regulated and the overproduction not allowed. To limit the production in good seasons, the authorities prohibited daily salt harvesting and limited the work to every second or third day and sometimes even to every fourth day. For example, at the beginning of the salt season in May 1707, the authorities issued a decision ordering the salt workers of Piran to harvest salt every third day. This measure was taken also to improve the quality of the salt. If the salt workers harvested the maximum quantity of salt allowed, they were forbidden to harvest any more from 20th August onward. If the warehouses were full and the salt workers harvested too much salt, they threw the surplus back into the sea. If the quantity of the salt produced was too small, the season was extended through September.

During the 17th and 18th century, the size of the salt-pans remained unchanged. As mentioned before, at the beginning of the MM the salt price increased twice: in 1650 by 13.7 % and in 1664 by additional 10.6 %. The final salt price of 19 lire per modio was maintained during the remaining 50 years of the MM. In 1721, immediately after a larger number of sunspots emerged, the price of salt decreased by 25.3 % to 14.2 lire. The organized data series for salt harvesting and salt price from year 1637 to year 1744 was partially published in Bonin (2001).

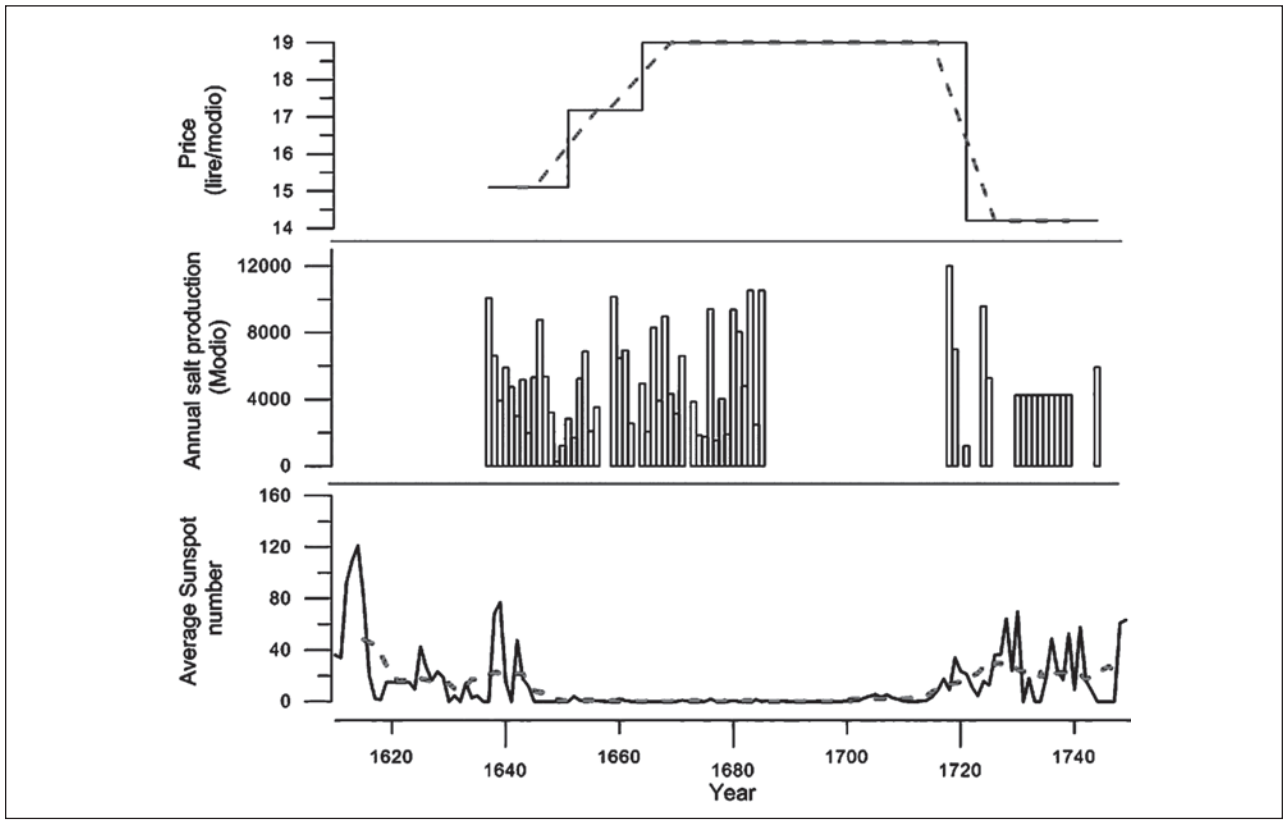

Fig. 1: Time series of salt production, salt price, and average sunspot number (dash lines represent 11-year running average smoothed data).
Sl. 1: Časovna vrsta pridelave soli, cene soli in povprečnega števila sončevih peg (črtkana črta prikazuje 11-letne drseče sredine)

Several sources of historical records have been used for historical climatic reconstruction. In collecting and organizing the historical records from different sources, substantial work was done by Ogrin (1995). In his book, he published the most complete record of climate related occurrences from the 7th to the 19th century for the Slovenia Istria, and updated previously published Braun's chronicles of weather conditions (Braun, 1934) with new historical sources. The sources contain direct or indirect information about the weather or meteorological phenomena. Most of the data he used are descriptive documentary data, in some cases describing weather consequences (flood, famine, and drought) rather than weather conditions. According to available information, he divided the weather conditions into six groups; hard winters, mild winters, drought in vegetation period, wet vegetation period, strong storms with wind and hail, years of famine and shortage. Cammuffo (1987), who researched the freezing of the Venetian Lagoon in the past, points out to the fact that during the Venetian Republic *i.e.* until 1797 the new year began after the March 1 and that this must be kept in mind when comparing Gregorian, Venetian and modern climatological dating. This, in some cases, could cause one year fictive difference between the events that occurred in the same year. Although we noticed some possible differences in dating of the same events studied in the course of this research, this problem is of secondary importance, since the data time series were smoothed for the analysis.

In order to study the correlation between sunspot number, salt production and price and different climate occurrences during the MM, the annual average sunspot number time series for the period from 1610 to 1950 was obtained from the National Geophysical Data Centre in Boulder USA (National Oceanic and Atmospheric Administration).

Visual inspection of Figure 1 shows a possible correlation between the sunspot number series and salt price series and some indices of correlation between the sunspot number series and salt production.

Different statistical tools were used to detect the relationship between different variables. For the analysis of a possible relationship between solar activity and historical events of extreme weather, the data of sunspot number and the data of extreme weather conditions were

Tab. 1: Correlation coefficients (rpb) of relationship between average sunspot number (original data and 11-year running average) and historical events of extreme weather (1610-1850).
Tab. 1: Korelacijski koeficienti (rpb) med povprečnim številom sončevih peg (izvirnimi podatki in 11-letno vrsto drsečih sredin) in pojavnostjo ekstremnih vremenskih dogodkov

Variable	rpb	Sig. (*P*)	Occurrence during MM (event/year)	Occurrence outside MM (event/year)	Fisher exact sig. (*P*)
Hard winter	-0.087	0.874	0.11	0.15	0.541
Mild winter	-0.041	0.522	0.04	0.04	0.929
Wet vegetation period	0.092	0.148	0.06	0.02	0.093
Drought in vegetation period	0.024	0.703	0.04	0.11	0.102
Strong storms	-0.101	0.112	0.16	0.07	0.034*
Correlation coefficient for smoothed data					
Hard winter	-0.104	0.143			
Mild winter	-0.072	0.161			
Wet vegetation period	-0.136	0.008*			
Drought in vegetation period	0.072	0.163			
Strong storms	-0.192	0.000*			

*coefficients are statistically significant at 0.05 levels

used. Weather conditions reported as hard winter, mild winter, drought in vegetation period, wet vegetation period and strong storms can be considered a dichotomous variable, with value 1 if the condition occurs. Sunspot number time series is a continuous quantitative variable. To study the relationship between these two variables, the point biserial correlation seems to be the most appropriate. Fisher's exact tests were used to identify differences in the frequency of extreme weather events during the MM compared with both earlier and later period. In order to determine how low sunspot number during the MM influenced the salt production and salt price, a cross-correlation analysis was applied.

The data series of salt production were incomplete, covering only the years from 1637 to 1685 and from 1718 to 1744 with some gaps. One of the main problems is the 33-year gap from 1686 to 1717. After the year 1680, the data is less accurate and the gaps in records are more frequent. For the period from 1730 to 1740 the records are available only as a sum of five years production. In Figure 1 the data for this period are presented as five yearly averages. Since the data for the second period is less accurate, only the first part of data series was used in the analysis. However, no data have been found for years 1657, 1658, 1663 and 1673. Instead, the mean values for the series were used.

RESULTS AND DISCUSSION

The overlapping period 1610-1850 of two time series, average sunspot number and extreme weather condition occurrence were used to investigate the influence of the MM on the Slovenian Istria climate. Additionally, to assess the influence of the MM on the frequency of a single group of extreme weather events, Fisher exact test was applied. Results of point biserial correlative analysis and Fisher exact test are presented in Table 1.

From the second and the third column it is evident that no significant correlation between observed variables exists. Relating the number of sunspots with climate/weather, it has been established (Reid, 1991; Waple, 1999; Hiremath & Mandi, 2004; Hiremath, 2006) that changes in climate are associated with the 11- year solar cycle. As suggested by previous studies (Lebitzke & Van Loon, 1988; Bottomley *et al.*, 1990; Tsiropoula, 2003), the sunspot number data were smoothed with 11-year running average and new values of correlation coefficients for sunspot number smoothed curve were calculated. This method also gained poor correlation (rpb < 0.19). However, the results suggest a possible negative correlation with wet vegetation period (rpb = -0.136; $P = 0.008$) and strong storms (rpb = -0.192; $P = 0.000$). The proposed significant correlation for strong storms and wet vegetation period is in good accordance with the findings of other studies, in which authors reported on the association between reduced solar activity and increased storminess (Björk & Clemmensen, 2004; Van der Schrier & Barkmeijer, 2005; Clarke & Rendell, 2009), and increased rain/snow precipitation (Svensmark & Friis-Christensen, 1997; Marsh & Svensmark, 2000; Kniveton & Todd, 2001). As seen in Figure 2, records of wet vegetation period are distributed only dur-

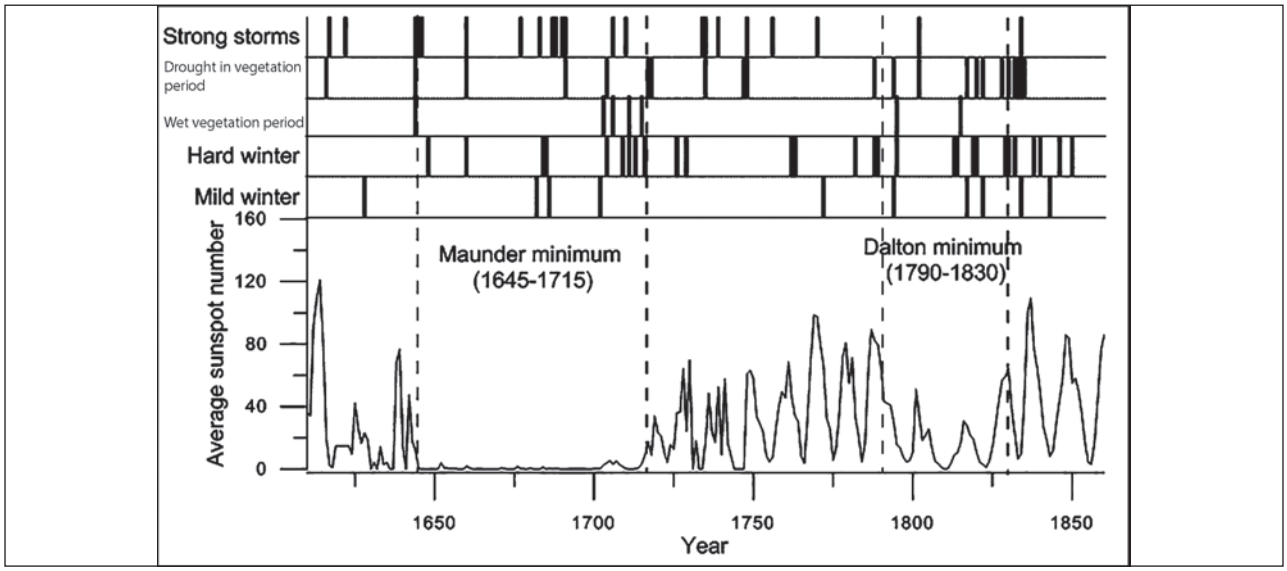

Fig. 2: Extreme weather events in the Slovenian Istria from 1600-1850.
Sl. 2: Prikaz ekstremnih vremenskih pojavov v slovenski Istri od leta 1600 do 1850

ing the two periods of reduced solar activity (Maunder and Dalton minima).

The last column in Table 1 shows the significance of Fisher exact tests. The results confirm higher frequency of strong storms with hail and strong wind during the MM compared with both earlier and later period (P = 0.034). Given the validity of the correlation between average sunspot number and some extreme weather events, the correlation between salt production and extreme weather events was also investigated. The results suggest a statistically weak positive correlation between strong storms and salt production (rpb = 0.255, P = 0.046).

According to the findings in the reviewed literature, we expected a significant negative correlation between average sunspot number and hard winter occurrences. However, the results in both models show no relationship (rpb < |0.104|, P > 0.143). As it is clearly evident from Figure 2, hard winters frequently occurred over the whole time period from 1650 to1850 regardless of the single solar cycle. The reason for poor correlation might be the fact that we analysed only a time segment in the period of the so called Little Ice Age (variously assessed as AD 1430-1850), while longer time series extended over the Little Ice Age may be required to confirm the proposed relationship between variables.

The purpose of this study was also to identify the possible influence of the MM on salt production and its price. For this purpose, data series of salt production from 1637 to 1687 and data series of salt price from 1937 to 1744 were cross-correlated with average sunspot number. For the salt production data series, the largest correlation coefficient (r = 0.316) was found at lag of -10 years. A larger correlation coefficient was obtained by using 11-year running average (r = 0.571) with lag of 6 years. In order to understand how the lag varies in time, a cross-correlation was calculated for every solar cycle before 1645 and the period after. In the first three cycles the lag has a decreasing trend, with correlation coefficients up to r = 0.80, afterwards the lag changes from positive to negative. It seems that the lag between average sunspot number and salt production varies in time with no understandable pattern. In other words, since the salt production was not limited only by weather but mostly by political decisions, the salt production time series contains "social noise" that is difficult to quantify, and strongly influences the results. The production of salt was strictly regulated with the salt contracts and limited to yearly production of 5,200 or 2,600 modio in total for the five-year period. In good seasons the authorities prohibited daily salt harvesting and even ordered the harvested salt to be thrown back into the sea when the warehouses were full. With strict regulation and control of salt production in good seasons, the authorities had much more influence on harvested quantity than the weather conditions.

As evident from Figure 1, there is almost no variability after year 1640 in sunspot number series, resulting in the largest discrepancy between the two series. Assuming that both, the lack of variability in average sunspot number during the MM, as well as "social noise" in salt production series are the causes of poor results, an extended time series over the end of the MM would be needed to completely understand the nature of the relationship. To gain complete understanding of how good individual harvest seasons were, additional information

i.e. the end of the season in a particular year, or the limitations of work in the salt-pans, would be needed to distinguish between good and excellent seasons. The fact that climate variations during the MM could in a certain year lead to favourable weather conditions for salt production (as in 1659, 1983, 1985) must also be considered since the salt production is less sensitive to annual totals or averages of different parameters (precipitation, irradiation, temperature) than to the distribution of this parameters in form of weather anomalies during the harvest season. Apart from this, one must not forget that the production of salt was arduous, labour intensive and time consuming process in which also poor maintenance of the salt fields and protective dykes could be the reasons for bad harvest. Thus, the question of the influence of low solar activity on the salt production in the Sečovlje salt-pans remains unanswered.

Furthermore, a cross-correlation between average sunspot number and salt price data series showed a moderate negative relationship ($r = -0.518$, $P = 0.000$). Even largest correlations coefficient exits between 11-year running average sunspot number series and 11-year running average salt price series ($r = -0.848$, $P = 0.00$). Since there is no statistical evidence of relationship between salt production and salt price ($r < 0.103$, $P > 0.482$), the influence of solar activity on salt price cannot be explained through the chain of linear connections: solar activity-terrestrial climate-salt production-salt price. It is possible that the link among sunspot numbers, salt production and price are not always linear, and relatively small variation in salt production can cause a sharp change in prices (similar to wheat prices - described in depth by Pustilnik & Yom Din, 2004). In a relatively isolated and monopolized salt market, the variability in weather conditions or low number of sunspots during the MM may lead to a precaution of the Salt Magistracy in salt price forming policy.

CONCLUSION

Although the influence of solar activity/weather on the salt production in open salt-pans is evident, our results failed to confirm a significant relationship between sunspot number and salt production. There are several reasons that could explain the lack of correlation, perhaps the two most important being the strictly regulated and limited salt production (mostly to keep the high salt price) and the absence of a common time interval extend to reliable sunspot observation data. The low variability in sunspot number observation data and salt price data causes a lot of problems in the analysis, as well. Another concern is the used methodology. The missing data in time series constrain us to smooth the series with 11-years running average, what may cause spurious results and findings should be interpreted with caution. Thus, the question of how if at all the climate during the MM influenced the salt production remains unanswered.

By analysing the frequency of extreme weather events during the period from 1610-1850 and the solar activity, overall conclusions are as follows:

1. The results suggest a possible negative correlation with wet vegetation period ($rpb = -0.136$, $P = 0.008$) and strong storms ($rpb = -0.192$, $P = 0.000$).
2. During the MM, strong storms with hale and strong wind were statistically more frequent compared to both earlier and later period ($P = 0.034$).
3. Opposite to our expectations, the results in both models show no relationship ($rpb < |0.143|$, $P > 0.143$) between hard winters and average sunspot number.
4. The weak correlation established between extreme weather conditions and solar activity may indicate that the MM influenced the climate in the Slovenian Istria.

Additionally, the results imply a causal connection between solar activity and salt price series ($r = -0.848$, $P = 0.00$). However, since the salt price changed only three times during the MM, these results are inconsistent and spurious due to lack of variability in the dataset. There are some other parameters that might influence the salt price, and caution should be taken in interpreting the results.

Despite our efforts, many questions remain unanswered. Additional data sets and much further investigation would be needed in order to understand how if at all, the MM influenced the salt production in the Slovenian Istria. The possibility of using other proxy of solar activity as ^{10}Be isotopes from Greenland ice (Beer *et al.*, 1998), and extended time series of salt production data could give us another chance of finding the answer to our question.

POSKUS PRIKAZA VPLIVA PODNEBJA IZ OBDOBJA MAUNDERJEVEGA MINIMUMA NA PROIZVODNJO SOLI IN NJENO CENO V SLOVENSKI ISTRI (SEČOVELJSKE SOLINE)

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POVZETEK

V članku obravnavamo žetev morske soli v Sečoveljskih solinah v letih 1637–1744, ki so tedaj spadale pod Beneško republiko. Obdobje 1645–1715 sovpada s t. i. Maunderjevim minimumom, ko so opazovalci ugotovili minimalno sončevo aktivnost. Kot kazalnik sončeve aktivnosti smo uporabili število sončevih peg. Pregledali smo različne historične klimatske podatke in predstavili rezultate empirične analize možne povezave med sončevo aktivnostjo v obdobju Maunderjevega minimuma in proizvodnjo soli kot tudi njeno ceno. Rezultati sicer kažejo na vzročno povezavo med sončevo aktivnostjo in ceno soli, a nas je težava z nezanesljivimi in kratkimi časovnimi vrstami ter manjkajočimi podatki prisilila v uporabo statističnih metod, ki lahko privedejo do nekonsistentnih in zavajajočih rezultatov. Na podlagi rezultatov analize zato ni možno potrditi povezanosti med pridelavo soli, ceno in sončevo aktivnostjo.

Ključne besede: Maunderjev minimum, število sončevih peg, sončeva aktivnost, podnebje v predinstrumentalnem obdobju, proizvodnja soli, Sečoveljske soline.

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CAN EVAPOTRANSPIRATION BE CONSIDERED AN ADDITIONAL INDICATOR FOR UNDERSTANDING THE CHANGED LANDSCAPE IDENTITY OF THE CLASSIC KARST?

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ABSTRACT

Evapotranspiration (ET) change is one of the most obvious ecohydrological effects of land use or vegetation cover change. In this regard, the landscape change process was initially observed by determining the fractional green vegetation cover difference between two time windows over a span of 12 years (2002 – 2014), followed by an estimation of the June mean daily actual evapotranspiration change within the Karst area in Slovenia, based on LANDSAT satellite imagery. Most of the study area has faced a clear gain in ET (74%), which perfectly matches the increase in scrub encroachment and forest progression. Furthermore, many surfaces with an ET rate decrease were also identified in the category of persistent forest land use mainly in the eastern part of the study area (76%), a finding which can be explained by the severe sleet event during the winter of 2014. It can be concluded that the estimated ET change rate can be an important complementary indicator for assessing the landscape change process from a more functional perspective.

Keywords: classic Karst, evapotranspiration, landscape change, land use, NDVI (normalized difference vegetation index)

PUÒ L'EVAPOTRASPIRAZIONE ESSERE CONSIDERATA UN NUOVO INDICATORE PER CAPIRE L'IDENTITÀ MUTATA DEL PAESAGGIO DEL CARSO CLASSICO?

SINTESI

Il cambiamento legato all'evapotraspirazione (ET) è uno dei più evidenti effetti eco-idrologici abbinati all'uso del suolo o alla modifica della copertura vegetazionale. In tale luce, il processo di cambiamento del paesaggio è stato inizialmente osservato determinando la differenza frazionaria della copertura vegetale verde tra due finestre temporali in un intervallo pari a dodici anni (2002 - 2014), seguita da una stima della media giornaliera del cambiamento evapotraspirazione reale nel mese di giugno all'interno della zona carsica in Slovenia, basata su immagini satellitari LANDSAT. La maggior parte dell'area di studio ha subito un evidente aumento in termini di ET (74%), che si abbina perfettamente all'aumento della vegetazione arbustiva e alla progressione della foresta. Molte superfici che hanno subito una diminuzione dei tassi di ET, invece, sono state identificate nella categoria d'impiego persistente dei terreni forestali, principalmente nella parte orientale dell'area di studio (76%), un dato che può essere spiegato con il grave evento nevischio verificatosi durante l'inverno del 2014. Gli autori asseriscono che il tasso di variazione di ET stimato può essere considerato un indicatore complementare importante per valutare il processo di cambiamento del paesaggio da un prospettiva più funzionale.

Parole chiave: Carso classico, evapotraspirazione, cambiamento del paesaggio, uso del suolo, NDVI (indice normalizzato differenza vegetazione)

INTRODUCTION

The Karst (Kras, Carso) is a limestone karst plateau, lying above the bay of Trieste in the northernmost part of the Adriatic Sea, and is known for its geological, geomorphological, and speleological phenomena. It is still perceived as a traditionally stony grassland area, where the clear-cuts existed since ancient times and where the black pine (*Pinus nigra*) - planted in the 19th century - is a symbolic tree. The deforestation actually started in Roman times and continued in the Middle Ages with population growth and an orientation to pastoralism. The peak of deforestation, reinforced by the processes of water and wind erosion, which substantially lessen the soil layer (sometimes to bare rock), is thought to have been in the seventeenth to nineteenth centuries (Kaligarič *et al.*, 2006), a fining which was confirmed using reliable cartographic materials such as the Austrian Military survey from the second half of the 18th century (Rajšp & Ficko, 1996). Large socio-economic changes in the first half of the 20th century caused negative demographic changes, which resulted in land abandonment, which became even more pronounced in the period after WWII. Thus, it was already perceived by the 80's that spontaneous reforestation was a key driving force for landscape change in the classic Karst (Feoli & Feoli Chiapella, 1979; Feoli *et al.*, 1980; Feoli & Scimone, 1982; Lausi *et al.*, 1979). These authors produced the first predictions and models, forecasting the forest progression on the abandoned karst grasslands (Favretto & Poldini, 1986); it was forecasted that the Trieste Karst area (the portion of the area on Italian territory) will be completely forested by 2013. The landscape identity really changed, as interpret by Kaligarič *et al.* (2006), but the situation is not so serious: there was still almost 20% of grassland present in 2012 (Kaligarič & Ivajnšič, 2014). However, the trends calculated on the basis of a ten-year time frame verification are straightforward: grasslands could cover 18 km^2 less area in 2025 compared to 2012 and could then shrink to just 6 km^2 (3%) in 2100. The forested area will expand by 18 km^2 by 2025 and could cover 88% of the whole study area by 2075, then achieving an almost steady-state situation in 2100 (Kaligarič & Ivajnšič, 2014). All the previous studies showed that the combined methods involving old maps, remotely sensed data and field surveys clearly show historical trends in assessing and changing the landscape identity – in this case in the classic Slovenian Karst. This methodology allowed us to demonstrate that an almost treeless stony grassland landscape was converted to a forest-dominated landscape in only 250 years (Kaligarič & Ivajnšič, 2014). However, is landscape change only the response of relatively simple two-dimensional input data on vegetation cover or land use? What happens to the landscape when the transition of grassland to scrub, or scrub to forest has occurred? Are there further changes that affect the landscape identity but which are not detectable through simple surface land use data? At this point we could perhaps re-consider the definition of "landscape identity". The definition of the European Landscape Convention is wide: "landscape is an area, as perceived by the people, the character of which is the result of the action and interaction of natural and/or human factors" (Council of Europe, 2000). Nevertheless, the basis for any interaction between the human and natural character of a landscape is its physical features, such as geomorphology (usually not changed), vegetation and climate. Is there any other complementary parameter that could replace or supplement the land use or vegetation cover data in order to better define landscape identity changes?

In this regard, remote sensing offers the promise of several spatially distributed geophysical variables (Brunsell & Gillies, 2000). Vegetation is important in climate studies, owing to its role in the hydrologic cycle with the actual evapotranspiration (ET) rate (Montandon & Small, 2008). ET change is one of the most obvious ecohydrological effects of land use/cover change (Riekerk, 1989; Li *et al.* 2012). Accordingly, remotely sensed land surface reflectance can be used to calculate those parameters such as the green vegetation fraction (Fg) or the Leaf Area Index (LAI), needed to represent vegetation in climate and hydrologic models. These two parameters represent the horizontal and the vertical density of live vegetation, respectively (Gutman & Ignatov, 1997). Both Fg and LAI are normally inferred from the Normalized Difference Vegetation Index (NDVI), an index calculated from reflectance measurements in the red and near-infrared wavelengths. These measurements are typically acquired by satellites over large areas (landscapes) divided into sub-units (pixels) that represents the average reflectance over a smaller area. A frequently used method for calculating Fg is to create a simple linear mixing model between two NDVI endmembers: bare soil NDVI ($NDVI_0$) and full vegetation NDVI ($NDVI_\infty$). In fact, the estimate of actual ET on a landscape level can then be calculated as a function of reference evaportranspiration and Fg (Ranade & Irmak, 2008). Many studies have been conducted to address the response of ET to climate change (Goyal, 2004; Diodato *et al.*, 2010; Liu & Yang, 2010), but little work has been done to investigate the impact of land use change on the pattern and process of ET (Jin *et al.*, 2009).

In this paper we initially aimed to identify and measure landscape change, perceived as the fractional green vegetation cover difference between two time windows over a span of 12 years (2002 – 2014). Secondly, the change in estimated actual evapotranspiration as its consequence was simultaneously determined, in order to look into the previously identified changed landscape identity of the classic Karst from a more functional perspective.

MATERIALS AND METHODS

Study area

A major part of the Karst Plateau in Slovenia (202km^2; 85% of the total area, owing to cloudiness in the northernmost part in the 2014 satellite image) was chosen to study relative actual evapotranspiration change over the last 12 years as a function of the green vegetation fraction (Fig. 1). Its geographical position lies between the Adriatic Sea and the Pre-Alpine region in Slovenia and north-eastern Italy (45,77°N and 13,84°E (Fig. 1)). It represents the north-easternmost branch of the Dinaric mountain range. The limestone dominated Karst Plateau stretches from 100 to 500 m a.s.l. and is characterized by its geomorphological phenomena (rocks, karst poljes, dolinas, caves, etc.) (Kaligarič *et al.*, 2006).

Climate conditions are sub-Mediterranean (Ogrin, 1995). The precipitation quantity varies from 900 to 1000 mm by the sea coast directly below the Karst Plateau (Portorož and Trieste), to around 1500 mm directly on the Karst Plateau (Ogrin, 1995). The characteristic strong bora wind causes desiccation and erosion in the area. The mean annual temperature on the Karst Plateau is 12°C (time interval from 1970 to 2000), but the mean annual temperature amplitude reaches 49°C (ARSO, 2015). Poldini (1989) characterized the climate as transitional between Mediterranean and continental pre-Alpine, with rainy cool winters and long dry summers.

NDVI data source

Landsat 5 and Landsat 8 (OLI/TIRS) systematic terrain-corrected (Level 1T) satellite images were obtained for Path 191, Row 28 for June 28, 2002 and June 27, 2014 from the Earth Explorer USGS site (http://earthexplorer.usgs.gov/) in order to gain insight into vegetation density change between the selected time frames (2002 and 2014) in the study area. Both satellite images were converted to reflectance (a physical property of the surface, where values near 0 represent surfaces that are very absorptive at a particular wavelength, and those near 1 very reflective) and additionally processed for atmospheric correction to remove haze with ATMOSC (Landsat 5 image) and LANDSAT (Landsat 8 image) modules in TerrSet (Eastman, 2015) by applying the Dark-object subtraction method. The normalized difference vegetation index (NDVI) for both observed time windows was further calculated by using the appropriate red and near-infrared bands of the satellite images.

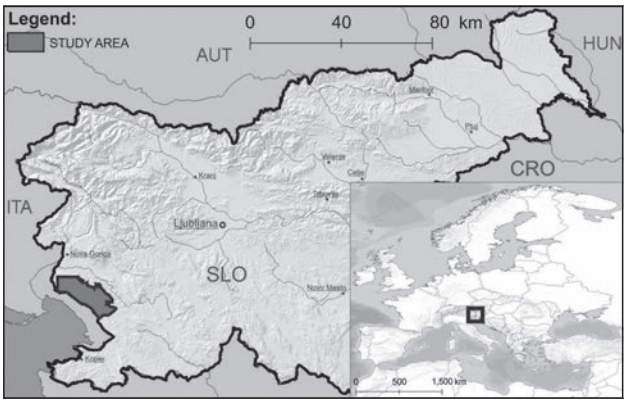

Fig. 1: Geographic position of the study area.
Sl. 1: Geografski položaj obravnavanega območja.

Estimating fractional green vegetation cover change

The fraction of green vegetation cover (Fg) was determined by applying the method proposed by Brunsell and Gillies (2002). This method scales the NDVI to obtain the fraction of vegetation cover and then scales the fraction between the emissivity of bare soil and of a full canopy.

$$Fg = (NDVI - MDVI_0)/(NDVI_{max} - NDVI_0)^2$$

Where $NDVI_0$ is the bare soil NDVI value of the scene and $NDVI_{max}$ is the maximum NDVI value of the scenario corresponding to full cover dense vegetation. It is usually assumed that $NDVI_0$ is close to zero ($NDVI_0$ ~0.05) and is generally chosen from the lowest observed NDVI values. In contrast, Montandon and Small (2008) proved that underestimating $NDVI_0$ yields overestimating the green vegetation fraction. However, because the main focus of this study is orientated towards relative change of actual evapotranspiration between two time windows in the same study area as a function of vegetation density change, the most commonly used $NDVI_0$ value (0.05) was chosen for Fg estimation (Zeng et al., 2000; Oleson *et al.*, 2000; Matsui *et al.*, 2005; Gan & Burges, 2006).

Spatial distribution of reference ET

The reference evapotranspiration (ET_0) data, based on the Penman-Monteith method (ARSO, 2016), from all five adjacent meteorological stations (Bilje, Godnje, Postojna, Vojsko and Portorož) were used to produce a reference evapotranspiration surface for both observed time windows over the study area. The daily mean value of ET_0 for the month of June for each geolocated point representing the meteorological station was calculated and then interpolated by applying the Spline method in ArcGIS 9.3 Spatial analyst tools (ESRI, 2010).

Estimating relative actual ET change

Actual ET (June daily mean in mm/m^2) was calculated by multiplying the fraction of vegetation cover with the reference ET surface for either the 2002 or the 2014 time window (Ranade & Irmak, 2008). Additional-

ly, both ET images were transformed, having a relative scale and then subtracted (ET2014 - ET2002), resulting in a relative ET difference map measured in proportion of change.

The relation between landscape and actual ET change

In order to link change in actual ET between the observed time span with the land use change processes which took place in the study area, the resulting actual ET difference image was ovelayed with the land use change (transition from one to another category) and persistence maps developed with the Land Change Modeler tool in Terrset (Eastman, 2015). The Zonal statistics module within ArcGIS 9.3 Spatial analyst tools was applied to determine mean relative actual ET change and the corresponding standard deviation per land use transition or persistence category identified beneath the ET loss or ET gain areas. Land use data for both observed time windows (2002 and 2014) were gathered from the freely accessible database owned by the Slovenian Ministry of Agriculture, Forestry and Food (http://rkg.gov.si/GERK/; 4.1.2016).

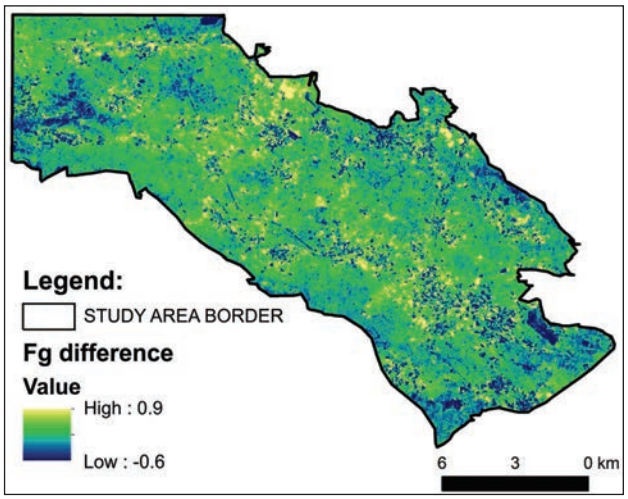

Fig. 3: The differences in fractional green vegetation cover in the study area between 2002 and 2014.
Sl. 3: Razlika v deležu vegetacijskega pokrova na obravnavanem območju med letoma 2002 in 2014.

RESULTS

12 years of land use and vegetation density change

A decreasing trend in the land use categories of grassland, overgrowing and fields was detected (Fig. 2). The largest retreat in area can be assigned to the grassland category (4.4%), followed by overgrowing areas (3.1%), which were mostly replaced by forest (in 98%). The latter expanded to 33.7 km^2 (5.7 % of area), followed by an 2.3 km^2 (0.4%) increase in settlement and infrastructure area.

However, the NDVI, based on LANDSAT imagery (Fig. 2), enabled the estimation of fractional green vegetation cover (Fg) change in the study area between 2002 and 2014 (Fig. 3). In only 2.1% of the study area (4,2 km^2) was a decrease in fraction of green vegetation within a pixel detected. Two square kilometers of area remained unchanged, whereas all other parts of the observed classic Karst area (196.8 km^2) did in fact increase in vegetation greenness. The intensity of Fg change in those 12 years is measured in a range from a 60% decrease to a 90% increase.

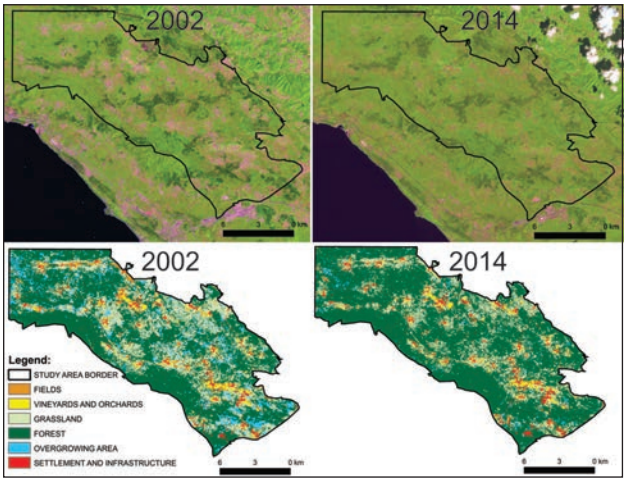

Fig. 2: False color composite LANDSAT satellite images of the study area in 2002 and 2014 with corresponding land use maps.
Sl. 2: LANDSAT satelitski posnetek ter raba tal na obravnavanem območju v letih 2002 in 2014.

Spatial distribution of actual evapotranspiration change as a climatic indicator for landscape identity change

By comparing the June daily mean reference ET surfaces of 2002 and 2014, a general spatial pattern can be recognized (Fig. 4). There is a clear decreasing ET trend from the SW to the NE direction, which has recently become more pronounced (Fig. 4B). The largest difference in the June daily mean reference ET between the two time windows was observed at the Godnje and Vojsko meteorological stations (both with a 0.6 mm/m^2 decrease). The other three stations do not differ more than 0.1 mm/m^2 in June daily mean reference ET.

However, the estimate of the June daily mean actual ET difference as a function of fractional green vegetation cover change, triggered by land use dynamics, shows a more detailed geospatial pattern of local climate change (Fig. 5A, B). In 17.6% of the study area (35.5 km^2), mo-

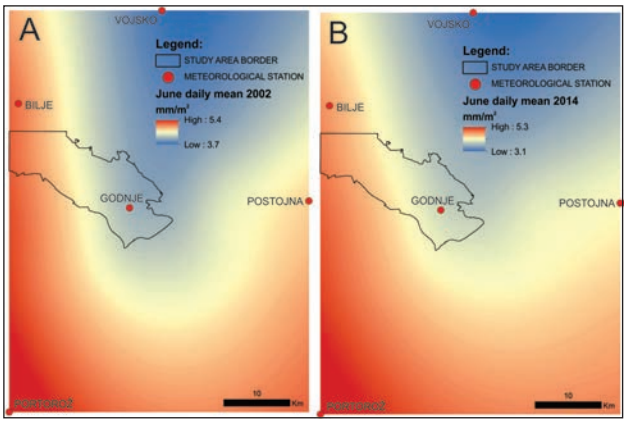

Fig. 4: Reference evapotranspiration surfaces (daily mean in mm/m²) for June in 2002 (A) and 2014 (B).
Sl. 4: Prostorska razporeditev povprečne dnevne junijske referenčne evapotranspiracije v letu2002 (A) in letu 2014 (B).

stly in the E and SE part, a clear decrease in actual ET (ET Loss) can be detected. An area of 17.4 km² (8.6%), more or less randomly scattered over the study area, remained constant, according to the June daily mean actual ET (ET Persistence). Consequently, almost 74% of the area (149.4 km²) shows a clear increase (up to 75%) in ET (ET Gain). The northern part of the observed classic Karst has evidently been pumping more water into the June atmosphere in recently than it was in 2002.

By looking into the estimated actual ET loss category from the angle of land use dynamics between 2002 and 2014, it became clear that 23% of the superficial cover in that category did in fact change in land use, while 77% persisted (Table 1). In other words, the estimated actual ET rate has been lower recently, even though most areas remained under the same land use (76% forest, 17% grassland, 3% vineyards and orchards). The highest average decrease in actual ET, measured at 9%, was detected in the Vineyards and orchards land use category, followed by Fields (8%) and Settlements and infrastructure (6%). The highest percentage of area exhibiting a land use transition and simultaneously an actual ET decrease surprisingly coincided with the Grassland to Forest transition (25%) and the Overgrowing area to Forest transition (27%). On the other hand, these two transitions have the lowest negative mean change in actual ET (-4% and -5%) compared to other land use transitions. The highest relative mean change in actual ET belongs, as expected, to the transition Grassland to Settlement (-11%).

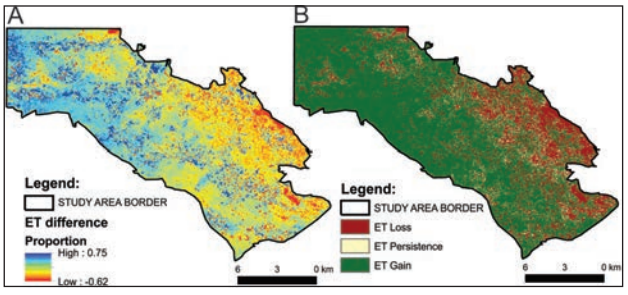

Fig. 5: Relative actual ET difference between 2002 and 2014 in the study area (A) and the indication of ET loss, gain and persistence distribution (B).
Sl. 5: Prostorska razporeditev relativne razlike v povprečni dnevni junijski ET med letoma 2002 in 2014 (A) ter območja izgubljanja, ohranjanja in pridobivanja vrednosti ET(B).

In the actual ET gain category, 25% of the area corresponds to changed land use, whereas 75% relates to persistent land use. Here, as expected, Grassland to Forest (32%) and Overgrowing area to Forest (30%) are the most frequent land use transitions showing an actual ET increase. Nevertheless, the highest positive mean change in actual ET is recorded in the Grassland to Vineyards and orchards transition (15%), followed by the transition Field to Grassland (14%). As in the actual ET loss category, even in this case the estimated actual ET change trend (now positive) is superficially grater in persistent land use, which indicates the ongoing landscape change process beyond the simple two-dimensional scale of geospatial land use data.

DISCUSSION

We found that by far the largest proportion of the study area has faced a clear gain in ET, which perfectly matches with the increased scrub encroachment on grassland surfaces in the given time frame, following the fact that more scrub/trees means higher ET. However, this was already well documented in the literature; scrub encroachment actually has many functional effects, among which, the increased evapotranspiration estimate is one of most visible and measurable (Zhang *et al.*, 2001; Huxman *et al.*, 2005). Further increases in evapotranspiration occur in conjunction with forest progression. We found that, among those polygons where land use has changed and ET increased, one- third of the surfaces represent the transition "grassland to forest" and another third the transition "overgrowing areas to forest", which was expected according to the above mentioned trends. However, the surprising outcome of this study is that, among the total area which gained ET, 75% are "land use persistence" polygons. In other words, for three-quarters of the areas with increased evapotranspiration, no land use change was detected between the given time windows. From the view of the two-dimensional vegetation perception of the landscape, nothing has changed here. Of course, most changes occurred in the most widespread land use categories – forest and grassland. 70% of the areas where land-use was stable but ET increased are forests. It explains that

Table 1: The relation between relative actual ET change and land use dynamics in the study area.
Tabela 1: Zveza med relativno spremembo v ET in procesom spreminjanja rabe tal med letoma 2002 in 2014.

LAND USE CATEGORY		ET GAIN			ET LOSS		
		% AREA	MEAN CHANGE IN %	STD	% AREA	MEAN CHANGE IN %	STD
	Total percentage of area corresponding to persistent land use	75			77		
LAND USE PERSISTENCE	FIELDS	0.6	14.1	8.8	0.5	-8.0	6.3
	VINEYARDS AND ORCHARDS	2.5	12.1	8.3	3.3	-9.0	8.9
	GRASSLAND	22.2	11.7	7.8	17.4	-5.9	4.9
	FOREST	69.6	8.3	5.2	75.7	-4.8	4.5
	OVERGROWING AREA	1.4	9.7	6.1	0.8	-5.2	6.2
	SETTLEMENTS AND INFRASTRUCTURE	3.6	9.2	5.9	2.2	-6.4	5.8
	Total percentage of area corresponding to changed land use	25			23		
LAND USE CHANGE	GRASSLAND to FIELD	3.0	11.8	8.1	5.1	-8.9	7.0
	GRASSLAND to VINEYARDS AND ORCHARDS	3.3	14.6	9.4	3.2	-7.6	6.0
	FIELD to GRASSLAND	6.1	14.2	8.7	4.8	-7.7	6.0
	VINEYARDS AND ORCHARDS to GRASSLAND	2.3	11.6	7.8	3.3	-8.1	6.4
	FOREST to GRASSLAND	3.3	10.1	6.8	5.5	-7.4	7.5
	OVERGROWING AREA to GRASSLAND	2.8	8.9	5.9	3.4	-6.1	6.3
	GRASSLAND to FOREST	31.9	9.5	6.0	24.9	-4.4	3.8
	OVERGROWING AREA to FOREST	29.7	8.8	5.5	26.7	-4.8	4.5
	GRASSLAND to OVERGROWING AREA	6.4	10.8	7.0	3.9	-5.6	5.5
	FOREST to OVERGROWING AREA	1.9	13.7	11.8	2.2	-7.6	7.0
	GRASSLAND to SETTLEMENTS AND INFRASTRUCTURE	1.5	10.9	7.0	3.5	-10.8	10.1
	LAND USE TRANSITION BELOW THE 10 Ha TRESHOLD	8.0	0.0	0.0	13.0	0.0	0.0

when forest is perceived, its development has not ceased: succession is an ongoing process, where woody species turnover takes place, and the trees are growing and increasing their above-ground phytomass.

Thus, if functional features of the landscape are investigated, the simple forest/non-forest landscape categorization is simply too weak. The age of the forest, or at least roughly defined forest typology, is essential to explain the relation between the ET change.

Furthermore, 20% of the area where land-use has not changed and ET nevertheless increased, constitutes grassland. This means that some functional differences must have occurred in that time interval, even though grasslands were perceived. However, the weakness of remotely sensed data was discussed and questioned from the early beginning of remote sensing tools development (*e.g.* Congalton & Green, 2008). How remotely sensed data can lead to misleading results, if no measurements, or at least observations, are made on the ground, has been shown in several examples. One of these refers to the study area: Watts (2004) identified eleven "communities" along the altitudinal range on the basis of satellite survey data only.

However, among them, two "communities" do not exist in the northern Balkans at all, and other types were incorrectly geo-located and named.

The discrepancy between the remotely sensed map of agricultural land use and a field-surveyed habitat (vegetation) map was substantially found in the study by Kaligarič *et al*. (2006), performed on 626 Ha in the same Karst area. With remote sensing, only one half of the identified grasslands were found to be without tall-herb invasions (*Apiaceae*, *Dictamnus albus, Thalictrum aquilegiifolium, Paeonia officinalis, Asparagus acutifolius*) or dominance of forest edge species (*Geranium sanguineum, Polygonatum odoratum, Aconitum, Aquilegia*). These are all long-leaved perennial plants, which have been recognized to decline slowly and may survive for decades after environmental change (Eriksson, 1996; Helm *et al*., 2006; Lindborg, 2007). Since there may exist a considerable time lag between the onset of habitat change (abandonment) and the final demise of populations (Eriksson & Ehrlén, 2001), the fragmented grasslands are still floristically rich, but their floristic composition has changed in favour of long-leaved perennials; among these, most are tall herbs with substantial above-ground phytomass, prone to high evapotraspiration rates. In other words – within the category "grassland" identified by remote sensing tools, substantial functional and morphological changes can occur derived from species turnover and plant growth.

Can however, the opposite also appear? Tat ET rates on the surface decline within the time frame, while the land-use category remains unchanged? Of course, it is crucial here in which time period of the year the near infra-red (satellite) images are taken – in the beginning, at the peak, or at the end of the vegetation cycle. We considered and processed satellite images that were taken in the same time period in both time windows (one day difference), in order to minimize the difference regarding the vegetation development stage. However, there are also surfaces where ET decreased in the unchanged land-use category. Here, by far the highest rates again belonged to forest (76% of all such surfaces). This would be hard to explain if the map (Fig. 5) had not shown that such cases are concentrated in the eastern part of the study area. This part was severely damaged by sleet during the winter of 2014. The spatial data (http://www.zgs.si/slo/delovna-podrocja/varstvo-gozdov/sanacija-posledic-ujme-2014/index.html; 20.11.2015) show that the areas damaged by varying quantities of sleet overlap perfectly with the forest category in which an ET decrease was identified. Sleet substantially affected the landscape of Slovenia in 2014 (mostly in the central and western regions). Some trees collapsed; some of them lost their usual appearance, owing to reduced canopies, and the forest tree composition might change in the long run, not to mention potential forest pests, which spread out on the damaged wood (Chen & Yang, 2009). Are these factors the precise ones that can change landscape identity?

We can conclude that the estimated ET rate can be an important indicator in assessing landscape change from a more functional perspective than from a rather static approach to land-use or vegetation change. So, the final answer to the question raised in the title of the paper is "yes": there are several landscape attributes – from climatic and natural, to cultural and socio-economic – which are influenced by ET and contribute to a changed landscape identity, which goes far beyond the usual two-dimensional assessment of land use change.

ALI LAHKO EVAPOTRANSPIRACIJO SMATRAMO KOT DODATNI POKAZATELJ ZA RAZUMEVANJE SPREMENJENE IDENTITETE KLASIČNEGA KRASA?

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POVZETEK

Sprememba evapotranspiracije (ET) je ena izmed najbolj očitnih sprememb povezanih s spremembo rabe tal oziroma vegetacijske odeje; povezava med njima pa je še slabo poznana. V tem prispevku smo krajinske spremembe najprej zaznali kot spremembo vegetacijske odeje med dvema časovnima oknoma (2002 – 2014), nato pa to spremembo povezali s spremembami v ocenjeni dnevni ET za mesec junij na območju klasičnega Krasa v Sloveniji, pri čemer smo se poslužili posnetkov satelita LANDSAT. Tako smo relativne razlike v ET povezali z dinamiko spremenjene rabe tal v omenjenem časovnem intervalu in tako pogledali na spreminjanje kraške identitete z bolj "funkcionalnega" zornega kota. Na večini površine (74%) se je ET v obdobju 12 let povečala, kar se ujema z dejstvom da se krajina zarašča; najprej z grmišči in nato z gozdom, kar pomeni višje vrednosti ET. Vendar pa so površine s povečano ET sovpadale tudi s površinami, kjer v časovnem intervalu ni bilo sprememb, še posebno v kategoriji gozd (75%). To je bilo še posebej očitno na vzhodnem delu območja, kar razlagamo s hudim žledom pozimi 2014. Lahko zaključimo, da je sprememba v ocenjeni ET lahko pomembno orodje in dopolnilna mera za obravnavo krajinskih sprememb z bolj »funkcionalnega vidika«. S tega stališča bi morali morda pojem »krajinske identitete« ustrezno razširiti.

Ključne besede: klasični Kras, evapotranspiracija, krajinske spremembe, raba tal, NDVI

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DELO NAŠIH ZAVODOV IN DRUŠTEV

ATTIVITÁ DEI NOSTRI ISTITUTI E DELLE NOSTRE SOCIETA

ACTIVITIES BY OUR INSTITUTIONS AND ASSOCIATIONS

22. SIMPOZIJ O OKOLJSKI BIOGEOKEMIJI V PIRANU

V dneh med 28. septembrom in 3. oktobrom 2015 je potekal v Piranu 22. simpozij o okoljski biogeokemiji v organizaciji Morske biološke postaje Nacionalnega inštituta za biologijo in Odseka za znanosti o okolju Instituta Jožef Stefan (www.iseb22.ijs.si). Tovrstne simpozije že več kot trideset let vsako drugo leto pripravlja Mednarodno združenje za okoljsko biogeokemijo (International Society for Environmental Biogeochemistry – ISEB). S svojo naravno lepoto, zgodovinskimi in kulturnimi znamenitostmi in ugodno zemljepisno lego v Tržaškem zalivu je Piran skoraj idealna lokacija za tovrstne kongrese. Tržaški zaliv in severni Jadran nasploh sta bila v zadnjih petdesetih letih področji intenzivnih biogeokemijskih raziskav, kar ju uvršča med znanstveno-raziskovalno relevantna področja za simpozij. ISEB se je v svoji zgodovini delovanja posvečal razvoju znanstvene misli in uporabi ter izobraževanju na področju okoljske biogeokemije. Ker je ISEB vedno stremel k združevanju raziskovalcev iz različnih disciplin, je tudi tokratni simpozij privabil znanstvenike s področja znanosti o tleh, mikrobne ekologije ter znanosti o morju in atmosferi in limnologije. Simpozija se je udeležilo več kot 100 raziskovalcev iz 23 držav. Glavni namen simpozija je bil razširiti spoznanja in izmenjati izkušnje s področja interdisciplinarnih biogeokemijskih raziskav, ki se navezujejo na znanosti o okolju, mikrobiologijo, kemijo, pedologijo, geologijo, limnologijo, ekologijo, študij morskih in kopenskih procesov in ekosistemov. Posebna pozornost je bila namenjena biogeokemijski problematiki onesnaženja tal, voda in ozračja, pri čemer sta za njeno reševanje izredno pomembna povezovanje in izmenjava znanja, izkušenj ter dobrih praks na lokalnem in globalnem nivoju. Sekcije so bile organizirane v obliki sledečih tematskih sklopov: morsko in obalno okolje, površinske in talne vode, tla, klimatske spremembe, mikrobna biogeokemija, nanodelci in koloidi, izotopi v biogeokemijskih procesih, biogeokemija onesnaževal in arheološka biogeokemija. Program je vseboval tudi dve

Udeleženci 22. simpozija o okoljski biogeokemiji na ekskurziji v Škocjanskih jamah
Symposium participants during excursion in Škocjanske Caves.

sekciji GMOS in GEOTRACES (raziskave morskega in obalnega okolja) ter GLOBAQUA (raziskave površinskih in podzemnih vod). Sekcije o biogeokemiji tal so bile posvečene Mednarodnemu letu tal (IYS), njihov glavni namen je bil širjenje pomena o varnosti hrane, prilagajanju kmetijstva klimatskim spremembam, zmanjševanju revščine in trajnostni razvoj. Močna mednarodna zasedba šestih vabljenih predavateljev, 54 ustnih predstavitev in 54 posterjev je v štirih dneh predstavila današnjo okoljsko biogeoekmijsko tematiko. Program je vseboval še strokovni ogled Piranskih solin in Morske biološke postaje ter izlet v Lipico, Škocjanske jame in Hrastovlje. Drugi dan simpozija je udeležence sprejel piranski župan.

Jadran Faganeli in Nives Ogrinc

OCENE IN POROČILA

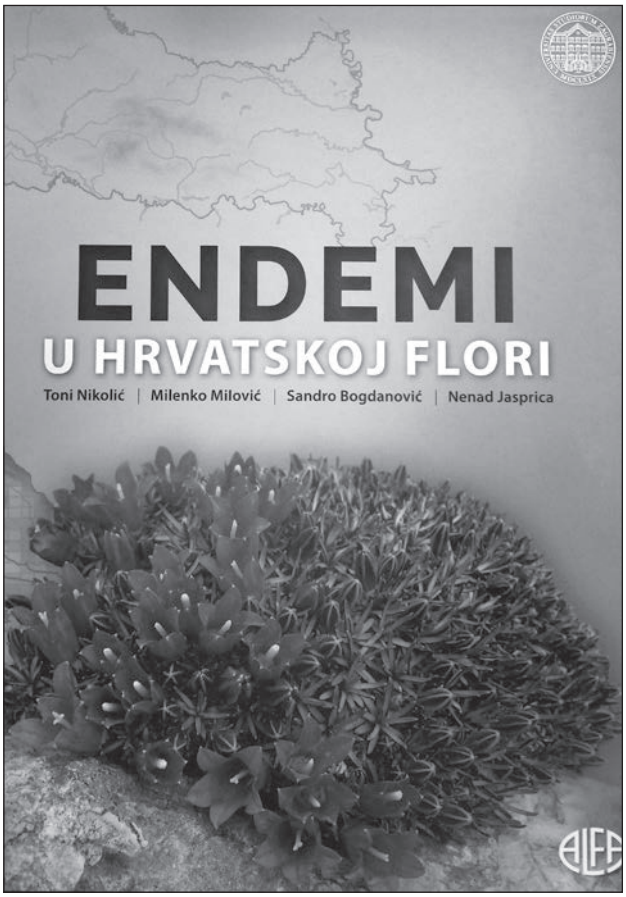
RECENSIONI E RELAZIONI

REVIEWS AND REPORTS

Ocena knjige: »ENDEMI U HRVATSKOJ FLORI« avtorjev Tonija Nikolića, Milenka Milovića, Sandra Bogdanovića in Nenada Jasprice

V letu 2015 je kot učbenik Zagrebške univerze (Sveučilište u Zagrebu) v produkciji založniške hiše Alfa d. d. na skoraj 500 (!) straneh izšla bogato ilustrirana in tudi sicer likovno izvrstno opremljena knjiga o endemitih Hrvaške. Avtorji pripadajo srednji oziroma mlajši generaciji hrvaških botanikov; kot prvi avtor je zapisan Toni Nikolić, profesor sistematske botanike na zagrebški Naravoslovno-matematični fakulteti. Milenko Milović je prizadeven in razgledan florist, ki poučuje na šibeniških srednjih šolah. Sandro Bogdanović je taksonom in florist z zagrebške Agronomske fakultete. Nenad Jasprica pa prihaja z dubrovniške univerze. Vsi so izvrstni poznavalci flore, nekateri tudi avtorji pomembnih taksonomskih in filogenetskih znanstvenih del, ki obravnavajo hrvaško floro. Kratkemu predgovoru sledi Uvod (avtor Toni Nikolić), kjer so jasno, a koncizno razdelani pojmi biodiverzitete, flore, endemizma kot pojava in posebej še endemizma v hrvaški flori. Beseda teče tudi o stopnji raziskanosti in ogroženosti endemitov.

Sledijo poglavja, v katerih je temeljito obdelanih 155 taksonov, v manjši meri pa je obravnavanih še dodatnih



53 taksonov, kar pa pomeni »le« 54 % hrvaških endemitov, kot jih avtorji razumejo na osnovi literaturnih virov. Hkrati pripominjajo, da kritični pregled skozi 384 na hrvaškem prepoznanih endemitov kaže na to, da je obstoj nekaterih skrajno dvomljiv, tako da ocenjujejo, da so v knjigi vendarle obdelali okrog tri četrtine (76 %) hrvaških endemitov. Kakorkoli že, temeljita obravnava 155 vrst zasluži pozornost tudi slovenskih botanikov in ljubiteljev rastlin z več vidikov. Na prvo mesto bi postavil sam način obdelave: vsaka obravnava posameznega taksona je avtorsko delo enega od soavtorjev in vsebuje vse relevantne podatke od mesta prve objave, *locus classicus*, sinonimov, ljudskih in tujih domačih imen v hrvaškem, italijanskem, angleškem, nemškem, francoskem in slovenskem jeziku. Sledi obširen opis vrste in razširjenosti, pri čemer je dodana tudi karta razširjenosti. Opisani so rastišče in ekologija rastišča, ogroženost ter zgodovinske in druge zanimivosti. Sledi obširen pregled relevantne literature za posamezno vrsto. Seveda je vsaka vrsta ilustrirana z več barvnimi fotografijami, pogosto pa še z risbami, herbarijskimi polami, starimi opisi in ilustracijami iz zgodnjih botaničnih del, fotografijami pomembnih botanikov, botaničnimi znamkami in podobnim materialom, ki vsestransko osvetli obravnavano vrsto z vseh vidikov. Ponekod so za boljše prepoznavanje taksonov dodani ključi za določanje, ki pa so lahko tudi v obliki tabel ali narisanih morfoloških ali mikroskopskih detajlov.

Knjiga je zanimiva za slovenske bralce tudi zato, ker se endemizem ne konča na političnih mejah, ampak na naravnih mejah. Zato je znaten delež obravnavanih taksonov razširjen tudi v Sloveniji (in drugih državah, ki mejijo na Hrvaško ali celo širše). Obravnavanih je nekaj vrst, ki jih tudi v Sloveniji obravnavamo kot karizmatične iz različnih razlogov. Tako so v knjigi zajete vrste in podvrste, ki so tudi v Sloveniji deležne posebne pozornosti – ali zato, ker so bile v Sloveniji opisane, ker so avtorji opisov Slovenci, ker se imenujejo po slovenskih botanikih, ker gre za rastline, ki v Sloveniji dosežejo mejo areala, se imenujejo po naših toponimih, ki jih je Slovenija predlagala na seznam »evropsko pomembnih rastlin« ali pa so na kak drug način »razvpite«: *Seseli malyi, Seseli tommasinii, Grafia golaka, Genista holopetala, Drypis spinosa* subsp. *jacquiniana, Allyssum montanum* subsp. *pluscanescens, Astragalus monspessulanium* subsp. *Illyricus, Crocus weldenii, Scabiosa silenifolia, Cerastium dinaricum, Dianthus tergestinus, Campanula cespitosa, Campanula waldsteiniana, Campanula justiniana, Chouardia (Scilla) litardieri, Arabis scopoliana, Edrianthus tenuifolius, Iris illyrica, Iris croatica, Moehringia tommasiniana* itd. Med opisanimi je veliko t. i. submediteransko-ilirskih vrst, ki sestavljajo floro kraških suhih travišč ter gozdnih ilirsko-balkanskih vrst. Oba geoelementa segata tudi v Slovenijo.

Prave poslastice za bralca pa so seveda hrvaški stenoendemiti, med katerimi je kar nekaj otoškega endemizma, pa endemizma posameznih predelov Jadrana (Kvarner) in Dinaridov (Biokovo).

Treba je opozoriti, da hrvaški taksonomi »ne mirujejo« in da nastajajo tudi v tem desetletju novi opisi endemičnih vrst. Primer je *Campanula teutana* z otoka Visa, opisana leta 2014.

Knjiga pomeni tudi izziv za slovenske botanike, saj ima kateri od endemičnih taksonov, opisanih v knjigi, morda širšo razširjenost in sega tudi v Slovenijo, pa to do sedaj še ni bilo dovolj zabeleženo v literaturi (*Berberis croatica, Anthyllis montana* subsp. *atropurpurea*, nekatere vrste rodu *Ophrys*, ipd.).

Dalo bi se razpravljati tudi o podrobnostih, na primer o izboru vrst ali nomenklaturi, ki je bila uporabljena za to knjigo, vendar gre za zanemarljive podrobnosti. Avtor teh vrstic je očaran nad bogato opremljenim delom, ki prinaša ogromno informacij in vsakega – profesionalnega ali amaterskega – ljubitelja rastlin kar »naganja« v naravo, na Hrvaško, da se z obravnavanimi taksoni tudi osebno sreča.

Na koncu bi rad čestital avtorjem za odlično opravljeno delo; za njim je ogromno porabljenega časa in truda, ki ga profesionalni botaniki v 21. stoletju – vsaj v Sloveniji – na žalost moramo porabiti za vse prej kot pa za pisanje takšnih časovno in vsebinsko zahtevnih znanstvenih monografij. Slovenski prenormiran sistem vrednotenja znanstveno-raziskovalnega dela (vzdrževanje sistema potrebuje vedno več sredstev in ljudi, medtem ko se sredstva za samo raziskovalno delo rapidno zmanjšujejo) takšnim monografijam, ki nastajajo leta in za katere je potrebno enormno znanje, odmeri zanemarljivo pičle »točke«. Morda zato takšna knjiga v Sloveniji še ne bo nastala kmalu … želel pa bi si, da se motim.

Mitja Kaligarič

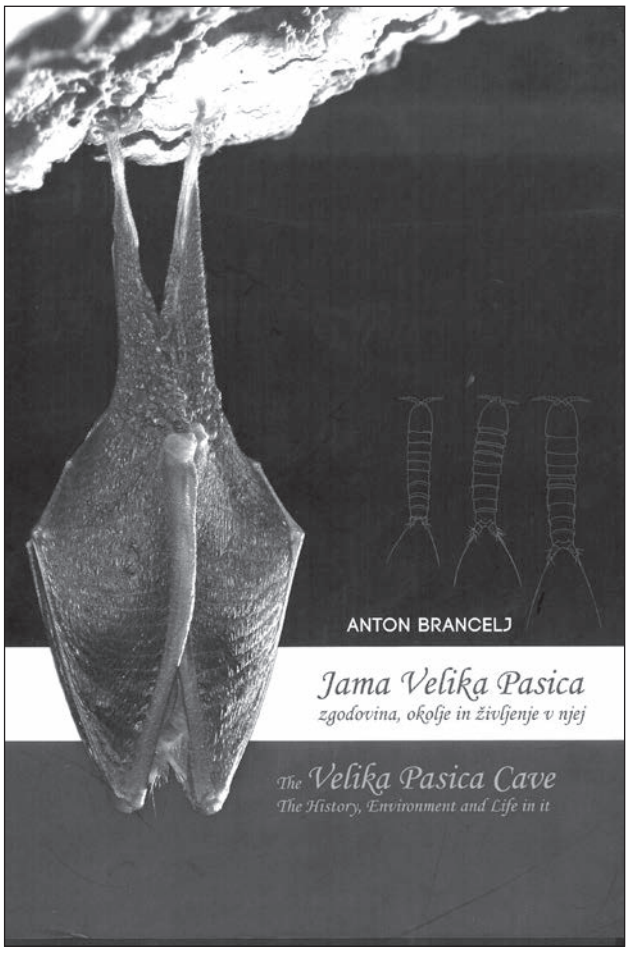
Anton Brancelj: JAMA VELIKA PASICA: ZGODOVINA, OKOLJE IN ŽIVLJENJE V NJEJ / *THE VELIKA PASICA CAVE: THE HISTORY, ENVIRONMENT AND LIFE IN IT*. Založba ZRC in Nacionalni inštitut za biologijo, Ljubljana, 2015, 110 str.

Prof. dr. Tone Brancelj je vrhunski zoolog in biospeleolog, ki se je že v mladih letih zapisal raziskovanju jamskega življa. Spoznal sem ga še kot dijak, ko je bil mentor na taboru nekje proti koncu sedemdesetih let prejšnjega stoletja, ki so ga priredili entuziasti Obalnega kluba mladih raziskovalcev iz Kopra. Danes je dr. Brancelj aktiven predvsem v dveh znanstvenih disciplinah, in sicer limnologiji in biospeleologiji. Zanimajo ga razne skupine jamskih nevretenčarjev, predvsem raki ceponožci (Copepoda) in vodne bolhe (Cladocera). Opisal je številne nove vrste pravih vodnih jamskih nevretenčarjev (stigobionti) in o tem tudi že pisal v reviji Annales.

Tokrat je pripravil monografsko delo o jami Velika Pasica, ki ima v tradiciji jamskega raziskovanja zelo velik pomen, pa čeprav gre za komajda 100 m dolgo jamo. Knjiga je napisana v privlačnem slogu in obsega zanimiva zgodovinska odkrivanja te jame ter sodobne raziskave z novimi tehnikami vzorčenja. Slikovno gradivo je raznoliko, od ličnih fotografij, zemljevidov, diagramov in raznih ilustracij do originalnih dokumentov iz katastra Društva za raziskovanje jam.

Jama Velika Pasica ni samo nahajališče novih in redkih vrst, ampak pomembna lokaliteta tudi s stališča zgodovine biospeleologije. V tej jami so raziskovala zveneča imena, kot so Ferdinand Schmidt, Georg Frauenfeld, Giuseppe Müller, Ljudevit Kuščer, Egon Pretner in drugi. Velika Pasica je povrhu vsega še lahko dostopna in nezahtevna, zato ne preseneča dejstvo, da so jo že pred poldrugim stoletjem obiskovali navdušeni zbiralci jamskih hroščev. Znani pa so tudi primeri vandalizma, saj so mnogi radovedneži iz Velike Pasice jemali jamske suvenirje, o čemer pričajo polomljeni kapniki. Danes jama ni več dostopna za obisk, pač pa so v njej postavili jamski laboratorij z namenom rednega merjenja ekoloških parametrov.

V monografiji izvemo veliko o različnih aspektih Velike Pasice. Velik del monografije avtor nameni sodobnim raziskavam, ki jim je posvetil osem let kontinuiranih raziskav živih in neživih dejavnikov v jami. Še posebej so ga zanimale prenikle vode. V različnih poglavjih avtor opiše raziskave meteoroloških in hidroloških značil-



nosti, kemijske sestave in jamske biodiverzitete. S tega vidika je še posebej zanimiva ekologija vodnih vrst in njihovih prilagoditev.

In zakaj je jama Velika Pasica nekaj posebnega? V Veliki Pasici so zoologi opisali 13 vrst jamskih nevretenčarjev, začenši z letom 1853, ko je Sturm opisal jamskega dlakavega brezokca (*Anophthalmus hirtus)*. Štiri izmed novo opisanih vrst je odkril avtor sam. Opisal je štiri jamske ceponožce, ki jih je lovil v curkih prenikle vode in v lužicah pod curki. Avtorjeva raziskovanja so odprla tudi veliko novih vprašanj o tako nabranih ali, bolje rečeno, odkritih živalskih vrstah.

V jami Velika Pasica so doslej našli 31 vrst jamskih živali, od katerih je 22 stigobiontov (vodnih jamskih živali) in 9 troglobiontov (kopenskih jamskih živali), kar je zelo veliko, saj je bilo doslej na svetu najdenih le še osem jam ali jamskih sistemov z večjim številom vrst. Če pa upoštevamo samo stigobionte, je jama Velika Pasica na sedmem mestu po številu vrst.

Avtorju je s knjigo uspelo dokazati, da je majhna jama nedaleč od Ljubljane še eden izmed izjemnih biserov z vidika biodiverzitete, s katerim se lahko ponaša naša deželica.

Lovrenc Lipej

Dr. Anton Brancelj pri vzorčenju v Veliki Pasici. (Foto: D. Tome)
Dr. Anton Brancelj during sample collection in the Velika Pasica cave. (Photo: D. Tome)

NAVODILA AVTORJEM

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Primeri navajanje različnih tipov bibliografskih podatkov:

članki v revijah:

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

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

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

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

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

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

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

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

UREDNIŠTVO

ISTRUZIONI PER GLI AUTORI

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Esempio di lavoro bibliografico:

Articoli in riviste:

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

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

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

Capitoli di libro:

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

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

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

14. La Redazione rimane a disposizione per eventuali chiarimenti.

LA REDAZIONE

INSTRUCTIONS TO AUTHORS

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Articles published in serial publications:

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

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

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

Chapters published in a book:

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

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

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

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

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

EDITORIAL BOARD

KAZALO K SLIKAM NA OVITKU

SLIKA NA NASLOVNICI:
Čeprav bi mante ali morske vrage običajno pričakovali le v tropskih morjih, ena izmed vrst, *Mobula mobular,* naseljuje tudi Sredozemsko morje. Pred kratkim pa je bila v njem odkrita še druga vrsta, *M. japanica*. Na sliki ena od tropskih mant tik pod površino. (Foto: B. Furlan)
Sl. 1: Morski psi, ki so nekoč vzbujali strah in trepet morij in oceanov, so danes ponekod priljubljena turistična atrakcija, ki privablja čedalje več potapljačev. (Foto: B. Furlan)
Sl. 2: Sečoveljske soline danes niso samo znana ornitološka lokaliteta in pomembno mokrišče, ampak jo raziskujejo tudi strokovnjaki iz drugih strok. (Foto: I. Škornik)
Sl. 3: O žetvi soli v Sečoveljskih solinah in njeni ceni izvirajo pomembni zapisi v piranskem mestnem arhivu že iz leta 1637. (Foto: I. Škornik)
Sl. 4: Srečanja med potapljači in morskimi psi so danes zaradi hudega upada populacij morskih psov v mnogih morjih sveta znatno redkejša kot včasih. Do njih lahko pride predvsem v okoljih, ki so dovolj oddaljena od obrežnih mest. (Foto: B. Furlan)
Sl. 5: Rastline z večjo biomaso imajo večjo listno površino, kar pomeni večjo evapotranspiracijo. V tej luči je pomembno, da razumemo, da se vegetacija ne spreminja zgolj v smislu vrstnega obrata in zunanjega izgleda, ampak tudi s funkcionalnega stališča. (Foto: M. Kaligarič)
Sl. 6: Kraški rob je biolog Andrej Gogala primerjal s koralnim grebenom. Zaraščanje z visokimi steblikami in grmi pa pomeni z vrstami najbogatejšo fazo v sukcesiji, ki vodi v gozd. (Foto: M. Kaligarič)

INDEX TO IMAGES ON THE COVER

FRONT COVER:
Although manta rays or devilrays would only be expected to inhabit topical seas, there is one species, the giant devilray *Mobula mobular,* that can also be found in the Mediterranean. Recently, a second species of devilray, *M. japonica,* has been discovered to reside in this region. The photo shows one of the tropical manta rays, swimming just below the surface. (Photo: B. Furlan)
Fig. 1: Sharks, which used to have a fearsome reputation, are nowadays in certain sites considered a tourist attraction, drawing more and more divers. (Photo: B. Furlan)
Fig. 2: Today, the Sečovlje salina is not only appreciated as a renowned ornithological locality and important coastal wetland, but is also investigated by researchers from other scientific fields. (Photo: I. Škornik)
Fig. 3: The Piran Archive has been an important source of information about salt harvesting and salt prices in the Sečovlje salina. (Photo: I. Škornik)
Fig. 4: Shark encounters have become increasingly rarer due to a steep decline in the shark populations in the seas around the world. Divers are more likely to run into sharks in areas away from coastal cities. (Photo: B. Furlan)
Fig. 5: Plants with higher biomass have a larger leaf area and, consequently, a higher evapotranspiration rate. In this light, it is important to understand that vegetation is changing not only in terms of species turnover and physical appearance, but also from a functional point of view. (Photo: M. Kaligarič)
Fig. 6: Biologist Andrej Gogala compares the Karst Edge to the coral reef. The tall-herb and scrub encroachment is the most species-rich phase in a succession towards the forest. (Photo: M. Kaligarič)

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