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VSEBINA / *INDICE GENERALE / CONTENTS*

SREDOZEMSKI MORSKI PSI

SQUALI MEDITERRANEI

MEDITERRANEAN SHARKS

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RECENT RECORDS OF THE GREAT WHITE SHARK, *CARCHARODON CARCHARIAS* (LINNAEUS, 1758) (CHONDRICHTHYES: LAMNIDAE), IN TURKISH WATERS (EASTERN MEDITERRANEAN)

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ABSTRACT

Between January 2016 and April 2018, 3 juvenile great white sharks, Carcharodon carcharias *(Linnaeus, 1758), were incidentally captured in the coastal waters of the Turkish Aegean Sea. Journeys of young-of-the-year (YOY) and juvenile specimens can increase the risk of their encountering fishing gears if the specimens head for regions where the fishery of the great whites is not banned. An understanding of the geographic range and knowledge of the vertical distribution of the YOY and juvenile great whites are therefore necessary to implement a management plan for great white populations in Turkish waters and to reduce the incidental fishing mortality of this vulnerable top predator.*

Key words: Great white shark, *Carcharodon carcharias*, conservation, nursery, distribution

RECENTI RITROVAMENTI DEL GRANDE SQUALO BIANCO, *CARCHARODON CARCHARIAS* (LINNAEUS, 1758) (CHONDRICHTHYES: LAMNIDAE), IN ACQUE TURCHE (MEDITERRANEO ORIENTALE)

SINTESI

Nel periodo tra gennaio 2016 e aprile 2018, 3 giovani esemplari del grande squalo bianco, Carcharodon carcharias *(Linnaeus, 1758), sono stati catturati accidentalmente nelle acque costiere del mar Egeo turco. Gli spostamenti degli esemplari che non hanno ancora raggiunto il primo anno di età (YOY) e degli stadi giovanili possono aumentare il rischio di incontrare attrezzi da pesca, se gli esemplari si dirigono verso regioni in cui la pesca dei grandi squali bianchi non è vietata. Una comprensione dell'estensione geografica e la conoscenza della distribuzione verticale degli esemplari YOY e degli stadi giovanili della specie sono quindi necessarie per attuare un piano di gestione per le popolazioni del grande squalo bianco nelle acque turche e per ridurre la mortalità causata dalla pesca accidentale di questo vulnerabile predatore.*

Parole chiave: grande squalo bianco, *Carcharodon carcharias*, conservazione, area di riproduzione, distribuzione

INTRODUCTION

The great white shark, *Carcharodon carcharias* (Linnaeus, 1758), has been known in Turkish waters since the Middle Ages (Bellonii, 1553; Kabasakal, 2014). In the 16th-century manuscript, Bellonii (1553) reported a great white shark caught off the İzmir coast (central Aegean Sea). Besides this historical anecdotal record, the majority of data on the occurrence of *C. carcharias* in Turkish waters have been gathered since the 1880s (Kabasakal, 2014, 2016). In a recent review on the historical and contemporary dispersal of the great white shark in Turkish waters, Kabasakal (2016) concluded that 54 specimens were recorded in the mentioned region between 1881 and 2014.

Since *C. carcharias* is a mythic species with the status of endangered large shark in the Mediterranean Sea (Cavanagh & Gibson, 2007), each capture constitutes an ichthyological event of which the world of ichthyology deserves to be informed. In the present article, the authors report on the recent captures of the great white shark in the Aegean Sea, off the Turkish coast, which are considered valuable data for the general understanding of the eastern Mediterranean distribution of *C. carcharias*.

Fig. 1: *Carcharodon carcharias****, captured on January 2, 2016, in the Bay of Edremit. (Photo: IRS archives).***
Sl. 1: Primerek belega morskega volka, ki je bil ulovljen 2. januarja 2016 v edremitskem zalivu (Foto: arhiv IRS).

MATERIAL AND METHODS

Since the great white shark is an endangered species and protected in certain parts of the Mediterranean Sea (Cavanagh & Gibson, 2007; Serena, 2005), the selection of an appropriate sample for the present study was an instance of typical opportunistic research, consisting in dead animal sampling (Jessup, 2003). A regular screening of social media, local newspapers – both printed and internet based – and recreational fishing websites provided the authors with information on the present incidental captures of great white sharks. All three cases were verified by interviewing fishermen and were considered as confirmed if a properly shot photo of the specimen accompanied the record. For the three specimens, the following data were collected: total length

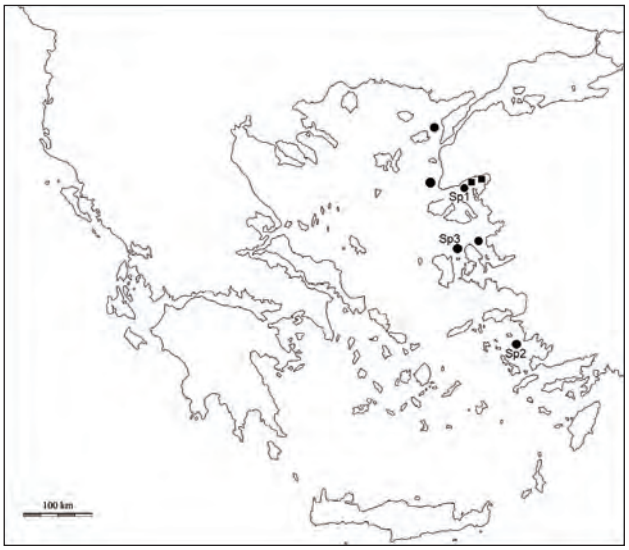

Fig. 2: Capture localities of new-born (■) and juvenile (●) specimens of *Carcharodon carcharias* ***incidentally captured in Turkish Aegean waters, from previous studies and the present research. Sp. 1: specimen from the present study captured on January 2, 2016, in the Bay of Edremit; Sp. 2: specimen from the present study captured on June 4, 2017, off the Didim coast; and Sp. 3: specimen from the present study captured on April 14, 2018, off the İzmir coast.***
Sl. 2: Lokalitete, kjer so bili v turškem delu Egejskega morja naključno ujeti novorojenec (n) in mladostni primerek (l) belega morskega volka na podlagi podatkov iz predhodnih raziskav in iz pričujoče študije. Sp. 1: primerek iz pričujoče študije, ujet 2. januarja 2016 v zalivu Edremit; Sp. 2: primerek iz pričujoče študije, ujet 4. junija 2017 ob didimski obali; in Sp. 3: primerek iz pričujoče študije, ujet 14. aprila 2018, ob obali Izmirja.

(TL) to the nearest cm, weight (W) to the nearest gram, sex, gear and capture depth. The photographs of the present specimens, referenced with dates of capture and fishing localities, are preserved in the digital archives of the Ichthyological Research Society (IRS).

RESULTS AND DISCUSSION

On January 2, 2016, a female great white shark (Sp. 1; Fig. 1) got entangled in a coastal stationary net in the Bay of Edremit (northeastern Aegean Sea; Fig. 2). The total length of the shark was 175 cm. The dried head, jaws and caudal fin of the specimen are preserved by local fishermen in Altınoluk province. A male great white shark (Sp. 2; Fig. 3), measuring 200 cm in total length and weighing 60 kg, was captured by a commercial purse-seiner off the Didim coast (central Aegean Sea; Fig. 2) on June 4, 2017. On April 14, 2018, a female great white shark (Sp. 3; Fig. 4), was captured by a coastal stationary-netter, off the İzmir coast (central Aegean Sea; Fig. 2), and the total length of the specimen was 180 cm. After being displayed at the fishmonger's for a few days, specimens 2 and 3 were discarded, and no body parts were preserved to be available for further inspection.

Fig. 3: *Carcharodon carcharias****, captured on June 4, 2017, off the Didim coast. (Photo: IRS archives).***
Sl. 3: Primerek belega morskega volka, ki je bil ulovljen 4. junija 2017 ob didimski obali (Foto: arhiv IRS).

Based on previous records (n = 54; Kabasakal, 2016) and the results of the present study, 57 specimens of *C. carcharias* were recorded in Turkish waters from the 1880s to date. In a recent inventory study, De Maddalena & Heim (2012) provided the details of 596 great white sharks recorded in the entire Mediterranean Sea and adjacent waters. Following Boldrocchi *et al*. (2017), who recently reviewed the distribution, ecology and status of great white sharks in the Mediterranean Sea, at least 629 great white sharks were recorded in the mentioned region between 476 and 2015. Therefore, the 57 specimens of *C. carcharias* recorded in Turkish waters represent 9% of all Mediterranean records of the great white shark. Based on the available data, it is safe to presume that the great white shark is a regular seasonal visitor of Turkish waters, and that a possible breeding and nursery ground is located in the central-northern Aegean Sea (Kabasakal 2014, 2016).

Specimens of the great white sharks examined in the present research were juveniles and incidentally captured in coastal waters. Along the Aegean coast of Turkey, coastal fishery possibly puts a threatening pressure on the survival of young great white sharks, which was also suggested by previous studies (Kabasakal & Gedikoğlu, 2008; Kabasakal & Kabasakal, 2015; Kabasakal *et al.*, 2009) and confirmed by the results of the present study.

Referring to the map depicted on Figure 2, capture localities of young-of-the-year (YOY) and juvenile great white sharks extend over a wide area from northern to southern parts of the Aegean Sea. Although the juvenile specimens were captured over the entire region, YOY specimens were only captured in the waters of the Bay of Edremit (Fig. 2). Therefore, based on the data on the occurrence of YOY and juvenile great white sharks in Turkish waters (Kabasakal, 2014, 2016; results of the present study), the Bay of Edremit can be considered as a breeding ground of *C. carcharias*, where pregnant females give birth to pups between late spring and midsummer, then the juveniles move to a wider nursery region that extends along almost the entire Turkish coast of the Aegean Sea (Fig. 2). Based on the captures of pregnant females with developing or near-term embryos, and juvenile specimens, Saidi *et al*. (2005) and Rafrafi-Nouira *et al*. (2015) suggest that central Mediterranean off the Tunisian coast could be considered as a possible nursery area for *C. carcharias*, as well. In a previous study focused on the movements, behaviour and habitat preferences of juvenile specimens of *C. carcharias* in the eastern Pacific, Weng *et al*. (2007) reported that YOY great white sharks can travel over 700 km in a few months. Weng *et al*. (2007) suggest that journeys of YOY and juvenile specimens can increase the risk of them encountering fishing gears if the specimens head for regions where the fishery of the great whites is not banned. To conclude, an un-

Fig. 4: *Carcharodon carcharias****, captured on April 14, 2018, off the İzmir coast. (Photo: IRS archives).***
Sl. 4: Primerek belega morskega volka, ki je bil ulovljen 14. aprila 2018 ob izmirski obali (Foto: arhiv IRS).

derstanding of the geographic range and knowledge of the vertical distribution of the YOY and juvenile great whites are necessary to implement a management plan for great white populations in Turkish waters and to reduce the incidental fishing mortality of this vulnerable top predator.

ACKNOWLEDGEMENTS

Authors wish to thank the fishermen, who kindly provided support in the field surveys of great white shark research, carried out by Ichthyological Research Society (İstanbul) since 2000. The first author extends special thanks to his wife, Özgür, and his son, Derin, for their endless love and patience.

RECENTNI PODATKI O BELEM MORSKLEM VOLKU, *CARCHARODON CARCHARIAS* (LINNAEUS, 1758) (CHONDRICHTHYES: LAMNIDAE), V TURŠKIH VODAH (VZHODNO SREDOZEMLJE)

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POVZETEK

Med januarjem 2016 in aprilom 2018 so bili v ribiške mreže v obalnih vodah turškega dela Egejskega morja naključno ujeti trije primerki belega morskega volka, Carcharodon carcharias *(Linnaeus, 1758). Potovanja enoletnih mladičev in mladostnih primerkov v okolja, kjer ni prepovedi lova na belega morskega volka, je zaradi ribolova zelo tvegano. Razumevanje areala in navpične razširjenosti enoletnih in mladostnih morskih volkov je zato nujno za vzpostavitev akcijskega plana za populacije morskih volkov v turških vodah in za zmanjšanje naključnega ulova tega ogroženega plenilca na vrhu prehranjevalne verige.*

Ključne besede: veliki beli morski volk, *Carcharodon carcharias*, ohranjanje, vzrejno območje, razširjenost

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ADDITIONAL RECORDS OF SANDBAR SHARK, *CARCHARHINUS PLUMBEUS* (CHONDRICHTHYES: CARCHARHINIDAE) FROM THE NORTHERN TUNISIAN COAST (CENTRAL MEDITERRANEAN SEA)

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ABSTRACT

Recent investigations conducted off Ras Jebel in the northern Tunisian coast have allowed a collection of 9 specimens of sandbar shark Carcharhinus plumbeus *(Nardo, 1825), 5 males and 4 females. They ranged in size between 890 and 2030 mm and weighed between 3.5 and 38 kg. Such captures confirm the occurrence of the species in an area where a viable population seems to be successfully established. However, the origin of the species remains uncertain, it probably migrated from southern Tunisia, where the species is rather abundant, or, possibly, from western areas, the Algerian coast, where it is also commonly caught.*

Key words: *Carcharhinus plumbeus*, description, distribution, expansion range, central Mediterranean Sea

NUOVI RITROVAMENTI DELLO SQUALO GRIGIO, *CARCHARHINUS PLUMBEUS* (CHONDRICHTHYES: CARCHARHINIDAE) LUNGO LA COSTA SETTENTRIONALE DELLA TUNISIA (MEDITERRANEO CENTRALE)

SINTESI

Recenti indagini condotte al largo di Ras Jebel, lungo la costa settentrionale della Tunisia, hanno permesso di raccogliere 9 esemplari di squalo grigio, Carcharhinus plumbeus *(Nardo, 1825), ossia 5 maschi e 4 femmine. Le lunghezze degli esemplari variavano tra gli 890 e i 2030 mm, mentre il peso era compreso tra i 3,5 e i 38 kg. Tali catture confermano l'ipotesi che una popolazione vitale si sia stabilita con successo in quest'area. Tuttavia, il punto d'origine della specie rimane incerto. Gli autori ipotizzano che sia migrata dal sud della Tunisia, dove la specie è piuttosto abbondante, o da zone a occidente, quali la costa algerina, dove viene comunemente catturata.*

Parole chiave: *Carcharhinus plumbeus*, descrizione, distribuzione, intervallo di espansione, Mediterraneo centrale

INTRODUCTION

The sandbar shark *Carcharhinus plumbeus* (Nardo, 1827) is a migratory species widely distributed throughout the world and commonly reported from southern Mediterranean areas (Capapé, 1989). However, it disappeared from the northern areas of the western Basin, such as the coast of France, for instance (Capapé *et al*., 2000). The species has been only sporadically captured in the Adriatic Sea (Costantini & Affronte, 2003; Lipej *et al*., 2008; Dragičević *et al*., 2010) and in the southern Aegean Sea, off southwestern Turkey (Bilecenoglu *et al*., 2014), whereas it is still commonly and abundantly caught off the Maghreb coast (Hemida *et al*., 2002; Saïdi *et al*., 2005).

Carcharhinus plumbeus is abundant in southern Tunisian areas, such as the Gulf of Gabès, but rather rare in northern areas, its range extending as far as the Gulf of Tunis (Capapé, 1989). However, three specimens were captured in the waters surrounding the Cani Rocks (Rafrafi-Nouira *et al*., 2015), and a large female was caught off Tabarka, a city located in the northern Tunisian coast, close to the Algerian border (Soufi-Kechaou *et al*., 2018).

In the wake of a collaboration with experienced fishermen aware of fishing grounds, we were informed of other specimens of *Carcharhinus plumbeus* captured in the northern coast of Tunisia. These captures are presented and commented in this paper, offering us the opportunity to assess the real status of the species in the area.

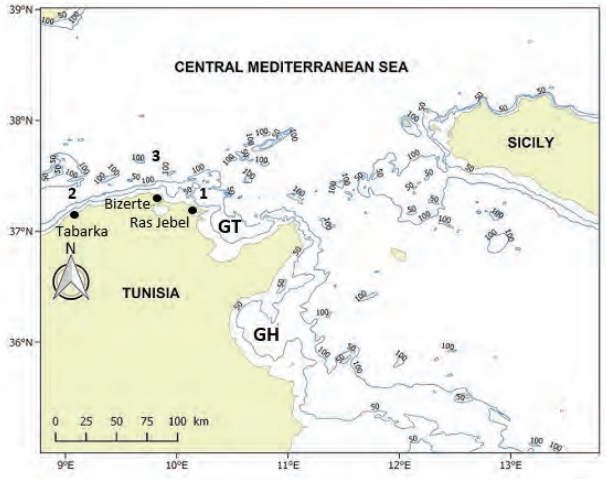

Fig. 1: Map of the northern Tunisian coast indicating two previous and the present capture sites of** Carcharhinus plumbeus**: 1. in the waters surrounding the Cani Rocks off Ras Jebel (Rafrafi et al., 2015); 2. in the waters surrounding the Galite Islands and the Cani Rocks off Tabarka (Soufi-Kechaou, 2018); 3. off Bizerte (this study). GT = Gulf of Tunis, GH = Gulf of Hammamet.
Sl. 1: Zemljevid severne tunizijske obale z označbo dveh predhodnih in nove lokalitete, kjer so ujeli sive morske pse: 1. vode, ki obkrožajo Cani Rocks blizu predela Ras Jebel (Rafrafi et al., 2015); 2. vode, ki obdajajo otoke Galite in Rocks blizu Tabarke (Soufi-Kechaou, 2018); 3. okoli Bizerte (pričujoča študija). GT = tuniški zaliv, GH = hammameški zaliv.

MATERIAL AND METHODS

On 11 July 2018, 9 specimens of *Carcharhinus plumbeus* were caught by pelagic longlines, on sandy-rocky bottoms, at depths between 140 and 170 m, together with sparid species and swordfish *Xiphias gladius* Linnaeus, 1758. These captures occurred off the city of Bizerte in northern Tunisia, at 37° 27′ 13″ N and 9° 51′ 03″ E (Fig. 1). All specimens were measured for total length (TL) to the nearest millimetre by digital callipers and weighed to the nearest gram. Due to the local economic value of *C. plumbeus*, they were immediately sold, except for the smallest specimen, which was donated by the fishermen for further laboratory examination. Morphometric measurements and tooth counts were performed on this shark following Rafrafi-Nouira *et al.* (2015). The head of the specimen was fixed in 10% buffered formalin, preserved in 75% ethanol and deposited in the Ichthyological Collection of the Faculté des Sciences de Bizerte (Tunisia), under the catalogue number FSB-Car-plu-02.

RESULTS AND DISCUSSION

The specimens were identified as *Carcharhinus plumbeus* following a combination of main morphological characters (Fig. 2): body stout, snout broadly rounded and short; first dorsal fin high, triangular, its origin over pectoral bases; pectoral fins broadly triangular, relatively long; interdorsal ridge present; upper teeth broadly triangular and serrated, with oblique cusp; lower teeth erect with narrow serrated cusp (Fig. 3), dental formula [13-1-13/12-1-12]; skin almost entirely covered by dermal denticles compactly arranged; denticles rounded, with 4 to 6 ridges extending from base to crown, exhibiting several cuspids (Fig. 4); colour of body grey to bronze on upper surface, belly whitish.

The morphology, the measurements (Table 1), the shape of the teeth in the upper and lower jaws and that of dermal denticles coincided with previous observations by Capapé *et al.* (1979), Cadenat & Blache (1981), Garrick (1982), Branstetter (1984) and Compagno (1984), allowing to identify these 9 captured specimens as *C. plumbeus*.

Of these 9 specimens, 5 were males and 4 females (Fig. 2). The total length ranged between 1367 and 2030 mm in males, and between 890 and 1258 mm in females. The total body weight in males and females ranged between 12 and 38 kg, and between 3.5 and 9.8 kg, respectively. Following previous observations related to the specimens from the Tunisian coast (Capapé,

Tab. 1: Morphometric measurements (in mm) and as percentages of total length (TL %) recorded in the specimens of *Carcharhinus plumbeus* ***(ref. FSB-Car-plu-02) caught off Bizerte.***
Tab. 1: Morfometrične meritve (v mm) in delež celotne dolžine (TL %) primerkov *Carcharhinus plumbeus* ***(ref. FSB-Car-plu-02) ujetih pri Bizerti.***

Reference	**FSB-Car-plu-02**	
Sex	**Male**	
Morphometric measurements	**mm**	**% TL**
Total length	890	100.00
Head length	170	19.10
Prebranchial length	165	18.54
Preorale length	65	7.30
Prenasal length	20	2.25
Intergill length	140	15.73
Eye with	11	1.24
Eye height	12	1.35
Internasal length	50	5.62
Mouth width	80	8.99
Distance between snout 1st gill	70	7.87
Precaudal length	250	28.09
First dorsal base	100	11.24
First dorsal inner margin	35	3.93
First dorsal posterior margin	110	12.36
First dorsal anterior margin	120	13.48
Second dorsal base	40	4.49
Second dorsal inner margin	35	3.93
Second dorsal posterior margin	40	4.49
Second dorsal anterior margin	40	4.49
Pectoral base	55	6.18
Pectoral inner margin	43	4.83
Pectoral anterior margin	140	15.73
Pectoral posterior margin	130	14.61
Pelvic base	40	4.49
Pelvic inner margin	30	3.37
Pelvic anterior margin	40	4.49
Pelvic posterior margin	50	5.62
Anal base	35	3.93
Anal inner margin	30	3.37
Anal anterior margin	50	5.62
Anal posterior margin	45	5.06
Dorsal caudal margin	220	24.72
Upper postventral caudal margin	130	14.61
Subterminal caudal margin	25	2.81
Lower postventral caudal margin	50	5.62
Preventral caudal margin	80	8.99
Terminal caudal margin	50	5.62
Caudal peduncle height	40	4.49
Weight		
Total body mass (g)	3500	

Fig 2: The nine specimens of** Carcharhinus plumbeus **caught off Bizerte. Scale bar = 300 mm.
Sl. 2: Devet primerkov sivega morskega psa, ujetih blizu Bizerte. Merilo = 300 mm.

1984; Saïdi *et al.*, 2005), male and female *C. plumbeus* mature between 1545 and 1600 mm, and between 1660 and 1720 mm, respectively. Therefore, of the 5 males captured, 4 were adults and 1 was juvenile, as confirmed by the observation of claspers, which were rigid, calcified and developed in the former (see Collenot, 1969). Conversely, it appears that all sampled females were probably juvenile, because they had not yet reached the size associated with sexual maturity (see Capapé, 1984; Saïdi *et al.*, 2005).

This is the first time that a significant number of *Carcharhinus plumbeus* was discovered in the northern Tunisian coast. Previous, even recent, captures of this species made in the same comprised large, adult and juvenile males and females (Rafrafi-Nouira *et al.*, 2015; Soufi-Kechaou *et al.*, 2018). Therefore, the presence of *C. plumbeus* in northern Tunisian waters supports the hypothesis of an established population in the area. So much so, as there exist nursery areas for *C. plumbeus* (Bradaï *et al.*, 2005) in southern Tunisia and migrations of elasmobranch species from these areas were

Fig. 3: Head of specimen FSB-Car-plu-02, with ventral surface showing teeth in the upper and lower jaws. Scale bar = 20 mm.
Sl. 3: Glava primerka FSB-Car-plu-02 s spodnje strani; vidni so zobje iz zgornje in spodnje čeljustnice. Merilo = 20 mm.

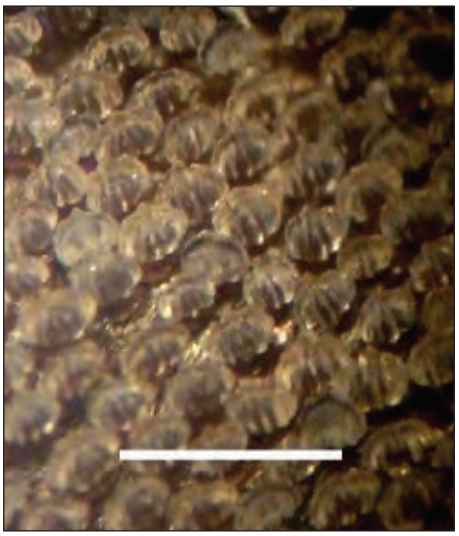

Fig. 4: Placoid scales removed from the skin of specimen FSB-Car-plu-02. Scale bar = 0.5 mm.
Sl. 4: Iz kože primerka FSB-Car-plu-02 pobrane plakoidne luske z dentikli. Merilo = 0,5 mm.

suggested by Rafrafi-Nouira *et al*. (2015). Additionally, *C. plumbeus* is rather abundant in the nearby Algerian waters, and migration from this region towards the east, including the Tunisian coast, has probably occurred. Due to the global warming of the Mediterranean (Francour *et al*., 1994), it appears that some species can be found in areas where they were previously considered rare or unknown (Ben Raïs Lasram & Mouillot, 2009); internal migration of fish has been reported throughout the Tunisian waters (Rafrafi-Nouira, 2016), with extensive migrations from distant regions, such as the Red Sea and the Eastern Tropical Atlantic, further enhancing the already important changes in the local biodiversity (Ben Amor *et al*., 2016; Ounifi-Ben Amor *et al*., 2016). Additionally, these findings may support the thesis that at present, this species cannot exactly be considered as threatened (Musick *et al*., 2009). However, following Souif-Kechaou *et al*. (2018), opposite patterns manifest in other large Mediterranean shark species, which have been faced with a drastic decline in population and are, therefore, on the way to becoming extinct in this sea (Ferretti *et al*., 2008).

NOVI ZAPISI O POJAVLJANJU SIVEGA MORSKEGA PSA, *CARCHARHINUS PLUMBEUS* (CHONDRICHTHYES: CARCHARHINIDAE) NA SEVERNI TUNIZIJSKI OBALI (OSREDNJE SREDOZEMSKO MORJE)

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POVZETEK

V okviru recentnih raziskav v vodah okoli lokalitete Ras Jebel na severni tunizijski obali je bilo ujetih 9 primerkov sivega morskega psa Carcharhinus plumbeus *(Nardo, 1825), 5 samcev in 4 samice. V dolžino so merili med 890 in 2030 mm in tehtali med 3,5 in 38 kg. Ta ujetja potrjujejo prisotnost vrste v predelu, kjer je še vedno prisotna ustaljena viabilna populacija. Kakorkoli že, izvor teh primerkov je še vedno slabo poznan; verjetno izvirajo iz voda južne Tunizije, kjer je vrsta še vedno razmeroma pogosta, ali pa iz zahodnih predelov iz Alžirije, kjer jo še vedno pogosto ulovijo.*

Ključne besede: *Carcharhinus plumbeus*, opis, razširjenost, razširjanje, osrednje Sredozemsko morje

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RECENTNE SPREMEMBE V SREDOZEMSKI BIODIVERZITETI

CAMBIAMENTI RECENTI NELLA BIODIVERSITÀ MEDITERRANEA

RECENT CHANGES IN MEDITERRANEAN BIODIVERSITY

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FIRST RECORD OF RED SEA GOATFISH *PARUPENEUS FORSSKALI* (OSTEICHTHYES: MULLIDAE) FROM TUNISIAN WATERS (CENTRAL MEDITERRANEAN SEA)

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ABSTRACT

The authors present the first record of a Lessepsian migrant identified as Parupeneus forsskali *(Fourmanoir & Guézé, 1976) based on an underwater photograph taken by a diver in the waters surrounding the Jerba Island (southern Tunisia). It is the fifth mullid species recorded in the area. The present note provides comments on the distribution of this species.*

Key words: description, distribution, expansion range, Tunisia, central Mediterranean Sea

PRIMA SEGNALAZIONE DI *PARUPENEUS FORSSKALI* (OSTEICHTHYES: MULLIDAE) IN ACQUE TUNISINE (MEDITERRANEO CENTRALE)

SINTESI

Gli autori presentano il primo ritrovamento di un migrante lessepsiano identificato come Parupeneus forsskali *(Fourmanoir e Guézé, 1976) in base ad una fotografia subacquea scattata da un subacqueo nelle acque che circondano l'isola di Gerba (Tunisia meridionale). È la quinta specie di mullidi confermata per l'area. La presente nota fornisce commenti sulla distribuzione di questa specie.*

Parole chiave: descrizione, distribuzione, intervallo di espansione, Tunisia, Mediterraneo centrale

INTRODUCTION

The Red Sea goatfish *Parupeneus forsskali* (Fourmanoir & Guézé, 1976) is known as the most common mullid species in the Red Sea and Gulf of Aden, and one with a high economic value (Golani *et al*., 2017). The species has recently entered the Mediterranean Sea through the Suez Canal. Two specimens were sighted in Turkish waters (Çinar *et al*., 2006), while other specimens were recorded in the Levant Basin (Bariche *et al*., 2013; Sonin *et al*., 2013; Ali *et al*., 2016). Following Ergüden et *al.* (2018), *P. forsskali* appears to be successfully established throughout the Turkish coast and probably in the entire eastern Mediterranean Basin. The species has migrated toward western areas and has also been recorded off the Egyptian coast (Mehanna *et al*., 2016).

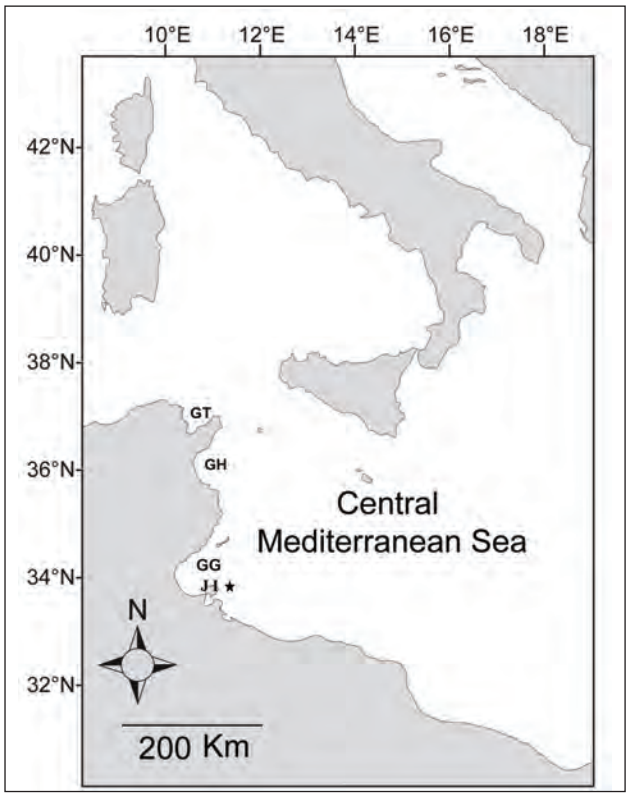

Fig. 1: Map of the Central Mediterranean Sea copied from Ben Amor** et al. **(2016) indicating the site where the photograph of** Parupeneus forsskali **was taken in the waters surrounding the Jerba Island (JI, black star) in the Gulf of Gabès (GG). Gulf of Tunis (GT). GH = Gulf of Hammamet.
Sl. 1: Zemljevid osrednjega Sredozemskega morja (prirejeno po Ben Amor in sod., 2016) z označeno lokaliteto, kjer je bil ob otoku Jerba (JI, črna zvezdica) v Gabeškem zalivu fotografiran primerek vrste** Parupeneus forsskali**. Oznake: Gabeški zaliv (GG), Tuniški zaliv (GT), Hammameški zaliv (GH).

The migration has been confirmed by underwater observations in Tunisian waters, as a diver photographed the species in the wild and provided us with information about this important sighting, all of which is presented herein.

MATERIAL AND METHODS

P. forsskali was observed for the first time in the southern waters of the Gulf of Gabès surrounding the Jerba Island (33° 45′ 35″ N and 11° 03′ 12″) on 14 August 2016, at a depth not exceeding 7 m, on sandy-muddy bottom partially covered by sea grass and algae (Fig. 1), together with several sparid and mullid species. The specimen is herein described on the basis of a photograph (Fig. 2).

RESULTS AND DISCUSSION

The specimen was identified from a photograph as *P. forsskali* following a combination of characters: body elongated, slightly compressed, depth from origin of the first dorsal fin 20.5 %, pointed large upper profile of head slightly concave, eyes located in the upper part of the head, two long barbels both located on the chin, body pink with a black stripe from front tip of snout through the eye, along upper side of body, ending below rear base of second dorsal fin; a round black spot, about as large as the eye, on posterior third of caudal peduncle above lateral line, head and body yellow above stripe, white below, caudal fin yellow.

The external morphology and colour patterns of the present specimen are in complete agreement with Sonin *et al.* (2013), Bariche *et al.* (2013) and Ali *et al.* (2016), which – despite the identification being based on a photograph – allows us to confirm this as the first record of *Parupeneus forsskali* in Tunisian waters. However, captures of additional specimens will be needed for a taxonomic verification following the suggestions of Bello *et al.* (2014) and assessment of the species' real status in the area where five mullid species have been reported to date. Two of them – the red mullet *Mullus barbatus* Linnaeus, 1758, and the striped red mullet *M. surmuletus* Linnaeus, 1758 – are native, the remaining three – the West African goatfish *Pseudupeneus prayensis* (Cuvier, 1829), found off the northern Tunisian coast (Azzouz *et al*., 2011), and two Lessepsian migrants, Por's goatfish *Upeneus pori* Ben-Tuvia & Golani, 1989, and the Red Sea goatfish *P. forsskali* – are allochthonous. *U. pori* was found in Bahiret El Biban, a brackish area located in southern Tunisia (Ben Souissi *et al*., 2006), migrating toward northern areas, where captures of the species occurred in the Lagoon of Bizerte (Azzouz *et al*., 2010). At present, *U. pori* is successfully established in the central Mediterranean and Italian seas (Deidun *et al*., 2018).

The frequency of records of *P. forsskali* suggests an expansion of this species similar to that of *U. pori* into

Fig. 2: *Parupeneus forsskali* ***(underwater photograph by Hédi Zaouali).***
Sl.. 2: *Parupeneus forsskali* ***(podvodni posnetek, foto: Hédi Zaouali).***

the central Mediterranean and probably into the western basin. Additionally, the underwater photographer informed us that other *P. forsskali* specimens surrounded the present specimen. Furtherly, *P. forsskali* and *U. pori* should be locally monitored to allow an assessment of their importance and role in their new habitats. Interspecific competition between them and other indigenous mullid species cannot be totally ruled out, nor that between *P. forsskali* and *U. pori* and other teleost species inhabiting similar biotopes and foraging for same preys.

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PRVI ZAPIS O POJAVLJANJU BRADAČA VRSTE *PARUPENEUS FORSSKALI* (OSTEICHTHYES: MULLIDAE) IZ TUNIZIJSKIH VODA (OSREDNJE SREDOZEMSKO MORJE)

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POVZETEK

Avtorji poročajo o prvem zapisu o pojavljanju lesepske ribje selivke vrste Parupeneus forsskali *(Fourmanoir & Guézé, 1976) v vodah okoli otoka Jerba (južna Tunizija). Podatek temelji na fotografiji, ki jo je posnel podvodni fotograf. To je peta vrsta bradačev, ki so bile doslej ugotovljene na obravnavanem območju. Avtorji nadalje razpravljajo o razširjanju vrste.*

Ključne besede: opis, razširjenost, širjenje areala, Tunizija, osrednje Sredozemsko morje

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THE NORTHERNMOST RECORD OF THE THERMOPHILIC MEDITERRANEAN PARROTFISH *SPARISOMA CRETENSE* (LINNAEUS, 1758) (PERCIFORMES, SCARIDAE) IN THE EASTERN MEDITERRANEAN SEA (NORTHWESTERN AEGEAN SEA)

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ABSTRACT

On July 2018 a specimen of the thermophilic fish Sparisoma cretense*, commonly known as Mediterranean parrotfish, was captured in the Thermaic Gulf in the northwestern Aegean Sea, Greece, constituting the first such record in the region. The species mainly inhabits the southeastern shores of the Mediterranean, and its presence is in line with previous records of other thermophilic species in the northern Aegean which can be associated with the rise of sea temperatures as one of the signs of climate change. This record is the northernmost in the Eastern Mediterranean and the second northernmost record for the whole Mediterranean basin.*

Key words: *Sparisoma cretense*, thermophilic species, new records, biodiversity, climate change, Aegean Sea

RITROVAMENTO PI*Ù* A NORD DEL PESCE PAPPAGALLO MEDITERRANEO TERMOFILO *SPARISOMA CRETENSE* (LINNAEUS, 1758) (PERCIFORMES, SCARIDAE) NEL MEDITERRANEO ORIENTALE (MAR EGEO NORD-OCCIDENTALE)

SINTESI

Nel luglio 2018 un esemplare del pesce termofilo Sparisoma cretense*, comunemente noto come pesce pappagallo mediterraneo, è stato catturato nel Golfo Termaico nel mar Egeo nord-occidentale, in Grecia, costituendo il primo ritrovamento della specie nella regione. La specie vive principalmente lungo le coste sud-orientali del Mediterraneo e la sua presenza è in linea con le precedenti segnalazioni di altre specie termofile nell'Egeo settentrionale, che possono venir associate all'innalzamento della temperatura del mare come uno dei segni del cambiamento climatico. Questo ritrovamento è il più settentrionale del Mediterraneo orientale e il secondo più settentrionale per l'intero bacino del Mediterraneo.*

Parole chiave: *Sparisoma cretense*, specie termofile, nuovi ritrovamenti, biodiversità, cambiamenti climatici, mar Egeo

INTRODUCTION

The Mediterranean parrotfish, *Sparisoma cretense* (Linnaeus, 1758) is the only native parrotfish species of the Mediterranean Sea and can be added to the records of a few other temperate species within the Scaridae family (Froese & Pauly, 2018). So far, two alien Scaridae species have been reported within the Mediterranean, *Chlorurus rhakoura* Randall & Anderson, 1997 off the Italian coast (Insacco & Zava, 2017), and *Scarus ghobban* Forsskål, 1775 reported for the first time off the coasts of Israel in 2002 (Goren & Aronov, 2002).

The Mediterranean parrotfish occurs along the east coast of the Atlantic Ocean from Senegal to Portugal and within the Mediterranean Sea, mainly inhabiting the south and east coasts (Louisy, 2015). Similar to *Thalassoma pavo* (Linnaeus, 1758), the Mediterranean parrot fish is an ancient Mediterranean colonizer of Atlantic origin (Domingues *et al.,* 2008). It can be found at a maximum depth of 50 m (Petrakis & Papaconstantinou, 1990), but more usually between 5-15 m of depth (Guidetti & Boero, 2002). Mainly active during the day (Azzurro *et al.,* 2007; 2013), it is a herbivorous species feeding on algae and seagrasses, *e.g. Posidonia oceanica* (Linnaeus) Delile, 1813 (de Girolamo *et al.,* 1999) and *Cymodocea nodosa* (Ucria) Ascherson, 1870 (Del Río *et al.,* 2016). While the adult population prefers mixed habitats with seagrass meadows and reefs, juveniles display no such preferences (Espino *et al.,* 2015). The species commonly measures from 14 to 32 cm (total length) (Petrakis & Papaconstantinou, 1990), but might grow as big as 52 cm (total length) (Filiz & Sevingel, 2015).

The Mediterranean parrotfish has a moderate longevity and is a slow-growing fish that may reach up to 8 years of age (Petrakis & Papaconstantinou, 1990). It spawns from July to September (Petrakis & Papaconstantinou, 1990; Guidetti & Boero, 2002), displays sexual dichromatism (de Girolamo *et al.,* 1999) and a dual mating system, with either multi-male groups or one dominant male holding harems (Alfonso *et al.,* 2002). The species has low economic importance but is locally exploited in the Dodecanese (Petrakis & Papaconstantinou, 1990). Recent records from the northern Mediterranean coast, off Italy (Azzurro *et al.,* 2011), from the Adriatic Sea, Croatia (Kruschel *et al.,* 2012), from the northwest Greek Ionian Sea (Perdikaris *et al.,* 2012), from Provence, France (Astruch *et al.,* 2016), and from the Genoa Gulf, Italy (Bianchi *et al.,* 2017), as well as observed expansions in the Aegean Sea, on both Greek and Turkish coasts (Papaconstantinou, 2014; Yapici *et al.,* 2016), also suggest a correlation with the sea temperature rise and climate change (Fogarty *et al.,* 2017).

Fig. 1: The male** S. cretense **specimen captured off the Thermaic Gulf.
Sl. 1: Samec morske papige ujet v zalivu Thermaikos.

MATERIAL AND METHODS

A single adult male *S. cretense* (Fig. 1) was caught on 23 July 2018 in the Thermaic Gulf, at approximately 40° 04′ 10.7″ N and 23° 19′ 59.3″ E (Fig. 2), by trammel nets with a mesh size of 22 mm, on hard bottom mixed with *P. oceanica* meadows. The depth ranged from 30 to 35 m. Morphometric and meristic data were obtained. Lengths (Tab. 1) were measured with the use of digital callipers to the nearest 0.01 mm. Weight (Tab. 1) was measured with an electronic scale to the nearest gram. The specimen was deposited at the Ichthyology laboratory of the Department of Marine Sciences, University of the Aegean.

RESULTS AND DISCUSSION

The identification was based on the criteria description by Golani *et al.* (2006) and Louisy (2015). Table 1 presents the related morphometric and meristic data. This study reports the northernmost record in the eastern Mediterranean Sea as acknowledged by F.A.O (2018), and the second northernmost record in the whole basin

Fig. 2: Map of the Thermaic Gulf, NW Aegean Sea, indicating sampling location (black dot).
Sl. 2: Zemljevid obravnavanega območja (zaliv Thermaikos, SZ Egejsko morje) z označeno lokaliteto ulova morske papige (črna pika).

(see Kruschel *et al.,* 2012 for details). The species was described by the fishermen as "never before seen," which further supports the importance of this finding.

The Aegean Sea has a complex topography (Olson *et al.,* 2007). The area displays important physiochemical variations between north and south (Zervakis & Georgopoulos, 2002). The northern Aegean Sea is an area of high productivity compared to the eastern Mediterranean, due to its interconnection with the Black Sea (Petihakis *et al.,* 2014). Also, the northern Aegean Sea exhibits unique bottom topography features (the North Aegean Trough) that divide the area into three sub-basins: the Lemnos-Saros Islands Basin in the east, the Athos Basin in the centre, and the North Sporades Basin in the west (Zervakis & Georgopoulos, 2002, Olson *et al.,* 2007).

Recently some thermophilic fish species, native and alien, were reported off the northern Aegean Sea, with Kampouris *et al*. (2013) reporting the first record of oilfish, *Ruvettus pretiosus* Cocco, 1833, from the Chalkidiki Peninsula. Minos & Economidis (2015) report further occurrences of the tripletail *Lobotes surinamensis* (Bloch, 1790) from the Thermaic Gulf. The most striking is perhaps the record of the alien fish *Plectorhinchus gaterinus* (Forsskål, 1775) from the Thracian Sea, with no further records along the southeast Aegean and Levantine coasts (Corsini-Foka & Sarlis, 2016), which presents similarities with the first report of the African surgeonfish *Acanthurus monroviae* Steindachner, 1876 in Hellenic waters (Batjakas *et al.,* 2015).

Tab. 1: Morphometric and meristic characters of the** S. cretense **specimen captured off the Thermaic Gulf.
Tab. 1: Morfometrija in meristični znaki pri morski papigi, ujeti v zalivu Thermaikos.

Morphometric characters	**Value**
Total length	262.57 mm
Standard length	218.78 mm
Head length	65.36 mm
Snout length	24.27 mm
Eye diameter	11.76 mm
Body depth	71.14 mm
Depth of caudal peduncle	34.24 mm
Max body width	34.94 mm
Min body width	26.57 mm
Weight	317 g
Meristic counts	
Dorsal fin	XI+10
Anal fin	III+9
Pectoral fin	12
Pelvic fin	I+5

CONCLUSIONS

The in-depth knowledge and experience of fishers has been recognized as a valuable source of scientific information that should be further acknowledged and utilized. Wider collaboration should be established among scientists, practitioners and policy makers (Azzuro *et al.,* 2018). Moreover, the contribution of naturalists and citizen-scientists on biodiversity monitoring (e.g., Kampouris *et al.*, 2018a) and on the detection and expansion of invasive alien species is already highly acknowledged (e.g. Kondylatos *et al.,* 2017; Giovos *et al.,* 2018; Kampouris *et al.,* 2018b) and wider stakeholder synergies should be established.

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NAJSEVERNEJŠI ZAPIS O POJAVLJANJU TOPLOLJUBNE MORSKE PAPIGE *SPARISOMA CRETENSE* (LINNAEUS, 1758) (PERCIFORMES, SCARIDAE) V VZHODNEM SREDOZEMSKEM MORJU (SEVEROZAHODNO EGEJSKO MORJE)

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POVZETEK

Julija 2018 je bil v zalivu Thermaikos v severozahodnem Egejskem morju (Grčija) ujet primerek morske papige Sparisoma cretense*, kar predstavlja prvi primer pojavljanja te vrste v regiji. Vrsta domuje pretežno v predelih jugovzhodnih obal Sredozemlja. Njeno pojavljanje je tako kot v primerih pojava drugih toploljubnih vrst v severnem Egejskem morju, povezano z dvigom temperature morja in podnebnimi spremembami. Gre za najsevernejši podatek o pojavljanju te vrste v vzhodnem Sredozemlju in drugi najsevernejši podatek za celoten sredozemski bazen.*

Ključne besede: *Sparisoma cretense*, termofilna vrsta, nov zapis, biodiverziteta, podnebne spremembe, Egejsko morje

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OCCURRENCE OF PEARL FISH, *CARAPUS ACUS* (OSTEICHTHYES: CARAPIDAE) IN ÇEŞME, IZMIR (AEGEAN SEA, TURKEY)

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ABSTRACT

A specimen of Carapus acus*, 181 mm in total length, was captured by a commercial trawl net off Çeşme, Izmir, on muddy bottom, at a depth of 60-80 m. This paper presents the real occurrence of the rare pearl fish off Izmir in the Aegean Sea.*

Key words: Pearl fish, measurement, sea cucumber, Izmir, Aegean Sea

PRESENZA DI GALIOTTO, *CARAPUS ACUS* (OSTEICHTHYES: CARAPIDAE), A ÇEŞME, SMIRNE (MAR EGEO, TURCHIA)

SINTESI

Un esemplare di Carapus acus*, 181 mm di lunghezza totale, è stato catturato con una rete commerciale a strascico al largo di Çeşme, Smirne (Izmir), su fondale fangoso, ad una profondità di circa 60-80 m. L'articolo riporta la presenza di questa rara specie ittica al largo di Smirne nel mar Egeo.*

Parole chiave: galiotto, misurazioni, cetriolo di mare, Smirne, mar Egeo

INTRODUCTION

The pearl fish *Carapus acus* (Brünnich, 1768) is a non-migratory marine fish species inhabiting the 1-150 m depth range and reaching up to 200 mm in TL. Adults of *C. acus* live in the body cavities of holothurian species, such as *Holothuria tubulosa* Gmelin, 1791 and *Parastichopus regalis* (Cuvier, 1817). At night, the species leaves the host to feed on small benthic invertebrates and small fish (Trott & Olney, 1986; Golani *et al.*, 2006; Froese & Pauly, 2018). *C. acus* is known throughout the Mediterranean Sea; while it is most commonly found in the western part, mainly around Italy, Spain and France, it also occurs in the Adriatic and Aegean Seas (González-Wangüemert *et al.*, 2014).

C. *acus* larvae were identified from a total of 12 individuals in the bongo-net collections during the June 1995 and June 1996 surveys in the northern Aegean Sea (Somarakis *et al.*, 2002). Fischer *et al.* (2007) stated that the occurrence of the *C. acus* species was very rare in Ibiza, Spain. In Tunisia, this species was first recorded in the Gulf of Gabes (Enajjar & Bradai, 2016).

C. acus used to be mentioned only by name among the fishes of the Turkish waters of the Aegean Sea (Geldiay, 1969), until trawl catch records of *C. acus* were given by Gücü & Bingel (1994) from the Mersin and Iskenderun Bays in the northeastern Levantine Sea.

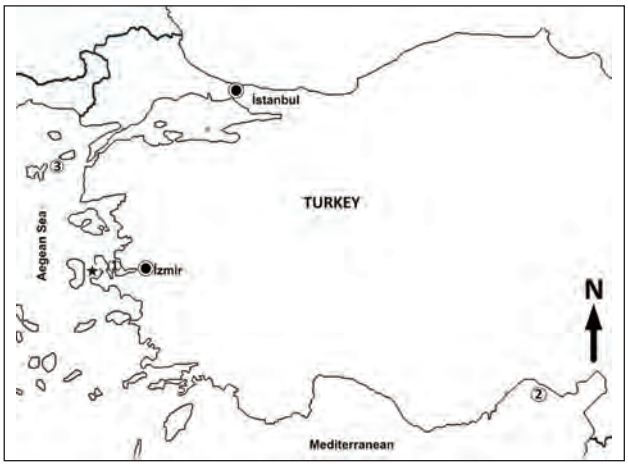

Fig. 1: Capture sites of the** Carapus acus **specimens in the Turkish sea, eastern Mediterranean: 1. Bay of Izmir (Geldiay, 1969), 2. Off Mersin Bay (Gücü & Bingel, 1994), 3. Off Bozcaada Island (Eryılmaz, 2003); the black star indicates the sampling location of this study.
Sl. 1: Lokalitete, kjer so bili ujeti primerki strmorinca** Carapus acus **v turškem morju, vzhodno Sredozemsko morje: 1. Izmirski zaliv (Geldiay, 1969), 2. zaliv Mersin (Gücü & Bingel, 1994), 3. otok Bozcaada (Eryılmaz, 2003); črna zvezdica označuje vzorčevalno lokaliteto iz pričujoče raziskave.

Fig. 2: A.** Carapus acus **(ref.: ESFM-PIS/2018-03). B. Sea cucumber,** Parastichopus regalis**, captured off Çeşme, Izmir (scale bar: 50 mm).
Sl. 2: A.** Carapus acus **(ref.: ESFM-PIS/2018-03). B. Morska klobasa,** Parastichopus regalis**, ujeta v vodah predela Çeşme, Izmir (merilo: 50 mm).

Eryılmaz (2003) reported four specimens (149-161 mm TL) from off Bozcaada Island, northern Aegean Sea. This paper presents the real occurrence of the rare pearl fish off the shores of Izmir in the Aegean Sea.

MATERIAL AND METHODS

On 30 March 2018, a specimen of *Carapus acus* was captured by a commercial trawl net (44 mm stretched mesh size) off Çeşme, Izmir at 38°25′ N - 26°16′ E (Fig. 1), on muddy bottom, at a depth of between 60 and 80 m. The specimen (Fig. 2a) was collected together with some sea cucumbers, *P. regalis* (Fig. 2b), but not in the body cavity of any of them. The specimen was measured to the nearest millimetre, fixed in 5% formaldehyde solution and deposited in the Ichthyological Collection of Ege University, Faculty of Fisheries, under catalogue number ESFM-PIS/2018-03.

RESULTS AND DISCUSSION

The specimen of *Carapus acus* measured 181 mm in total length, the morphometric data corresponding to the following ratios as percentages of standard length (TL) or head length (HL): maximum body depth 9.4, head length 13.3, predorsal length 43.6, preanal length 13.8, prepectoral length 12.7 (all in TL); eye diameter 16.7, preorbital distance 12.5, interorbital 20.8, (all in HL); 20 pectoral fin rays. The description, measurements and percentages of total length in *C. acus* are in complete accordance with Trott & Olney, (1986), Nielsen *et al*. (1999), Golani *et al*. (2006) and Froese & Pauly (2018).

The small number of records of larvae and adult specimens indicates that *C. acus* is a very rare species throughout the Mediterranean. The species is known to live in association with the sea cucumber, but recently, Gonzáles-Wangüemert *et al*. (2014), reported that among the six sea cucumber species, *C. acus* is only found in *P. regalis,* and that it apparently chooses its host regardless of its size. The present study, given that *C. acus* and *P. regalis* were caught together in the same trawl operation, seems to support this thesis. However, further research is necessary to establish the species' abundance, geographical distribution and the nature of the host with regard to commensalism.

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POJAVLJANJE STRMORINCA, *CARAPUS ACUS* (OSTEICHTHYES: CARAPIDAE) V PREDELU ÇEŞME, IZMIR (EGEJSKO MORJE, TURČIJA)

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POVZETEK

Primerek strmorinca (Carapus acus)*, ki je meril v dolžino 181 mm, je bil ujet v ribiško mrežo na lokaliteti Çeşme (Izmir), na muljastem dnu, na globini med 60 in 80 m. Avtorja poročata o dejanskem pojavljanju te redke vrste v vodah okoli Izmirja v Egejskem morju.*

Ključne besede: strmorinec, meritve, morske klobase, Izmir, Egejsko morje

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ADDITIONAL RECORDS AND EXTENSION OF THE RANGE OF BLACKFISH, *CENTROLOPHUS NIGER* (OSTEICHTHYES: CENTROLOPHIDAE) FROM THE TUNISIAN COAST (CENTRAL MEDITERRANEAN SEA)

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ABSTRACT

On 1 May 2018, five specimens of Centrolophus niger *(Gmelin, 1789) were captured by a shrimp trawler on the sandy bottom at a depth of 35 m in the Gulf of Gabès; they measured between 185 and 433 mm in total length and weighed between 47.9 and 698.8 g. On 17 May 2018, another, single specimen was captured by a shrimp trawler on the sandy-muddy bottom at a depth of 85 m in the Gulf of Tunis; it measured 271 mm in total length and weighed 195.9 g. These additional captures of* C. niger *are indicative of an extension of the range of this species toward southern areas and migration toward lower depths.*

Key words: Distribution, additional records, *Centrolophus niger*, extension range, depth, Tunisian waters

NUOVE SEGNALAZIONI E INTERVALLO DI ESPANSIONE DELLA RICCIOLA DI FONDALE, *CENTROLOPHUS NIGER* (OSTEICHTHYES: CENTROLOPHIDAE) LUNGO LA COSTA DELLA TUNISIA (MEDITERRANEO CENTRALE)

SINTESI

Il 1° maggio 2018, cinque esemplari di Centrolophus niger *(Gmelin, 1789) sono stati catturati da un peschereccio a strascico per la pesca dei gamberi sul fondo sabbioso, a una profondità di 35 m, nel Golfo di Gabès. La loro lunghezza totale variava tra i 185 e i 433 mm, mentre il peso era compreso tra i 47,9 e i 698,8 g. Il 17 maggio 2018, un altro esemplare è stato catturato da un peschereccio a strascico sul fondo sabbioso-fangoso, a una profondità di 85 m, nel Golfo di Tunisi. L'animale misurava 271 mm di lunghezza totale e pesava 195,9 g. Queste nuove catture di* C. niger *indicano un'estensione della distribuzione della specie verso le aree meridionali e la migrazione verso profondità minori.*

Parole chiave: distribuzione, segnalazioni aggiuntive, *Centrolophus niger*, estensione, profondità, acque tunisine

INTRODUCTION

Centrolophus niger (Gmelin, 1789) is a pelagic teleost species widely distributed throughout temperate and warm temperate marine waters at depths between 200 and 400 m (Haedrich, 1986). It is also known in the Mediterranean Sea (Haedrich, 1986; Dulčić & Lipej, 2002). Having migrated toward eastern areas, the species is at present reported in the Aegean Sea (Akyol, 2008; Ceyhan & Akyol, 2011), in the Gulf of Iskenderun, off the Mediterranean coast of Turkey (Ergüden *et al*., 2012), and in the Levant Basin (Golani, 2005). In southern Mediterranean, juvenile forms have been recorded off the Algerian coasts by Dieuzeide *et al*. (1955), and a first record has been reported from the Tunisian coast (Capapé *et al*., 2017). Investigations that are regularly conducted throughout the Tunisian coast have allowed us to collect specimens from local areas where *C. niger* was previously unknown (Bradai *et al*., 2004).

MATERIAL AND METHODS

On 1 May 2018, five specimens of *Centrolophus niger* were captured on the sandy bottom, 35 m deep, in the Gulf of Gabès, southern Tunisia (37° 07′ 96″ N and 10° 76′ 69″ E). On 17 May 2018, another single specimen was captured on the sandy-muddy bottom

Tab. 1: *Centrolophus niger*. ***The morphometric measurements in mm and as percentages of total length (% TL) and standard length (% SL), meristic counts, and weight (in gram) recorded in two specimens from the Gulf of Gabès (ref. INSTM-Cent-nig-01 and INSTM-Cent-nig-05) and in the specimen from the Gulf of Tunis (ref. INSTM-Cent-nig-06).***
Tab. 1: *Centrolophus niger*. ***Morfometrične meritve in delež celotne dolžine (% TL) ter standardne dolžine (% SL), meristična štetja in teža (v gramih) pri dveh primerkih iz gabeškega zaliva (ref. INSTM-Cent-nig-01 in INSTM-Cent-nig-05) in pri primerku iz tuniškega zaliva (ref. INSTM-Cent-nig-06).***

Reference	**INSTM-Cent-nig-01**			**INSTM-Cent-nig-05**			**INSTM-Cent-nig-06**		
Measurements	**mm**	**%TL**	**%SL**	**mm**	**%TL**	**%SL**	**mm**	**%TL**	**%SL**
Total length	433	100.0	121.6	185	100.0	127.6	271	100.0	130.9
Fork length	380	87.8	106.7	160	86.5	110.3	226	83.4	109.2
Standard length	356	82.2	100.0	145	78.4	100	207	76.4	100.0
Head length	88	20.3	24.7	55	29.7	37.9	57	21.0	27.5
Pre-orbital length	23	5.3	6.5	13	7.0	9,0	15	5.5	7.2
Pre-dorsal fin length	125	28.9	35.1	84	45.4	57.9	102	37.6	49.3
Pre-pectoral fin length	95	21.9	26.7	64	34.6	44.1	71	26.2	34.3
Pre-anal fin length	192	44.3	53.9	79	42.7	54.5	167	61.6	80.7
Snout length	31	7.2	8.7	20	10.8	13.8	23	8.5	11.1
Eye diameter	19	4.4	5.3	13	7.0	9.0	15	5.5	7.2
Interorbital space	36	8.3	10.1	26	14.1	17.9	33	12.2	15.9
Dorsal fin length	190	43.9	53.4	80	43.2	55.2	155	57.2	74.9
Pectoral fin length	21	4.8	5.9	14	7.6	9.7	16	5.9	7.7
Anal fin length	105	24.2	29.5	78	42.2	53.8	88	32.5	42.5
Pelvic fin length	10	2.3	2.8	7	3.8	4.8	8	3.0	3.9
Body height	120	27.7	33.7	70	37.8	48.3	93	34.3	44.9
Caudal fin length	45	10.4	12.6	31	16.8	21.4	36	13.3	17.4
Counts									
Dorsal rays	V+39			V+37			V+38		
Pectoral rays	22			22			22		
Pelvic rays	5			5			5		
Anal rays	III+22			III+21			III+21		
Caudal rays	20			20			20		
Scales on lateral line	167			165			165		

at a depth of 85 m in the Gulf of Tunis, northeastern Tunisia (34° 43′ 70″ N and 10° 86′ 08″ E). All specimens were caught by shrimp trawlers. They were measured by digital calliper to the nearest millimetre and weighed to the nearest decigram. Morphometric measurements, percentages of total length (TL) and standard length (SL), and meristic counts were recorded following Capapé *et al.* (2017) and summarized in Table 1. All specimens were fixed in 10% buffered formalin, preserved in 75% ethanol and deposited in the Ichthyological Collection of the Institute des Sciences et Technologies de la Mer of Salammbô (Tunisia). The specimens collected from the Gulf of Gabès (Fig. 1) received catalogue numbers INSTM-Cent-nig-01 through INSTM-Cent-nig-05, and the specimen from the Gulf of Tunis received the catalogue number INSTM-Cent-nig-06.

RESULTS AND DISCUSSION

The Tunisian *Centrolophus niger* was identified by the following combination of characters: elongate, oval, slightly compressed body with a long, compressed caudal peduncle, small head with pores in the naked skin, large mouth without teeth on palate; eyes large and bright; a single long dorsal, originating slightly behind the head of the pectoral fin base; lateral line slightly arched, with small scales; colour ranges from chocolate brown to dark bluish, with black-edged fins.

The description, measurements and percentages of TL and SL (Table 1) recorded in the Tunisian specimens of *C. niger* are in total accordance with previous descriptions of the species, provided by Headrich (1986), Akyol (2008), Ceyhan & Akyol (2011), Ergüden *et al.* (2012) and Capapé *et al.* (2017). *C. niger* is an uncommon species in the areas where it was previously recorded.

The first well-documented discovery of *Centrolophus niger* occurred off Ras Jebel, close to the Cani Rocks in northern Tunisia (Fig. 2). Capapé *et al.* (2017) noted that such a finding could probably corroborate a southward extension of *C. niger* in the Mediterranean Sea, supporting the first confirmed record of a large specimen in this area in 1986 (Haedrich, 1986). These additional captures of *C. niger* attest to an extension of the range of the species toward southern areas and migration toward lower depths. The presence of small and large specimens suggests that a viable population of *C. niger* is probably established throughout the Tunisian coast. It could also indicate migration from western regions or a population established in poorly explored areas, but such hypotheses remain questionable.

Capapé *et al.* (2017) noted an increase in captures of *Centrolophus niger* in the eastern Mediterranean coast of Turkey (Akyol, 2008; Ceyhan & Akyol, 2011; Ergüden *et al.*, 2012) and suggested it could result from water warming (see Francour *et al.*, 1994; Ben Raïs Lasram & Mouillot, 2009). Such a phenomenon could also explain the recorded occurrence of the species in Tunisian waters, yet an improvement of monitoring in the area as a factor cannot be totally ruled out either. The drastic decline of local fisheries due to fishing pressure has forced the fishermen to keep and try to sell in landing sites and/or fish markets even species with poor economic value, instead of discarding them at sea, like they used to.

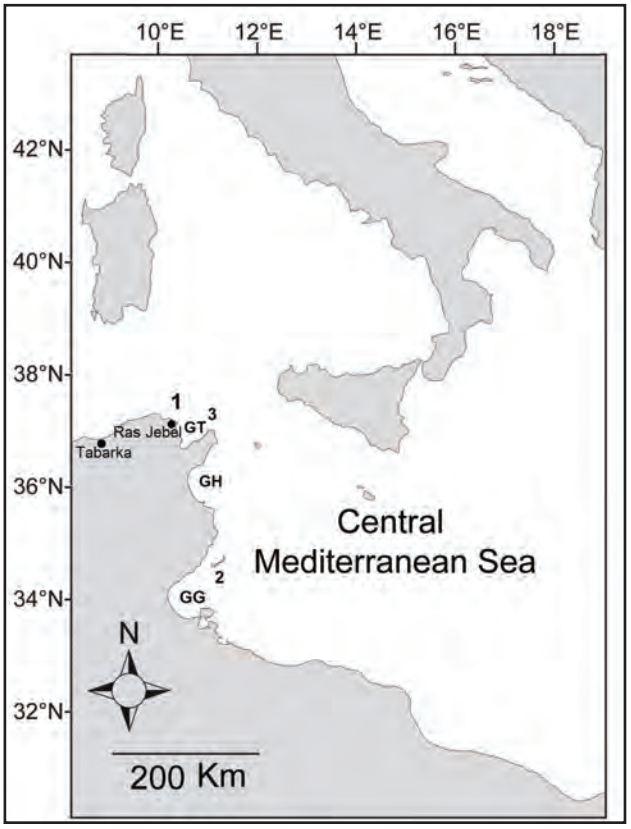

Fig. 2: *Centrolophus niger*. ***Map of the Central Mediterranean Sea copied from Ben Amor et al. (2016) with capture sites of the specimens caught in the Tunisian waters indicated: 1. between Ras Jebel and the Cani Rocks (1), off the northern Tunisian coast (Capapé*** *et al.*, ***2017); 2. in the Gulf of Gabès (GG); 3. in the Gulf of Tunis (GT). GH = Gulf of Hammamet.***
Sl. 2: *Centrolophus niger*. ***Zemljevid osrednjega Sredozemskega morja, prirejen po Ben Amor s sod. (2016) z označenimi lokalitetami, kjer so bili ujeti primerki v tunizijskih vodah: 1. med lokalitetami Ras Jebel in Cani Rocks (1), ob severni tunizijski obali (Capapé*** *et al.*, ***2017); 2. v gabeškem zalivu (GG); 3. v tuniškem zalivu (GT). GH = Hammameški zaliv.***

Similar patterns were reported by Capapé *et al.* (2018) for sharpnose sevengill shark *Heptranchias perlo* (Bonnaterre, 1788), a species previously captured off the northern coast of Tunisia, on deep-sea bottoms (El Kamel-Moutalibi *et al.*, 2014), which has been recently observed at lower depths and in southern Tunisian areas.

Fig. 1: The *Centrolophus niger* ***specimen (ref. INSTM-Cent-nig-01) captured in the Gulf of Gabès; scale bar = 80 mm.***
Sl. 1: Primerek vrste *Centrolophus niger* ***(ref. INSTM-Cent-nig-01), ujet v gabeškem zalivu; merilo = 80 mm.***

NOVI ZAPIS O POJAVLJANJU ČRNUHA, *CENTROLOPHUS NIGER* (OSTEICHTHYES: CENTROLOPHIDAE) IZ TUNIZIJSKE OBALE (OSREDNJE SREDOZEMSKO MORJE)

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POVZETEK

Prvega maja 2018 so ujeli pet primerkov črnuha Centrolophus niger *(Gmelin, 1789) v mrežo za kozice na peščenem dnu na globini 35 m v Gabeškem zalivu. V dolžino so merili med 185 in 433 mm in tehtali med 47,9 in 698,8 g. Sedemnajstega maja je bil v mrežo za kozice ujet še en primerek te vrste na muljevito-peščenem dnu na 85 m globine v tuniškem zalivu. V dolžino je meril 271 mm in tehtal 195,9 g. Ti novi podatki o vrsti* C. niger *kažejo na razširitev areala te vrste v smeri proti jugu in pojavljanju v plitvejših globinah.*

Ključne besede: razširjenost, novi podatki, *Centrolophus niger*, širjenje areala, globina, tunizijske vode

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OCCURRENCE OF RIBBON FISH (*TRACHIPTERUS TRACHYPTERUS*) IN SLOVENIAN WATERS (NORTHERN ADRIATIC SEA)

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ABSTRACT

*On 6th May 2018 a juvenile specimen of ribbon fish (*Trachipterus trachypterus*) was collected in shallow waters in Izola (Slovenia, northern Adriatic Sea). It measured 403 mm in total length and weighed 37.1 g. In stomach, fragments of seagrasses, pollen cones of pine, petals of terrestrial plant, fragments of terrestrial grass and beetles were found among food remains. The possible causes of this finding in Slovenian waters could be attributed to the ingression of southern Adriatic waters in its northern part. The specimen studied in this paper is the fifth record of this species in the Slovenian part of the Adriatic Sea. The cooperation between ichthyologists and fishermen proved to be crucial for the detection of the ribbon fish and other rare and less-known fish species, as well.*

Key words: ribbon fish, *Trachipterus trachypterus,* occurrence, diet, Adriatic Sea

PRESENZA DEL PESCE NASTRO (*TRACHIPTERUS TRACHYPTERUS*) IN ACQUE SLOVENE (ADRIATICO SETTENTRIONALE)

SINTESI

*Il 6 maggio 2018 un esemplare giovanile di pesce nastro (*Trachipterus trachypterus*) è stato trovato in acque poco profonde a Isola (Slovenia, Adriatico settentrionale). Il pesce misurava 403 mm di lunghezza totale e pesava 37,1 g. Fra i resti di cibo nello stomaco sono stati trovati frammenti di fanerogame marine, polline di pino, petali di piante terrestri, frammenti di erba terrestre e coleotteri. Le possibili cause di questo ritrovamento nelle acque slovene potrebbero essere attribuite all'entrata delle masse d'acqua dell'Adriatico meridionale nella parte settentrionale. L'esemplare studiato è il quinto ritrovamento di questa specie nella parte slovena del mare Adriatico. La collaborazione tra ittiologi e pescatori si è dimostrata fondamentale per l'individuazione del pesce nastro e di altre specie ittiche rare e meno note.*

Parole chiave: pesce nastro, *Trachipterus trachypterus*, presenza, dieta, mare Adriatico

INTRODUCTION

Despite the centennial tradition in marine research in the Gulf of Trieste, the ichthyological research in Slovenian part of the Gulf deserved considerably less attention than neighbouring areas. Only in last decades the research interest increased substantially. As a consequence, some papers were published on the occurrence of rare and less known species or otherwise neglected fish species which were recorded for the very first time by performing new approaches and non-destructive techniques in the area (Lipej *et al.,* 2005, 2007, 2008, 2009; Orlando-Bonaca & Trkov, 2016; Mavrič & Dragičević, 2018). The cooperation between fishermen and ichthyologists has also brought new insights on the fish fauna in the area.

The ribbon fish *T. trachypterus* is widely distributed in subtropical and tropical seas of the Pacific (Cortes *et al.,* 1995), in waters off Japan and New Zealand, on both sides of the Atlantic Ocean (Smith-Vaniz, 2015) and in Mediterranean Sea (Borme & Voltolina, 2006). It is an offshore fish that inhabits the mesopelagic zone (Borme & Voltolina, 2006). The ribbon fish is considered as a species with the status of least concern (Smith-Vaniz, 2015). However, *T. trachypterus* is still considered as a poorly studied fish. The majority of records are dealing with the finding of moribund or dead animals, stranded on the coast (Dulčić & Lipej, 1997; Borme & Voltolina, 2006; Farias *et al.,* 2010).

In the Adriatic Sea the ribbon fish is rarely observed or caught. Jardas (1980) mentioned 46 cases of captured ribbon fish in over 100 years long period from 1875 to 1980, while Dulčić (1996) reported about the first record of a ribbon fish larva near Stončica in eastern Adriatic Sea.

This paper deal with the new finding of the ribbon fish in Slovenian coastal waters and includes some new information on this species.

MATERIAL AND METHODS

On 6th May 2018 a specimen of ribbon fish was collected in shallow waters (< 1 m of depth) in Izola (Slovenia, northern Adriatic Sea) (Fig. 1). The specimen was put on ice and delivered to the Marine Biology Station (National Institute of Biology) in Piran. In the laboratory it was photographed with photocamera Olympus Tough 4. The specimen was then weighed with the Sartorius balance. Subsequently, morphometrical measurements and meristic counts were performed (Fig. 2). Measurements were taken to the nearest 1 mm and weight to 0.1 g. After that the specimen was dissected and internal organs were removed. The gut content was analysed under Olympus SZX16 stereomicroscope and photographed with the microscope camera Olympus DP74. The specimen is housed in the fish collection of the Marine Biology Station.

In order to contribute new data on the knowledge of

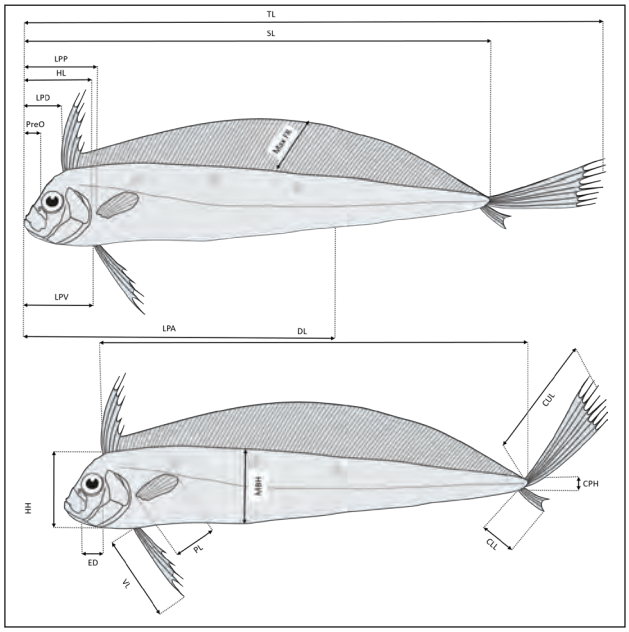

Figure 2: Biometric measurements on ribbon fish. See Table 1 for abbreviations.
Slika 2: Biometrične meritve opravljene na kosici. Glej Tabelo 1 za okrajšave.

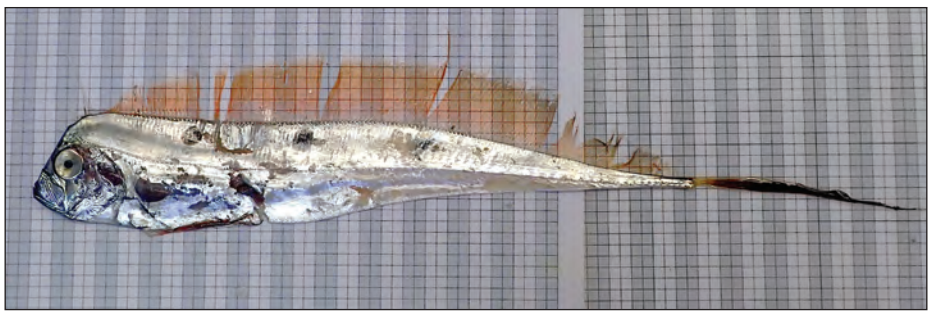

Figure 1: Specimen of the ribbon fish (TL=403 mm), found in Izola at 6th May 2018.
Slika 1: Primerek kosice iz Izole (TL=403 mm), z dne 6.5. 2018.

Tab. 1: Biometry and meristic data of the studied specimen of ribbon fish in comparison with other three specimens, previously reported in Slovenian Sea in 2004, 2006. Specimens marked with an asterisk were already published in work of Borme & Voltolina (2006).
Tab. 1: Biometrični in meristični podatki preiskanega primerka kosice v primerjavi s tremi primerki, ujetimi v slovenskem morju v letih 2004 in 2006. Podatki za primerke, označene z zvezdico, so že bili objavljeni v prispevku Borme & Voltolina (2006).

specimen		I	II*	III	IV*	V
Morphometric characters (mm)	**Abbreviation**	**6 May 2018**	**15 April 2004**	**27 Feb 2006**	**10 August 2006**	**13 April 2009**
total length	TL	403	-	1363	1033	427
standard length	SL	299	-	1282	925	346
preorbital length	PreO	9.3	5	-	23	8.1
eye horizontal diameter	ED	14.2	9	46	35	12.6
head length	HL	41.7	28	167	98	43.4
head height	HH	50.4	37	-	105	52.1
interorbital space	IOS	10.3	6	-	22	-
predorsal length	LPD	11.4	7	158	55	18.9
prepectoral lenght	LPP	40.4	29	174	99	44.3
preventral length	LPV	47.1	33	-	111	52.1
maximal body height	MBH	51.1	39	-	108	62.9
preanal length	LPA	151.5	110	-	405	186.5
caudal peduncle height	CPH	5.3	-	-	11	6.1
dorsal fin rays maximal length	MaxFR	35.3	29	-	68	31.7
dorsal fin length	DL	275.2	-	-	882	322.8
pectoral fin length	PL	16.7	7	-	33	15.1
caudal fin length (upper lobe)	CUL	105	-	-	125	82.3
caudal fin length (lower lobe)	CLL	1	-	-	1.2	-
ventral fin length	VL	58.6	46	-	0	38.7
sex		-	-	-	male	-

ribbon fish in the area, we include data about specimens of this species, which were not included in the work of Borme & Voltolina (2006), dealing with *T. trachypterus* occurrence in the Gulf of Trieste.

RESULTS AND DISCUSSION

Morphometric and meristic data of the studied specimen are presented in Tables 1 and 2. The body is elongated and laterally compressed. Greatest depth of the body is immediately behind the short head. Body is covered with tiny silvery cuticle and scaleless. Dorsal fin is very long, extending from above the eyes to the caudal fin. Dorsal, pectoral, ventral and caudal fins are reddish. Pectoral fin is rather small with the base inserted almost horizontally. Ventral fin is very small and the anal fin absent. Colour is silvery with three dark blotches. Meristic data of the studied specimen (Tab. 2) are in agreement with the data obtained by Bini (1970), Tortonese (1975), Šoljan (1975), Jardas (1980), Palmer (1984) and Borme & Voltolina (2006).

It is well known that *T. trachypterus* and relatives are ongoing considerable morphological changes during their ontogenetic development (Jardas, 1980). Juveniles differ from adults in regards to general body shape, fin length and number and pigmentation patterns (Martin, 2015).

Tab. 2: Weight, organ weight and meristic data of the studied specimen of ribbon fish in comparison with other specimens previously reported in Slovenian waters. Remarks: * juvenile specimens, ** the number of thorns may be underestimated due to damaged tissue.
Tab. 2: Celotna masa in masa notranjih organov ter meristični podatki za preiskani primerek v primerjavi s podatki primerkov, predhodno ujetih v slovenskem morju. Opombi: *mladostni primerki, ** število trnov je zaradi poškodovanega tkiva lahko podcenjeno.

specimen	I	II	III
Weight (g)	**6 May 2018**	**15 April 2004**	**10 August 2006**
total weight	37.1	-	477.7
heart	0.04	-	0.8
stomach	4.48	1.4	22.5
empty stomach	1.06	0.6	20.9
liver	0.23	-	6.8
pyloric caeca	0.8	-	8
gonads	0.13	-	1.1
Meristic characters			
dorsal fin rays D	172	-	180
ventral fin rays V	7	5	0
pectoral fin rays	10	10	11
caudal fin rays (upper lobe)	7	-	9
caudal fin rays (inferior)	5	-	5
spines along lateral line	92**	-	94
right lower jaw (dental) teeth	4	5*	5
left lower jaw (dental) teeth	3	5*	4
vomer teeth	2	1*	1
right upper jaw (praemaxillary) teeth	4	7*	5
left upper jaw (praemaxillary) teeth	5	4*	4
gillrakers (1st branchial arch)	13	12*	13

Both specimens (Figs. 1 and 3) had 4 dorsal spots and 1 ventral spot which is typical for juveniles. Gradually the number of spots decreases with the increase of total length.

Previously, the ribbon fish was reported in the Gulf of Trieste and in the Slovenian part of the Adriatic Sea (Dulčić & Lipej, 1997; Marčeta, 1999), as well. It was found on several occasions. Borme & Voltolina (2006) mentioned 15 records in the Gulf of Trieste, with 7 of them reported after 2000. Three of them were recorded in the Slovenian part of the gulf. The first case originated from cape Ronek in February 1992, when a 1100 mm

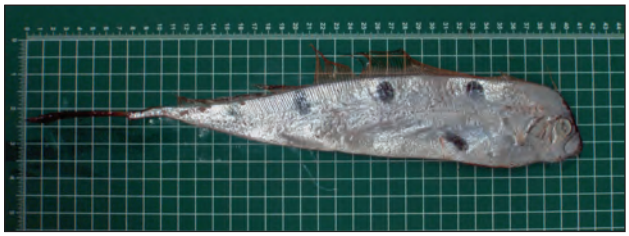

Figure 3: Specimen of the ribbon fish (TL=427 mm), caught in the Piran Bay at 13th April 2009.
Slika 3: Primerek kosice (TL=427 mm) ujet v Piranskem zalivu 13.4.2009.

Fig. 4: Gut content of the specimen, found in Izola at 6.5.2018 (a). A close-up of the pollen cones of pine (Pinus halepensis) (b). Scale = 5 mm.
Sl. 4: Vsebina želodca kosice z dne 6.5.2018 (a). Bližinski posnetek moških socvetij alepskega bora (Pinus halepensis) (b). Merilo = 5 mm.

ribbon fish was found stranded on the coast (Dulčić & Lipej, 1997). On 15th April 2004 a juvenile specimen, approximately 250 mm in total length was found dead in Piran. At 27th February 2006 a specimen, which was not mentioned in the work of Borme & Voltolina (2006), was caught by hand in Koper. It measured 1363 mm and weighed 3120 g. Later, in 10th August 2006, another specimen was found 2 Nm off Izola, which measured 1033 mm in total length. According to the local newspaper (Šuligoj, 2006), the fishermen of Izola caught three other specimens in summer 2006. At 13th April 2009 a 427 mm long juvenile ribbon fish was caught in the Piran Bay. The specimen, found at 6th May 2018, studied in this paper is therefore the fifth documented record of this species in the Slovenian part of the Adriatic Sea.

In the stomach the fragments of *Cymodocea nodosa* and *Zostera noltei* were found (Fig. 4). The great majority of the diet consisted of pollen cones of pine (*Pinus halepensis*). In addition, petals of terrestrial plants were found, together with numerous fragments of terrestrial grass. A tiny beetle (Coleoptera) was also found in remains. The obtained data are in agreement with the findings of the Adriatic studies published by Jardas (1980) and Borme & Voltolina (2006) who also found remains of sea grasses, beetles and many fragments of terrestrial origin in stomachs of the ribbon fish. We share the opinion of Borme & Voltolina (2006) that vegetal fragments, especially those of terrestrial origin should be probably considered as accidentally ingested.

The possible causes of the finding of *T. trachypterus* in Slovenian waters could be attributed to the ingression of southern Adriatic waters in the northern part, as already noted by many authors (Dulčić & Lipej, 1997, Dulčić *et al*., 1999). The pelagic character of these species, which can help their dispersal, is not sufficient to explain this fact. The majority of the studied specimens are juveniles which is in agreement with other records (Jardas, 1980). In fact, juveniles are more abundant and they occur more likely in near shore habitats in comparison with adults (Martin, 2015).

There are also other cases of mesopelagic and benthopelagic species, known to arrive in the shallow Gulf of Trieste. For example, there are many records of the occurrence of silver scabbardfish *Lepidopus caudatus* (Euphrasen, 1788) in the same area. The cooperation between ichthyologists and fishermen offers a great opportunity to monitor the fish fauna of the area. Interviews with local fishermen are very useful to track the presence of certain invaders and provide complementary information (Azzurro *et al*., 2018). This cooperation was crucial in discovering the occurrence of ribbon fish specimens in the area and also for the detection of other rare and less-known fish species.

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We are indebted with the fisherman who provides us with the specimen of ribbon fish. We would like to express our gratitude also to our colleague Bojan Marčeta from the Institute for fisheries in Ljubljana who provided us with the basic data of one of the studied specimen. Special thanks also to our dear friend Milijan Šiško who prepared the drawing for the manuscript.

POJAVLJANJE KOSICE (*TRACHIPTERUS TRACHYPTERUS*) V SLOVENSKEM MORJU (SEVERNI JADRAN)

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*Šestega maja 2018 je bil najden primerek kosice (*Trachipterus trachypterus*) v plitvini pri Izoli (Slovenija, severni Jadran). V dolžino je meril 403 mm in tehtal 37,1 g. V prebavilu so bili najdeni fragmenti morskih trav, moška socvetja alepskega bora, cvetovi kopenskih cvetnic, koščki kopenskih trav in hrošč. Možni razlog za pojavljanje te vrste v slovenskem delu Jadrana bi lahko bil povezan z ingresijo južnih jadranskih vodnih mas v severni Jadran. Preiskani primerek predstavlja peti primer pojavljanja te vrste v slovenskem delu Jadrana. Povezovanje med ihtiologi in ribiči se je izkazalo za ključno pri odkritju primerkov kosice in drugih redkih ter manj znanih ribjih vrst.*

Ključne besede: kosica, *Trachipterus trachypterus,* pojavljanje, prehrana

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SPECIES OF WILD FLORA AS INDICATORS OF ENVIRONMENTAL GENOTOXICITY

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ABSTRACT

The present study evaluated the applicability of wild species in investigating environmental genotoxicity. The level of mutation in cells of the root meristem was examined in 8 wild plant species growing in environments affected by different types of pollution. Seeds collected in the disposal areas of a wolfram-molybdenum factory (Kabardino-Balkaria, Russia) were used to study the influence of heavy metal pollution. In the case of pollution with products of oil combustion and refining, the seeds were collected in areas adjacent to mini-factories for domestic oil refining (Chechen Republic, Russia). Pollution induced a 2.5-to-10.2-fold increase in mutation frequency in plant seedlings from contaminated zones compared to plants from "clean" zones. Thus, species of wild flora have proven as convenient and sensitive objects for estimating environmental genotoxicity.

Key words: environmental genotoxicity, heavy metals, oil pollution, wild plant species

SPECIE DI FLORA SELVATICA QUALI INDICATRICI DI GENOTOSSICITÀ AMBIENTALE

SINTESI

Il presente studio ha valutato l'applicabilità delle specie selvatiche nello studio della genotossicità ambientale. Il livello di mutazione nelle cellule del meristema radicale è stato esaminato in 8 specie di piante selvatiche che crescono in ambienti affetti da diversi tipi di inquinamento. I semi raccolti nelle aree di smaltimento di una fabbrica di wolfram-molibdeno (Kabardino-Balkaria, Russia) sono stati utilizzati per studiare l'influenza dell'inquinamento da metalli pesanti. Nel caso dell'inquinamento da prodotti di combustione e raffinazione di petrolio, i semi sono stati raccolti in aree adiacenti alle mini-fabbriche per la raffinazione del petrolio (Repubblica Cecena, Russia). L'inquinamento ha indotto un aumento da 2,5 a 10,2 volte della frequenza di mutazione nelle piantine delle zone contaminate rispetto alle piante da zone "pulite". Le specie di flora selvatica si sono pertanto dimostrate utili e sensibili per la stima della genotossicità ambientale.

Parole chiave: genotossicità ambientale, metalli pesanti, inquinamento da petrolio, specie di piante selvatiche

INTRODUCTION

Understanding the influence of increasing environmental pollution on living organisms has been one of the most important problems to date. The progress of humankind is inseparably linked to the development of industry, which, in turn, inevitably leads to the contamination of the atmosphere, hydrosphere, lithosphere (soil) and biosphere. Water, air and soil pollution adversely affect living organisms, including humans.

A contaminated environment has both toxic and genetic effects on living organisms. While the toxic influences, as a rule, can easily be assessed, the impact of pollution on the genetic structures of an organism, including possible remote consequences, is difficult to determine.

There are a number of effective methods currently developed to estimate the quality of the environment. The classic methods include sampling of water, air and soil probes, and their laboratory analysis using physical-chemical procedures. This approach, however, does not allow the estimation of the hazardous effect of the detected pollutant on living organisms. Test systems designed to assess the genotoxic effects of pollution, on the other hand, can indicate the possible mutagenic, carcinogenic, teratogenic and other harmful consequences. An impressive number of newly synthesized chemicals and environmental components (soil, air, water and sediments) containing various types of pollutants have already been examined with this method throughout the world (Chen & White, 2004; Ohe *et al.,* 2004; White & Claxton 2004). However, even this approach cannot provide complete information about how a genotoxic effect detected with a test system can influence plants, animals or their associations. Currently, another approach is being developed to estimate the quality of the environment: the assessment of the genotoxic effect of pollution *in situ*, directly on plants and animals living in a determinate area (Vardar *et al.,* 2014; Watanabe *et al.,* 2014). In this case, the whole complex of hazardous compounds will be taken into consideration, including their synergism and antagonism.

Since the 1970s, higher plants have been widely used to screen mutagens and monitor genotoxicants in the environment (de Serres, 1978; Grant & Salamone, 1994; Sandhu *et al.*, 1994; Ma *et al.*, 2005; Sposito *et al.*, 2015; Amato-Lourenco *et al.*, 2017; Sposito *et al.*, 2017). Most experiments *in situ* were performed using standard test systems with *Tradescantia, Allium cepa* and *Vicia faba* (White & Claxton, 2004). Plant test systems have proven to be highly sensitive to heavy metals (Knasmuller *et al.*, 1998; Minissi *et al.*, 1998; Majer *et al.*, 2002; Correia *et al.*, 2014), products of oil-processing industry (Minissi *et al.,* 1998; Morais Leme & Aparecida Marin-Morales, 2008) and other organic substances (Herrero *et al.,* 2012; Mesi & Kopliku, 2013; Goujon *et al.,* 2015; Rodríguez *et al.,* 2015), as well as nanoparticles (Ghosh *et al.,* 2016; Panda *et al.,* 2016).

Nevertheless, plant test systems do have their limitations (Lazutka *et al.,* 2003), so it is preferable to use naturally growing plant species for genetic monitoring (Gers'kin *et al.,* 2005; Vardar *et al.,* 2014; Watanabe *et al.,* 2014). The aim of this work was to study the suitability of wild flora species to assess the genotoxicity of an environment.

MATERIAL AND METHODS

Characterization of the studied area and sampling

We used species of wild flora to test both inorganic (heavy metals) and organic (products of oil burning and refining) pollutants. The seeds collected at the tailing dump of a wolfram-molybdenum factory (Kabardino-Balkaria, Russia) were used to study the influence of heavy metal pollution. The factory was engaged in wolfram-molybdenum field exploitation and ore concentration until 2000, when it was closed down. The tailing dump we studied had been put into operation in 1967 and was located at an altitude of 1000-1200 meters above sea level. Surrounding areas similar to the studied areas in geo-climatic conditions (slope exposure and plants) were defined as the "clean zone" (background landscape).

In the case of pollution by the products of oil burning and refining, the seeds were collected in the Chechen Republic, in the surrounding areas of villages in which mini-factories for domestic oil refining were located. These mini-factories are usually built in the marginal areas of settlements or in woodland belts; their number can vary.

Several villages in which primary oil refining was practised for over 13 years were chosen as investigation sites. These were Dolynsk (Groznensky District), Alkhan-Yurt (Urus-Martanovsky District), Mesker-Yurt and Tsotsan-Yurt (Shalinsky Shalinskyi), and Geldegen (Kurchaloevsky District). They were selected for analysis because they are located in the same natural-climatic region and characterized by similar landscape features and vegetation. These villages were defined as the contaminated area. The village of Goity (Urus-Martanovsky District), which is known to be free of this type of industry and belongs to the same natural-climatic region was chosen as the "relatively clean" zone (termed as "relatively" because the benz(a)pyrene content in the soil was 0.03 mg/kg, which exceeds the legal limit of 0.02 mg/kg). The number of mini-factories in the studied polluted settlements ranged from 0 (Goity) to 62 (Dolynsk).

The plant collection proceeded as follows: a square territory of 10,000 ± 200 m^2 was marked off virtually and divided along the diagonal into areas of approximately 50 m^2. In each area, we selected 10 plants characterised by approximately the same behaviour at the stages of flowering and seed ripening, and then collected their seeds. Altogether, at each investigation site we collected seeds from at least 30 specimens of the same plants spe-

cies, and mixed them. Where only a few specimens of a plant species were available, the seeds were collected from all plants growing in that territory.

Test organisms

Plants of broadly distributed species were preferentially used for the investigation of genotoxicity of the environment in the Chechen Republic. These were waybread (*Plantago major* L.), medicinal dandelion (*Taraxacum officinale* Wigg. *s.l.*), Russian dock (*Rumex confertus* Willd.), and mayweed (*Matricaria recutita* L.). When studying the genotoxic effect of the waste from the wolfram-molybdenum factory, we used plants that grew in the surrounding regions and had ripe seeds at the moment of analysis (July-August). From the plants growing in dump areas we chose five species, specifically, cheatgrass (*Anisantha tectorum*); junegrass (*Koeleria cristata*); black henbane (*Hyoscyamus niger*); *Jurinea ciscaucasica* and medicinal dandelion (*Taraxacum officinale* Wigg. *s.l.*) to study the level of mutations; these species belong to distinct genera.

Tests procedure

The anaphase-telophase method was used to assess the level of chromosomal aberrations in plant seedlings. This method is based on the registration of chromosomal aberration at the anaphase and telophase stages. Owing to dormancy, the seeds only germinated in 1-3 months (or more) after harvesting, depending on plant species. Dandelion and grass seeds can germinate earlier, probably due to a shorter dormant period. It was important for the seeds of the same botanical species collected in "clean" and "contaminated" zone to have the same time of storage.

The seeds were germinated in glass Petri dishes on filter paper soaked with tap water in a thermostatic chamber at +26 °C. Germination times varied from 4 to 10 days, depending on the plant species. When necessary, the filter paper was additionally moisturized. The 5-10 mm long roots were fixed in a mix of ethanol and glacial acetic acid (3:1) for at least 2-3 hours. The material fixed this way can be stored up to 1-2 months in a refrigerator at 4 °C. The fixed seedlings were stained in acetocarmine (a 2% solution of carmine in 45% acetic acid) during a 10-12 min water bath. Temporary squash slides were prepared from the root meristem according to the standard method (Dubinina, 1978). At least 1000 anaphases were scored. Chromosome fragments, single and double "bridges" were registered. The percentage of abnormal anaphases against the total number of scored anaphases was calculated.

Chemical analysis

Soil samples were taken during dry summer days on the terraces of the dump area or in territories located approximately 100±20 m away from the oil-refinery factories, when the seeds of wild plants were also collected. Portions of soil were removed by probe from the upper 0-20 cm horizon in five repeats, then 5 kg of soil was mixed to prepare the sample for analysis (1 kg). The soil samples were put in tightly sealed polyethylene containers and marked with a tag indicating the place and time of sampling. For the purposes of chemical analysis, the soil was dried to obtain air-dry mass.

The level of heavy metals in the soils examined was determined using atomic-adsorption spectrophotometry (AAS). Analysis of soil samples for the presence of oil products was carried out in collaboration with the Laboratory of the Soil Sciences Department, Lomonosov Moscow State University by method of infrared spectroscopy (Orlov & Grishina, 1981). The method of low-temperature fluorescence spectroscopy developed by E. V. Shpolsky was used for the assessment of benz(a) pyrene content in soil (Shpolsky *et al.,* 1968).

Statistical processing

To determine the reliability of the observed differences we used Fisher's conversion for the match against shares, and two-factor dispersion analysis.

RESULTS

Tables 1 and 2 summarize the obtained data on heavy metal content in the soils of the studied areas. The content of metals in the tailing dump of the tungsten-molybdenum factory (Kabardino-Balkaria, Russia) was significantly higher (Tab. 1). In the Chechen Republic, where the main pollutants are oil products, the content of heavy metals in the soil in the "relatively clean" village of Goity was not significantly different from other studied villages, in some cases it was even higher (Tab. 2). As for benz(a)pyrene and other petroleum products, their contents in the contaminated zone were 60–80 times higher than those in the "relatively clean" zone of Goity (Tab. 3). In Table 3 and all subsequent tables, the

Tab. 1: Heavy metal concentrations in the soils of the disposal areas of a wolfram-molybdenum factory (Kabardino-Balkaria, Russia).
Tab. 1: Koncentracije težkih kovin v prsti na odlagališčih tovarne volframa in molibdena (Kabardino-Balkaria, Rusija).

Sampling area	Heavy metal content (mg/kg)					
	Mo	Pb	Cu	Zn	Bi	Sn
Tailing dump	>40	33	37	30-60	6.5	4.5
Clean zone	<2	8-13.5	9.5-13	10-15	0	0

Tab. 2: Heavy metal concentration (mg/kg) in the soils of the studied villages of the Chechen Republic.
Tab. 2: Koncentracije težkih kovin (mg/kg) v prsti preiskanih naselij v Čečenski republiki.

No	Site of soil sampling	Pb	Cd	Cr	Co	Mn
1	Goity	38.21	0.68	56.23	15.41	40.66
2	Tsotsan-Yurt	32.64	1.89	20.14	17.54	18.26
3	Geldegen	59.85	1.35	85.60	18.64	114.68
4	Mesker-Yurt	34.33	1.62	20.28	19.06	15.96
5	Alkhan-Yurt	54.70	1.22	72.44	17.80	136.78
6	Dolynsk	61.22	1.35	95.32	19.48	170.02

villages of the Chechen Republic are listed in order of increasing benz(a)pyrene content.

The anaphase-telophase method was used to assess the level of chromosomal aberrations in root meristem cells of plant seedlings. Figures 1a and 1b show a normal anaphase and telophase, respectively. Abnormal anaphases display acentric fragments and "bridges." Fragments of variable sizes emerge as a result of deletions (Fig. 1c) and chromosome lagging (Fig. 1d) during their movement to the poles. The joining of two centromere-containing fragments leads to the formation of a dicentric chromosome, which is affected by two mitotic centres and, being stretched between two daughter groups of anaphase or telophase chromosomes, forms a "bridge." Depending on the type of chromosome damage, different types of "bridges" may occur. The re-joining of two broken sister chromatids leads to the formation of a chromatid (usually single) "bridge" (Fig. 1e), whereas lateral re-joining of two broken chromosomes leads to the formation of a chromosomal (usually double) "bridge" (Fig. 1f).

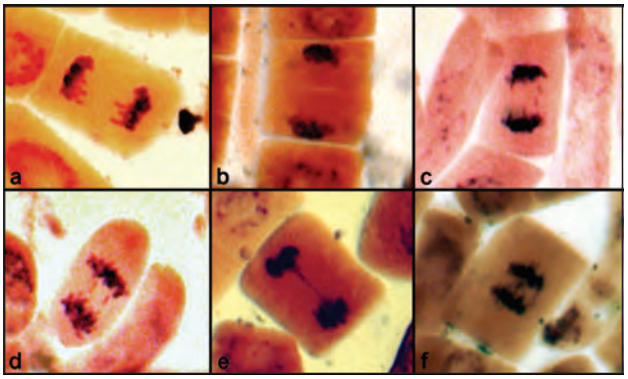

Fig. 1: Meristematic cells of** Taraxacum officinale **Wigg. s.l.: a – normal anaphase; b – normal telophase; c – anaphase with fragments; d – anaphase with lagging chromosomes; e - telophase with single "bridge"; f – anaphase with double "bridge".
Fig. 1: Meristemske celice regrata** Taraxacum officinale **Wigg. s.l.: a – normalna anafaza; b – normalna telofaza; c – anafaza s fragmenti; d – anafaza z zamikom kromosomov; e – telofaza s posameznim "mostom"; f – anafaza z dvojnim "mostom".

Table 4 shows the results of the estimation of the levels of chromosomal aberrations (CA) in plants collected in the disposal areas of the wolfram-molybdenum factory (Kabardino-Balkaria, Russia) contaminated with heavy metals. The frequency of CA in the root meristem of plants collected in disposal areas was statistically significantly higher than the frequency of CA in plants from the "clean zone." Fragments proved to be the prevailing type of chromosomal aberration in all plant species we studied, with "bridges" found in minor quantities.

Wild flora species were also used for genetic monitoring of oil products pollution. Table 5 shows the results of the estimation of mutation level in seedlings obtained from seeds collected in the vicinity of the Chechen villages with mini-factories for domestic oil refining.

The study also revealed significantly increased levels of mutation in plant species collected in contaminated zones compared to the "relatively clean" zone of Goity. Of all types of induced alterations, the studied species displayed the highest increase in the frequency of fragments. The highest level of chromosomal rearrangement was recorded in plants from the village of Dolynsk, which is situated in the most contaminated zone.

Dispersion analysis has shown that in the case of contamination with oil products, mutation frequency was more dependent on the level of soil pollution than on the plant species used for testing. The influence of soil pollution was 67.1 %, the influence of species 22.5 %, their combined effect only 8.56 %.

DISCUSSION

In our studies we used 8 plant species, including common (*T. officinale, P. major, R. confertus*) and rare plants. All of them were quite suitable for genetic monitoring and fairly sensitive to various types of pollutants. All species from contaminated zones showed a significant increase in the level of anaphase/telophase abnormalities compared to the clean zone. In the case of the environmental pollution with heavy metals (dumps

Tab. 3: Oil products and benz(a)pyrene content in the soils of some villages of the Chechen Republic.
Tab. 3: Derivati nafte in vsebnost benz(a)pirena v prsti nekaterih naselij v Čečenski republiki.

No	Soil sample site	pH	benz(a)pyrene content (mg/kg)	Hydrocarbons (%)	Oil products (%)
1	Goity	8.30	0.03	0.03	0.02
2	Tsotsan-Yurt	8.42	0.06	0.86	0.73
3	Geldegen	7.79	0.14	0.63	0.52
4	Mesker-Yurt	8.63	0.15	1.17	1.10
5	Alkhan-Yurt	8.42	0.26	1.48	1.48
6	Dolynsk	7.86	1.83	1.72	1.56

of the tungsten-molybdenum factory), the frequency of CA was 1.5-5 times higher compared to the clean zone. In the case of oil and benz(a)pyrene pollution (Chechen Republic), the frequency of mutations increased 5-10 times. A comparison of results related to the two types of pollutants (heavy metals and oil products) revealed both similarities and differences in their actions. In the case of oil product influence, we observed an emergence of double "bridges" in seedlings, which was not detected in the case of contamination with heavy metals. In both cases, fragments were the predominant type of disturbance.

The results obtained using species of wild flora are in agreement with data obtained through standard plant test systems (Reutova, 2005, 2017). In these works the genotoxicity of the soil from the tailings of the same tungsten-molybdenum factory was studied using standard plant test systems, and the results indicated a 2-fold increase in the frequency of mutations. The same studies were performed on soils of the villages in the Chechen Republic (Dzambetova & Reutova 2006). Soils contaminated with petroleum products caused a 5-fold increase in the frequency of mutations in plant test systems.

Virtually any plant species growing in a particular territory can be used for estimating genotoxic effects on the environment. It should be noted, however, that all species are not equally suitable objects for analysis. It is easier to work with species from the *Poaceae* and *Asteraceae* genera, as their seeds germinate easily and the roots are not very thick, which allows for good squash preparations. It is more difficult to work with seeds which have a dense, thick peel, as they germinate poorly and very slowly (*e.g.* the seeds of black henbane).

Mutagenic effects of HM, hydrocarbons, oil products and benz(a)pyrene have been studied for several dec-

Tab. 4: Level of chromosomal aberration in a wild plant from areas around a wolfram-molybdenum factory (Kabardino-Balkaria, Russia).
Tab. 4: Stopnja kromosomskih aberacij na divje rastočih rastlinah iz predelov okoli tovarne volframa in molibdena (Kabardino-Balkaria, Rusija).

Species	No of cells (ana/telo)	cells with aberrations	Aberrations (%)	P
Yurinea ciscaucasica Clean zone dumps	976 1264	17 46	1.76 3.64	<0,01
Anisantha tectorum Clean zone dumps	1024 1004	15 51	1.46 3.09	<0,05
Koeleria cristata Clean zone dumps	1043 1187	8 41	0.77 3.45	<0,001
Hyoscyanus niger Clean zone dumps	270 322	3 9	1.10 2.79	<0,05
Taraxacum officinale Clean zone dumps	1033 1007	41 194	3.97 19.72	<0,001

ades, using various test systems and providing detailed reports of the results in the reviews (Chen & White, 2004; Ohe *et al.*, 2004; White & Claxton, 2004). But there are very few works devoted to the study of environmental genotoxicity employing wild flora species growing in contaminated areas. In the past years, there have been some studies in which species of wild flora (mostly wood plants) were used for genetic monitoring and determining genotoxic effect on the environment. To this end, a micronuclei (MN) test was applied to the root meristem of pine (Geras'kin *et al.,* 2005) and silver birch (Kalaev *et al.,* 2006) seedlings. In all cases an increase of micronuclei frequencies was observed, even when the types of pollutants were different: ionizing radiation and heavy metals.

Herbaceous plants – *Arabidopsis thaliana* and *Crepis tectorum* – have previously been used to study the genetic processes in permanently irradiated plant populations. These studies revealed that plants with rearranged karyotypes started to appear two years after the Chernobyl accident, their frequency correlated with the frequency of CA in the cells of the root meristem. Thirty-eight years after the Kyshtym nuclear accident no increase in the frequency of plants with rearranged karyotype has been detected, because such plants did not have any selective advantages and were subjected

Tab. 5: Level of chromosomal aberration in a wild plant from areas contaminated with oil refinery products (Chechen Republic, Russia).
Tab. 5: Stopnja kromosomskih aberacij na divje rastočih rastlinah iz predelov pod vplivom onesnaženja iz rafinerije (Čečenska republika, Rusija).

Plant species	Collection site	Number of cells (ana/telo)	Cells with aberrations	Aberrations (%)	P
Taraxacum officinale Wigg. *s.l.*	Goity	1056	24	2.27	
	Tsotsan-Yurt	1007	96	9.53	<0.001
	Geldegen	1050	114	10.85	<0.001
	Mesker-Yurt	1012	104	10.28	<0.001
	Alkhan-Yurt	1026	121	11.7	<0.001
	Dolynsk	1044	126	12.07	<0.001
Matricaria recutita L.	Goity	1164	18	1.55	
	Tsotsan-Yurt	1062	106	9.98	<0.001
	Geldegen	1018	98	9.63	<0.001
	Mesker-Yurt	1013	118	11.65	<0.001
	Alkhan-Yurt	1071	89	8.31	<0.001
	Dolynsk	1070	121	11.31	<0.001
Rumex confertus Willd.	Goity	1002	17	1.69	
	Tsotsan-Yurt	1027	89	8.67	<0.001
	Geldegen	1020	106	10.39	<0.001
	Mesker-Yurt	1006	96	9.54	<0.001
	Alkhan-Yurt	1082	87	8.04	<0.001
	Dolynsk	1051	113	10.75	<0.001
Plantago major L.	Goity	1018	9	0.89	
	Tsotsan-Yurt	1101	53	4.81	<0.001
	Geldegen	1059	61	5.76	<0.001
	Mesker-Yurt	1006	47	4.67	<0.001
	Alkhan-Yurt	1023	36	3.52	<0.001
	Dolynsk	1004	91	9.06	<0.001

to negative selection along with a decreasing irradiation dose rate (Abramov *et al.,* 2006). The authors also noticed that the plant species they used in their studies could be recommended as test objects for the registration of genetic effects of low-dose ionizing radiation. Our study, too, has proved the suitability of wild flora species for identifying the genotoxicity of an environment when contaminated with inorganic (HM) and organic (hydrocarbons, oil products and benz(a)pyrene) substances.

CONCLUSIONS

Species of wild flora are very convenient objects for genetic monitoring, because they allow *in situ* analysis and an evaluation of the effects of all complex of environmental factors, they are highly sensitive to different types of pollutions, and their testing does not require expensive facilities or highly qualified personnel.

To perform a comparative analysis of the results it is necessary to have an indicator species with a fairly broad distribution. From our point of view, medicinal dandelion (*Taraxacum officinale* Wigg. *s.l.*) is the best candidate. Dandelion proves to be a universal species, as its flowering or fruiting plants can be found throughout the summer period, with massive flowering typically occurring in May and early June. Dandelion seeds have a short dormant period; their germination rate is high and they germinate fast. The seedling roots are of an optimal size for making good squash preparations and the species is sensitive to various types of pollution (heavy metals, organic pollutants). Given all these factors we suggest that dandelion be used as a standard species for the examination of genotoxic effects on the environment.

RASTLINSKE VRSTE KOT INDIKATORJI OKOLJSKE GENOTOKSIČNOSTI

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POVZETEK

Pričujoča raziskava opredeljuje uporabnost divje rastočih rastlinskih vrst za ugotavljanje okoljske genotoksičnosti. Nivo mutacij v celicah v koreninskem meristemu je bil preiskan na 8 rastlinskih vrstah, ki uspevajo v okolju pod vplivov različnih okoljskih dejavnikov. Za ugotavljanje vpliva onesnaženja s težkimi kovinami so uporabili semena, nabrana na odlagališčih tovarne wolframa in molibdena (Kabardino-Balkaria, Rusija). V primeru onesnaževanja z produkti izgorevanja in rafiniranja nafte so bila semena pobrana v predelih z mini-tovarnami za predelavo nafte (Čečenska republika, Rusija). Onesnaženje je *povzročilo 2,5 do 10,2 – kratno povečanje frekvence mutacij na sadikah iz onesnaženega okolja v primerjavi s sadikami v "čistem" okolju. S tega vidika so divje rastoče rastlinske vrste uporabne kot občutljivi objekti za ugotavljanje okoljske genotoksičnosti.*

Ključne besede: okoljska genotoksičnost, težke kovine, onesnaženje z nafto, divje rastoče rastlinske vrste

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LE ORCHIDACEAE DEL COMUNE DI PISINO (PAZIN, CROAZIA)

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SINTESI

Pisino (Pazin, Croazia) è un comune situato nell'Istria centrale il cui territorio occupa la superfice di circa 135 km^2. *Nel presente lavoro, tenendo conto di ricerche dirette, fonti bibliografiche e segnalazioni inedite,* è riportata e discussa *una check-list aggiornata di tutte le Orchidaceae comprendente 40 taxa, di cui 3 ibridi. Inoltre è stata fatta anche l'analisi corologica che evidenzia la prevalenza dell'elemento Mediterraneo seguito dall'Eurasiatico.*

Parole chiave: Pisino, Orchidaceae, check-list, contingenti floristici

THE ORCHIDACEAE OF THE MUNICIPALITY OF PAZIN (CROATIA)

ABSTRACT

The territory of the Municipality of Pazin covers the surface of ca 135 km^2. In the present work we reported an updated check-list of Orchidaceae recorded in the area, comprising 40 taxa, of which 3 are hybrids. The check-list includes unpublished field observations and literature records taking into account direct research, bibliographic sources and unpublished reports. Furthermore, a chorological spectrum was built which highlights the prevalence of the Mediterranean element followed by the Eurasian.

Key words: Pazin, Orchidaceae, check-list, floristic composition

INTRODUZIONE

Negli ultimi tempi i ricercatori botanici appassionati hanno dimostrato un notevole e crescente interesse verso le Orchidaceae Juss., una famiglia che essendo costituita da circa 27.800 specie ripartite in 880 generi (Givnish *et al.,* 2016), è considerata la più ricca del mondo vegetale dopo le *Asteraceae*. Grazie al loro importante contributo, le conoscenze in generale su questa famiglia sono notevolmente aumentate ed esse hanno portato alla descrizione di nuovi taxa e a una miglior definizione degli areali di distribuzione delle specie che vi appartengono.

Il presente saggio, in linea con la tendenza in precedenza delineata, ha per finalità la compilazione di una check-list comprendente le specie, le sottospecie e gli ibridi di Orchidaceae presenti nell'area d'indagine, attraverso studi noti in letteratura, ricerche sul campo dell'autore e informazioni inedite fornite da studiosi.

Allo stato attuale non è stato pubblicato nessun lavoro monografico specifico sulle orchidee spontanee dell'ambito di studio qui considerato, nonostante le numerose ricerche condotte in quest'area da alcuni secoli. Tra i pionieri delle ricerche floristiche nel pisinese va considerato Pospichal (1897) che a Volovica cita il ritrovamento di *Ophrys pseudospeculum* (*O. sphegodes*). Le ricerche sono continuate in seguito e tra esse vanno evidenziate quelle condotte da Biel (2001), Hertel & Hertel (2002) e Griebl (2009) che in tre loro importanti monografie sulle orchidee istriane citano il ritrovamento di vari taxa nel pisinese.

Inquadramento dell'area di studio

Il Comune di Pisino (Pazin in croato) è situato quasi al centro dell'Istria, in una vasta vallata ove si alternano aree pianeggianti e colline con altitudine media compresa tra 300 e 500 metri. La sua superfice copre circa 135 km² mentre la popolazione residente è di oltre 8600 abitanti con una densità media di circa 66 ab/km². Di questi, circa 5000 abitanti vivono nel centro storico, mentre il resto si ripartisce in 18 frazioni e vari casolari sparsi che con i loro toponimi ricordano i cognomi delle famiglie che nei secoli passati vissero in quei luoghi (Alberi, 1997). Negli ultimi anni il numero di abitanti delle frazioni e case sparse si è ridotto.

Aspetti geologici e geomorfologici

Il territorio pisinese si trova in un ambito in cui s'incontrano i terreni e rocce calcaree dell'Istria rossa emersi tra il Giurassico e il Cretaceo con quelli marnoso-arenacei dell'Istria grigia che si depositarono dal Paleocene fino all'Eocene (D'Ambrosi, 1931; Babić, 2007). Dal Miocene, i terreni marnoso-arenacei della zona sono stati interessati dalla costituzione di ricca idrografia superficiale con la formazione di valli profonde e numerosi canaloni (D'Ambrosi, 1931).

I più importanti corsi d'acqua che lo attraversano sono il torrente Foiba (Pazinčica) che, dopo un corso superficiale di circa 17 km s'inabissa nel sottosuolo, ed il fiume Bottonega (Butoniga) che alimenta un lago artificiale (*Butoniga Jezero*). Lungo i percorsi dei torrenti che scendono dalle colline, si osservano depositi alluvionali di origine postglaciale. Degna di nota nell'area di studio è la cosiddetta Foiba di Pisino, un profondo abisso lungo circa 500 metri, costituito da pareti verticali e dirupi alti circa 120 metri che si aprono tra le rocce calcaree del Cretaceo.

Il clima

La morfologia del territorio e la sua posizione nell'entroterra istriano influiscono sulle condizioni climatiche del pisinese in cui generalmente si osservano: inverni umidi con gelate occasionali e abbondanti precipitazioni; estati calde e mediamente secche. Ad avviso di Feresini (1972) e Alberi (1997) la conca di Pisino è caratterizzata da un clima temperato-umido con forti escursioni termiche. I dati termopluviometrici registrati nel periodo 1961-1990 sono stati i seguenti: temperatura minima assoluta -18,7 °C; temperatura massima assoluta 38,2 °C; temperatura media annua 11,1 °C; temperatura media del mese più freddo (gennaio) 2,5 °C e di quello più caldo (luglio) 20,4 °C, valori medi di precipitazioni annue attorno a 1168 mm (Zaninović *et al*., 2008). La stagione con precipitazioni più abbondanti è l'autunno, mentre nel periodo estivo si registrano i valori minimi. Il mese con maggiori precipitazioni si colloca attorno a ottobre mentre i valori più bassi si osservano tra luglio e agosto. Tali particolari parametri sono tipici di un clima submediterraneo di transizione (Walter & Lieth, 1960; Šegota & Filipčić, 1996). In effetti, la penisola istriana è considerata un'area di transizione climatica fra gli ambiti centro-europeo e mediterraneo.

Aspetti botanici, vegetazionali e fitogeografici

Dal punto di vista vegetazionale il territorio pisinese appartiene all'orizzonte del bosco misto di latifoglie decidue tendenzialmente termofilo in cui si sviluppa la tipica vegetazione submediterranea e submontana, ma a causa dell''influsso combinato degli elementi del paesaggio, le sue vicende storico-geologiche, l'andamento climatico e la pressione antropica attuale e del passato, sono osservabili varie formazioni vegetali costituite da entità di diversa origine geografica: varie tipologie di boschi più o meno estesi, arbusteti, associazioni prative, pinete artificiali, etc.

Il tipo di bosco più diffuso è l'*Ostryo-Quercetum pubescentis* (Ht.) Trinajstić 74 (Čarni, 2003), un'associazione vegetale tipicamente submediterranea. A causa dei forti tagli cui è stato sottoposto sino ad alcuni decenni fa, è presente come una foresta bassa e negli ambiti più degradati *Ostrya carpinifolia* Scop. è la specie

dominante assieme all'onnipresente *Fraxinus ornus*.

Un'altra associazione arborea che si rinviene negli ambiti più freschi e riparati della zona è Il *Seslerio autumnalis-Fagetum* M. Wraber ex Borhidi 1963 (Šugar, 1984). Nella valle del torrente Foiba (Pazinčica) inoltre si rinvengono anche piccoli esempi di boschi con il carpino bianco (*Carpinus betulus* L.). L'associazione prativa più diffusa è il *Danthonio-Scorzoneretum villosae Horvat &* Horvatić 1958, che è molto comune nella parte sub-mediterranea della Croazia (Čarni, 2003). Accanto a queste associazioni principali si rinvengono altre tipiche degli ambiti rocciosi, delle zone umide e delle aree sottoposte a una forte pressione antropica (associazioni sinantropiche tipiche dei centri abitati, gli orli stradali e le aree coltivate).

Dal punto di vista fitogeografico, Šugar (1984), rileva che la vegetazione della zona è un mosaico costituito da piante mesofile e termofile appartenenti a due principali regioni: l'Eurosiberiana-Nordamericana e la Mediterranea.

MATERIALI E METODI

L'elenco floristico comprende le specie, le sottospecie e gli ibridi della famiglia Orchidaceae mentre non sono state prese in considerazione le varietà cromatiche e morfologiche. Nell'elenco non sono riportate le antiche segnalazioni storiche di specie non ritrovate recentemente.

In tale sede sono stati inseriti in bibliografia, i saggi botanici pubblicati negli ultimi trent'anni. Le prime osservazioni dello scrivente iniziarono circa 10 anni fa e si sono protratte nel tempo cambiando di anno in anno località e periodo d'indagine. Le stazioni in cui lo stesso ha fatto dei ritrovamenti sono contrassegnate dai loro nomi con l'aggiunta del punto esclamativo. Accanto ad ogni taxon sono riportati: il tipo corologico, gli autori che l'hanno segnalato, le località di presenza ed eventuali osservazioni sul rango tassonomico.

La nomenclatura segue il recente volume del GIROS (2016) e per le specie non riportate in tale testo si è seguito Delforge (2016). Per l'assegnazione dei tipi corologici si è tenuto conto di quanto riportato in Pignatti (1982), Delforge (2016) e Pezzetta (2018).

RISULTATI E DISCUSSIONE

Elenco floristico

Nell'elenco al fine di evitare troppe ripetizioni, sono state utilizzare delle sigle costituite da lettere maiuscole che si riferiscono agli autori delle segnalazioni. Esse hanno il seguente significato:

AX: Biel 2001; AY: Pericin 2001; BX: Hertel & Hertel 2002; BY: Griebl 2009; CX: Starmühler 2010; CY: Rottensteiner 2018; DX: Souche inedito (informazione personale).

1. *Anacamptis coriophora* (L.) R.M. Bateman, Pridgeon & M.W. Chase subsp. *coriophora* – Eurimediterraneo. (CY). Stazione di rinvenimento: Pazin.
2. *Anacamptis coriophora* (L.) R.M. Bateman, Pridgeon & M.W. Chase subsp. *fragrans* (Pollini) R.M. Bateman, Pridgeon & M.W. Chase – Eurimediterraneo. (AX, AY, BX). Stazioni di rinvenimento: Beram, Pazin!, Trviž.
3. *Anacamptis laxiflora (*Lam.) R.M. Bateman, Pridgeon & M.W. Chase – Eurimediterraneo. (AX, BX). Stazioni di rinvenimento: Beram, Pazin!, Trviž.
4. *Anacamptis morio* subsp. *morio* (L.) R.M. Bateman, Pridgeon & M.W. Chase – Europeo-Caucasico. (AX, BX, BY, DX). Stazioni di rinvenimento: Beram!, Cvitani!, Grdoselo!, Lindar, Marčani, Miličići, Mohorići, Pazin!, Trviž.
5. *Anacamptis papilionacea* (L.) R.M. Bateman, Pridgeon & M.W. Chase – Eurimediterraneo. (AX). Stazioni di rinvenimento: Beram, Pazin.
6. *Anacamptis pyramidalis* (L.) Rich. subsp. *pyramidalis* – Eurimediterraneo. (AX, BX, BY, CX, CY, DX). Stazioni di rinvenimento: Beram!, Grdoselo!, Lindar, Miličići, Pazin!, Trviž!. Sono state ricondotte alla specie tutte le segnalazioni di *Anacamptis pyramidalis* subsp. *serotina*.
7. *Cephalanthera damasonium* (Mill.) Druce – Eurimediterraneo. (AX, BX, BY, DX). Stazioni di rinvenimento: Beram!, Grdoselo!, Lindar, Marčani, Miličići, Mohorići, Pazin!, Trviž
8. *Cephalanthera longifolia* (L.) Fritsch – Eurasiatico. (AX, BX, BY, DX). Stazioni di rinvenimento: Beram!, Grdoselo!, Lindar, Marcani, Miličići, Mohorici, Pazin!,
9. *Epipactis atrorubens* (Hoffm.) Besser – Europeo. Stazioni di rinvenimento: (BY). Beram!.
10. *Epipactis helleborine* subsp. *helleborine* (L.) Crantz – Paleotemperato. (AX) Stazioni di rinvenimento: Beram!, Lindar, Pazin.
11. *Epipactis microphylla* (Ehrh.) Sw. – Europeo-Caucasico (AX). Stazione di rinvenimento: Beram.
12. *Epipactis muelleri* Godfery – Centro-Europeo. (BX, CY). Stazioni di rinvenimento: Grdoselo!, Pazin!.
13. *Epipactis palustris* (L.) Crantz – Circumboreale. (AX, BX, CY). Stazioni di rinvenimento: Grdoselo, Lindar, Pazin!, Trviž.
14. *Gymnadenia conopsea* (L.) R. Br. in W.T. Aiton susbp. *conopsea* – Eurasiatico. (AX, BX, BY, CX, DX). Stazioni di rinvenimento: Beram!, Grdoselo!, Lindar, Miličići, Mohorići, Pazin!, Trviž.
15. *Himantoglossum adriaticum* H. Baumann – Eurimediterraneo. (AX, BX, BY, CX, DX) Stazioni di rinvenimento: Beram!, Grdoselo!, Cvitani!, Miličići, Pazin!, Trviž.
16. *Limodorum abortivum* (L.) Sw. – Eurimediterraneo. (AX, BX, BY, DX). Stazioni di rinvenimento: Beram, Lindar, Marčani, Pazin!, Trviž.

17. *Listera ovata* (L.) R. Br. – Eurasiatico. (AX, BX, BY, DX). Stazioni di rinvenimento: Beram, Grdoselo!, Lindar, Miličići, Marčani, Mohorići, Pazin!, Trviž.
18. *Neotinea tridentata* (Scop.) R.M. Bateman, Pridgeon & M.W. Chase – Eurimediterraneo. (AX, BX, BY, DX). Stazioni di rinvenimento: Beram! Grdoselo!, Lindar, Marčani, Miličići, Mohorići, Pazin!, Trviž!.
19. *Neotinea ustulata* (L.) R.M. Bateman, Pridgeon & M. W. Chase – Europeo-Caucasico. (AX, AY). Stazioni di rinvenimento: Beram, Pazin!, Trviž.
20. *Neottia nidus-avis* (L.) Rich. – Eurasiatico. (AX, BY). Stazioni di rinvenimento: Lindar, Miličići, Pazin!, Trviž.
21. *Ophrys apifera* Huds. – Eurimediterraneo. (AX, BX, BY, DX). Stazioni di rinvenimento: Beram, Grdoselo!, Lindar, Miličići, Pazin!, Trviž.
22. *Ophrys holosericea* (Burm. f.) Greuter subsp. *tetraloniae* (W.P. Teschner) Kreutz – Appennino-Balcanico. (AX, BX). Stazioni di rinvenimento: Grdoselo!, Pazin!, Trviž.
23. *Ophrys holosericea* (Burm. f.) Greuter *subsp. untchjii (*M. Schulze) Kreutz – Subendemico. (AX, BX, DX). Stazioni di rinvenimento: Beram, Lindar, Pazin! Sono state ricondotte al taxon le segnalazioni di *Ophrys hol*. II fatte da Hertel & Hertel (2002).
24. *Ophrys incubacea* Bianca subsp. *incubacea* – Stenomediterraneo. (AX, BX, BY). Stazioni di rinvenimento: Beram, Grdoselo, Lindar, Miličići, Pazin!, Trviž.
25. *Ophrys insectifera* L. – Europeo. (AX, BY, DX). Stazioni di rinvenimento: Beram, Grdoselo!, Lindar, Marčani, Miličići, Mohorići, Pazin!, Trviž.
26. *Ophrys sphegodes* subsp. *sphegodes* Mill. – Eurimediterraneo. (AX,, BX,, BY, CX). Stazioni di rinvenimento: Beram!, Cvitani!, Grdoselo!, Marcani, Lindar, Miličići, Mohorići, Pazin!.
27. *Ophrys sulcata*. Devillers-Tersch. & P. Devillers – Mediterraneo-Occidentale. (AX). Stazione di rinvenimento: Beram. Segnalata da Biel (2001) come *O. fusca* Link. In accordo con Delforge gli individui vanno assegnati al taxon in oggetto. Secondo Romolini (2002) la specie va assegnata a *O. funerea* Viv. Il taxon in Istria raggiunge il limite orientale di distribuzione geografica.
28. *Orchis mascula* L. subsp. *speciosa* (Mutel) – Centro-Europeo. (AX, AY, BY). Stazioni di rinvenimento: Beram!, Grdoselo!, Lindar, Marčani, Miličići, Mohorići, Pazin!, Trviž.
29. *Orchis militaris* L. – Eurasiatico. (AX, BX, BY). Stazioni di rinvenimento: Beram, Grdoselo!, Lindar, Miličići, Mohorići, Pazin!, Trviž.
30. *Orchis pallens* L. – Europeo-Caucasico. (BY). Stazioni di rinvenimento: Grdoselo, Pazin.
31. *Orchis purpurea* Huds. – Eurasiatico. (AX, BX, BY, DX). Stazioni di rinvenimento: Beram!, Cvitani!, Grdoselo!, Lindar, Marčani, Miličići, Mohorići, Pazin!, Trviž.
32. *Orchis simia* Lam. – Eurimediterraneo. (AX, BX, BY, DX). Stazioni di rinvenimento: Beram, Grdoselo!, Marčani, Miličići, Mohorići, Pazin!.
33. *Platanthera bifolia* (L.) Rchb. subsp. *bifolia* – Paleotemperato. (AX, AY, BX, BY, CX, CY, DX). Stazioni di rinvenimento: Beram!, Butoniga, Cvitani!, Lindar, Miličići, Pazin!, Trviž!.
34. *Platanthera chlorantha* (Custer) Rchb. – Eurosiberiano. (AX, BY). Stazioni di rinvenimento: Beram, Lindar, Marčani, Miličići, Pazin!
35. *Serapias vomeracea* (Burm.f.) Briq. subsp. *vomeracea* – Eurimediterraneo.(AX, BX, BY). Stazioni di rinvenimento: Beram, Pazin!.
36. *Spiranthes spiralis* (L.) Chevall. – Europeo-Caucasico. (BX). Stazione di rinvenimento: Pazin.
37. *Traunsteinera globosa* (L.) Rchb. – Orof. Sud-Europeo. (AX). Stazioni di rinvenimento: Beram, Pazin.

Ibridi

1. *Ophrys* x *obscura* G. Beck (O. *holosericea* x *O. sphegodes*). (BY). Stazione di rinvenimento: Pazin.
2. *Ophrys* x *todaroana* Macchiati (O. *incubacea* x *O. sphegodes*). (BY). Stazione di rinvenimento: Miličići.
3. *Orchis* x *hybrida* (Lindl.) Boenn. ex Rchb. (*O. militaris* x *O. purpurea)*. (AX, BX). Stazioni di rinvenimento: Beram, Pazin.

Nell'elenco floristico sono riportati 37 taxa infragenerici. Al loro insieme si aggiungono 3 ibridi e pertanto il numero complessivo dei taxa presenti è di 40. Nel territorio comunale di Pisino sono segnalate oltre il 45.12 % delle Orchidaceae della penisola istriana che ammonta a 82 taxa ripartiti tra specie e sottospecie (Pezzetta, *in prep.*) e il 25 % di quelle di tutta la Repubblica di Croazia, che sulla base di quanto riportato in Nikolić (2015) ammonterebbe a 148 taxa, esclusi gli ibridi.

L'elenco non riporta entità nuove mentre comprende diverse segnalazioni e stazioni inedite (Cvitani) che contribuiscono ad allargare l'areale di diffusione dei singoli taxa. Le varie entità si ripartiscono in 17 generi, tra cui il più rappresentato è il genere *Ophrys* con 7 taxa. Seguono i generi: *Anacamptis* con 6 taxa, *Epipactis* e *Orchis* con 5 taxa ciascuno, *Cephalanthera*, *Platanthera* e *Neotinea* con 2 e poi gli altri con 1. I vari taxa sono segnalati in località diverse, variano da un minimo di 5 osservati presso Cvitani a un massimo di 31 presenti nei dintorni del Capoluogo e dimostrano che le orchidacee sono ampiamente diffuse in tutto il territorio comunale.

Tab. 1: Corotipi delle Orchidaceae pisinesi.
Tab. 1: Horotipi kukavičevk pazinske občine.

Elementi geografici	**Numero taxa**	**%**
Endemico e Subendemico	**1**	**2,7**
Subendemico	1	
Mediterraneo	**15**	**40,54**
Eurimediterraneo	13	
Stenomediterraneo	1	
Mediterraneo-Occidentale	1	
Eurasiatico	**14**	**37,84**
Eurasiatico *s.s.*	6	
Europeo-Caucasico	5	
Eurosiberiano	1	
Paleotemperato	2	
Nordico	**1**	**2,7**
Circumboreale	1	
Europeo	**6**	**16,22**
Europeo *s.s.*	2	
Centro-Europeo	2	
Orofita Sud-Europeo	1	
Appennino-Balcanico	1	
Totale	**37**	**100**

La Tabella 1 evidenzia che le Orchidaceae dell'ambito di studio si ripartiscono in 13 tipi corologici raggruppati in 5 elementi geografici tra cui domina l'elemento Mediterraneo con 15 taxa. Esso è seguito dagli elementi: Eurasiatico con 14 taxa, Europeo con 6, Nordico ed Endemico con un taxon ciascuno. I corotipi in cui si registra la maggior presenza di specie sono: l'Eurimediterraneo (13), l'Eurasiatico (6) e l'Europeo-Caucasico (5).

Confrontando i valori della Tabella 1 con quelli riguardanti i corotipi delle Orchidaceae presenti nel Comune di Valle, situato sulla costa occidentale istriana, a soli 30 Km circa in linea d'aria da Pisino e caratterizzato da un numero di entità abbastanza vicino (31 taxa distinti tra specie e sottospecie) (Pezzetta, 2017), si osserva che nel territorio pisinese si ha una forte riduzione in valori assoluti e percentuali dei taxa degli elementi Endemico (da 3 a 1 e in valori percentuali dal 9.7 % al 2.7 %) e Mediterraneo (da 16 a 15 e in valori percentuali dal 51.6 % al 40,1 %); aumentano i taxa degli elementi Europeo ed Eurasiatico.

Questi semplici dati confermano che le orchidee dell'ambito di studio presentano un carattere fitogeografico diverso rispetto a quelle di Valle e tale differenza sembra essere legata alle diverse situazioni climatiche e ambientali: Valle risulta essere un'area con ancora una forte impronta mediterranea, mentre l'area presa qui in considerazione mostra un netto passaggio verso un clima temperato in cui sussiste però ancora una certa mediterraneità: si tratta del clima submediterraneo.

CONCLUSIONI

L'alto numero di Orchidacee presenti nel pisinese è un importante indicatore della sua ottima qualità e integrità ambientale. Diverse entità ivi presenti si rinvengono nei prati da sfalcio e potranno persistervi sino a quando le attività umane manterranno un moderato disturbo che assicurerà la conservazione del loro habitat (Kaligarič & Otopal, 2012; Slaviero *et al.*, 2016).

KUKAVIČEVKE PAZINSKE OBČINE (PAZIN, HRVAŠKA)

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POVZETEK

Občina Pazin (Hrvaška) se nahaja v osrednji Istri in pokriva površino približno 135 km². V pričujočem delu avtor na podlagi neposrednih raziskav, bibliografskih zapisov in neobjavljenih opažanj podaja dopolnjeni seznam kukavičevk, ki šteje 40 taksonov, med katerimi so trije križanci. Poleg tega je opravil še horološko analizo, ki kaže, da prevladujejo sredozemski elementi, tem pa sledijo evraziatski floristični elementi.

Ključne besede: Pazin, Orchidaceae, popis, floristična sestava

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FIRST RECORD OF THE BRYOZOAN *TRICELLARIA INOPINATA* (D'HONDT & OCCHIPINTI AMBROGI, 1985) FROM THE SLOVENIAN SEA

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ABSTRACT

In this paper we present the first record of Tricellaria inopinata *d'Hondt & Occhipinti Ambrogi, 1985 for the Slovenian coastal sea. The colonies of this bryozoan were found attached to the mussel shells in the sight of Sečovlje, Strunjan and Debeli rtič mussel cultures from April to October 2018 and in Valdoltra harbour in November 2018. After the introduction into the Lagoon of Venice in the 1980s and its rapid spread throughout the lagoon in the following years, the species was regarded as an invasive taxon for that area and it is highly expected to colonize the whole Northern Adriatic region. The status of* T. inopinata *and its ecological impact has yet to be determined for the Slovenian coastal sea.*

Key words: *Tricellaria inopinata*, alien species, Gulf of Trieste, Adriatic Sea, mussel aquaculture

PRIMA SEGNALAZIONE DEL BRIOZOO *TRICELLARIA INOPINATA* (D'HONDT & OCCHIPINTI AMBROGI, 1985) PER IL MARE SLOVENO

SINTESI

L'articolo tratta il primo ritrovamento di Tricellaria inopinata *d'Hondt & Occhipinti Ambrogi, 1985 per le acque costiere slovene. Le colonie di questo briozoo sono state trovate attaccate ai gusci delle cozze nelle mitilicolture di Sicciole, Strugnano e Punta grossa da aprile a ottobre 2018, e nel mandracchio di Valdoltra nel novembre 2018. Dopo l'introduzione della specie nella Laguna di Venezia negli anni '80 e la rapida diffusione in tutta la laguna negli anni seguenti, la specie* è stata *considerata invasiva per quell'area e si prevede che colonizzi l'intero Adriatico settentrionale. Lo stato di* T. inopinata *e il suo impatto ecologico devono ancora venir determinati per le acque costiere slovene.*

Parole chiave: *Tricellaria inopinata*, specie aliena, Golfo di Trieste, mare Adriatico, mitilicoltura

INTRODUCTION

The arborescent Cheliostomatid Bryozoan *Tricellaria inopinata* d'Hondt & Occhipinti Ambrogi, 1985 (Bryozoa: Candidae) is creamy-light brown in colour and it forms bushy colonies on hard substrata. The species is tolerant to a broad range of temperatures and salinity and it is capable of year-round reproducing, which makes it very competitive (Cook *et al*., 2013).

T. inopinata was first described from the Venice lagoon (Mediterranean Sea) in 1982 (d'Hondt & Occhipinti Ambrogi, 1985). Although the precise native origin of the Bryozoan remains unclear, it is assumed that the species originates from the Pacific (Dyrnda *et al*., 2000), where the T. *inopinata –occidentalis - porteri* complex of several closely related morphospecies occurs (Occhipinti Ambrogi & d'Hondt, 1994).

The complex of species is widespread in the whole Pacific, classified either as an introduced species in the case of New Zealand (Gordon & Mawatari, 1992) or as a cryptogenic species on the coast of the USA, Canada, Japan and Australia (Dyrynda *et al*., 2000). It has been reported from several locations in the Eastern Atlantic: Portugal, Spain, Scotland, Ireland, Southern coast of England, France, Germany, Belgium and Netherlands (De Blauwe & Faasse, 2001; Breton & d'Hondt, 2005; Arenas *et al*., 2006; Marchini *et al*., 2007; Buschbaum *et al*., 2012; Cook *et al*., 2013); in the Western Atlantic: Massachusetts (Johnson *et al*., 2012); as well as in the Arctic Ocean: Norwegian Sea (Porter *et al*., 2015).

In the Mediterranean Sea, *T. inopinata* has most frequently been recorded in the Italian part of the Northern Adriatic (Occhipinti-Ambrogi, 2000). It has also been reported in some other parts of Italy (harbours La Spezia and Olbia in Ligurian and Tyrrhenian Sea, respectively) (Lodola *et al*., 2012), in Tunisia (Ben Souissi *et al*., 2006) and in marinas of Agde and Le Grau-du-Roi, France and Heraklion in Greece (Ulman *et al*., 2017).

Besides the records from the Italian part of the northern Adriatic there were no other records so far in the Adriatic. The finding presented in this work is thus the first record of *T. inopinata* outside Italian waters of the Adriatic Sea and the first record for the Slovenian Sea.

MATERIAL AND METHODS

The colony of *T. inopinata* was collected from the mussel aquaculture in Sečovlje (GPS coordinates: 45°29′21.18″, 13°34′57.96″) on 6th of April 2018 (Fig. 1). It was found attached to a shell of *Mytilus galloprovincialis* from the depth of 0.5 m. Mussels were scraped

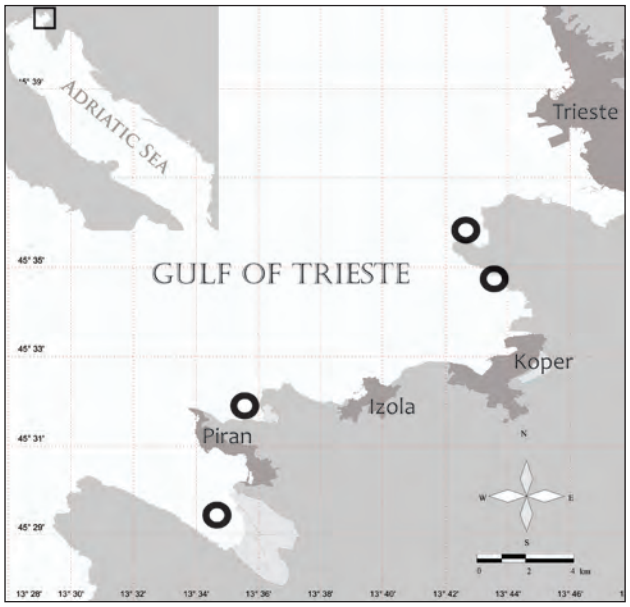

Fig. 1: Map of the Gulf of Trieste with four locations where colonies of *Tricellaria inopinata* ***were found (circle).***
Sl. 1: Zemljevid Tržaškega zaliva z označenimi štirimi območji (krogec), kjer so bile najdene kolonije vrste *Tricellaria inopinata***.**

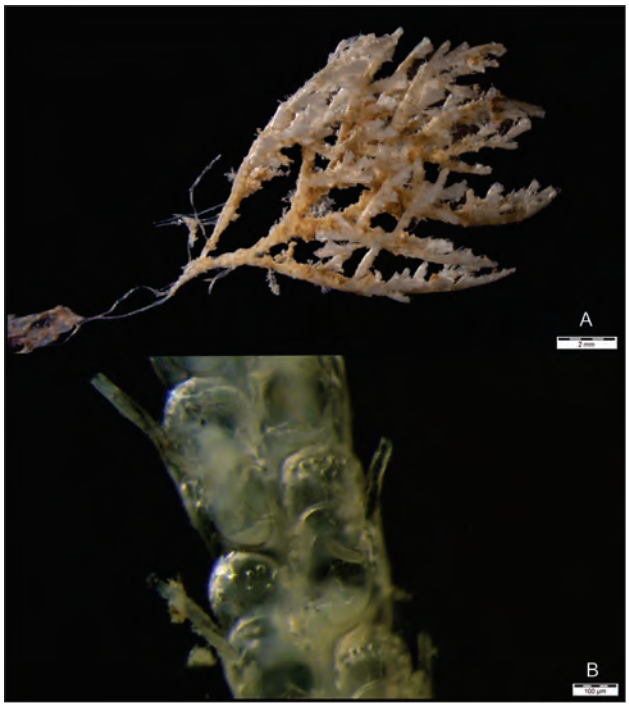

Fig. 2: Photographs of the colony of *Tricellaria inopinata****: A – a broad view of the colony, B – a close-up view of one branch of the colony with autozoids (photos: A. Fortič).***
Sl. 2: Fotografije kolonije mahovnjaka *Tricellaria inopinata****: A – široki posnetek razvejane kolonije, B – približani posnetek dela kolonije z vidnimi avtozoidi (fotografiji: A. Fortič).***

off a buoy and a rope with a scraping net and brought back to the laboratory. Detailed inspection of the fouling community with the dissection microscope revealed a cream-coloured arborescent bryozoan colony (Fig. 2A). It was preserved with an ethanol-based fixation reagent (FineFIX) and is stored as a part of species record collection of Marine Biology Station (National Institute of Biology) in Piran.

Consequent samplings were performed on three sites of mussel aquaculture in Strunjan, Debeli rtič and Sečovlje. On six occasions we found several colonies of *T. inopinata*, using the same sampling procedure. We employed the similar protocol, when sampling in some Slovenian harbours. Fouling community was scraped off the hulls of boats and later inspected in the laboratory. *T. inopinata* was found in Valdoltra harbour, attached both to mussel shells and directly to the boat hull (Tab. 1).

RESULTS AND DISCUSSION

The colonies of *T. inopinata* were found attached to the mussel shells and in one case on the boat hull with smooth rhizoids. The bryozoan was determined due to certain diagnostical features. The stem is dichotomously branched, bearing autozoids arranged in two rows, with large lateral avicularia. The colony is composed of autozoids with or without distally positioned globular shaped brooding chambers (ovicells), which are multi-pored. The scuta, partially covering opesia are highly diverse throughout the colony, but are mainly antler-shaped (Fig. 2B). Some of the proximal external spines have double tips, but not all. The specimen was assigned to the species *T. inopinata*, following the description from Dyrynda *et al*. (2000), Johnson *et al*. (2012) and Lodola *et al*. (2012).

Tab. 1: Dates and sites of sampling in three Slovenian mussel aquacultures and one harbour when colonies of** T. inopinata **were found.
Tab. 1: Datumi in lokacije vzorčenja v treh slovenskih školjčiščih in enemu mandraču, kjer smo našli mahovnjaka** T. inopinata**.

Date	Site	GPS coordinates
6.4.2018	Sečovlje	45°29'21.18", 13°34'57.96"
7.5.2018	Sečovlje	45°29'21.18", 13°34'57.96"
5.6.2018	Debeli rtič	45°35'54.31", 13°42'29.32"
3.7.2018	Strunjan	45°31'50.22", 13°35'45.78"
27.9.2018	Sečovlje	45°29'38.00", 13°34'36.00"
5.10.2018	Debeli rtič	45°36'01.68", 013°42'19.92" and 45°35'58.56", 13°42'33.00"
5.10.2018	Sečovlje	45°29'24.54", 13°34'56.76"
16.11.2018	Valdoltra	45°34'47.68", 13°43'32.42"

The ability to colonize brackish and fully saline environments, combined with high tolerance to temperature variations and eutrophication levels, along with high reproductive potential, caused the rapid spread of *T. inopinata* (Occhipinti Ambrogi & d' Hondt, 1994; Dyrynda *et al*., 2000; Occhipinti Ambrogi, 2000). Ecological consequences of introduction of *T. inopinata* to the Lagoon of Venice were quickly evident. A rapid spread of *T. inopinata* through the canals of Venice, caused a disappearance of some native bryozoan species, consequently reducing biodiversity in the fouling community (Occhipinti Ambrogi, 2000). Competition with other bryozoan species was also observed in other parts of the world (Johnson *et al*., 2012). Another mention-worthy aspect of the colonisation of *T. inopinata* into new environments, is harbouring of the mobile alien fauna, such as *Caprella scaura*, *Monocorophium sextonae* (both Amphipoda) and *Paracerceis sculpta* (Isopoda) in Cádiz, Spain (Gavira-O'Neill *et al*., 2016).

Most likely the bryozoan is being transferred by means of shipping or aquaculture and secondary diffused by small boat traffic (Watts *et al.,* 1998; de Blauwe & Faasse, 2001; Occhipinti Ambrogi, 2002; Lodola *et al.,* 2012; Porter *et al*., 2015), as concluded from the occurrence of the species in harbours and marinas (Dyrynda *et al*., 2000). It was also found in Japanese tsunami debris that landed on the coast of North America in 2011 (Calder *et al.,* 2014).

Recently, Johnson and Woollacott (2015) have successfully assessed the introduction and spread of *T. inopinata* in Western Atlantic through multiple introduction events by the means of characterizing polymorphic microsatellite loci. It might be sensible to perform a similar study analysing both Pacific and Mediterranean specimens.

Although this species is highly expected for the whole area of the northern Adriatic, this is the first record of *T. inopinata* in Slovenian coastal sea. Currently we do not have enough data to assess the population status of this species in Slovenia. Up to date we have found the colonies of *T. inopinata* in Sečovlje, Strunjan and Debeli rtič mussel aquacultures, however in neither of those sites was the bryozoan abundant. We have yet to discover, whether the species is mostly present in mussel aquacultures, or it is already established and distributed over larger area. As earlier data show, *T. inopinata* often appears in marinas, harbours, ports and canals (d'Hondt & Occhipinti Ambrogi, 1985; Breton & d'Hondt, 2005; Porter *et al.,* 2015). Our sampling effort in Slovenian harbours has in fact recently revealed few colonies of this bryozoan in the Valdoltra harbour. In the future, we are keen on continuing to study the spatial and temporal patterns of *T. inopinata* in Slovenian waters and to assess its possible impact on the ecosystem.

The unclear taxonomic status of *T. inopinata –occidentalis - porteri* complex, caused by the missing type species for *T. occidentalis* and lack of conclusive

morphological and molecular information on both *T. occidentalis* and *T. porteri (*Dyrynda *et al.,* 2000*)*, causes confusion around the origin and introduction pathways of *T. inopinata*. The status of *Tricellaria inopinata* in the Northern Adriatic remains unclear and further studies, namely ecological and molecular, are necessary in order to elucidate it.

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PRVI ZAPIS O POJAVLJANJU MAHOVNJAKA *TRICELLARIA INOPINATA* (D'HONDT & OCCHIPINTI AMBROGI, 1985) IZ SLOVENSKEGA MORJA

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POVZETEK

V članku predstavljamo prvi primer pojava mahovnjaka Tricellaria inopinata *d'Hondt & Occhipinti Ambrogi, 1985 v slovenskem morju. Kolonije mahovnjaka smo našli na lupinah klapavic v školjčiščih Sečovlje, Strunjan in Debeli rtič med aprilom in oktobrom 2018 in v mandraču v Valdoltri novembra 2018. Po vnosu v Beneško laguno v osemdesetih letih prejšnjega stoletja in naglem širjenju v naslednjih letih, so vrsto označili za invazivno za to območje in jo zato lahko pričakujemo v celotni regiji severnega Jadrana. Status vrste* T. inopinata *v slovenskem priobalnem morju še ni jasen, prav tako je potrebno v prihodnje razjasniti možne vplive mahovnjaka na tukajšnji ekosistem.*

Ključne besede: *Tricellaria inopinata,* tujerodna vrsta, Tržaški zaliv, Jadransko morje, školjčišče

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MACROZOOBENTHOS OF ARID WATERCOURSES OF KAZAKHSTAN: THE ILEK RIVER CASE

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ABSTRACT

The paper aims to study the quantitative characteristics, taxonomic composition and structure of the macrozoobenthos of the arid Ilek River (Kazakhstan). The topic is relevant to the global biodiversity preservation problem. The frequency of taxon occurrence, abundance, biomass and composition of macrozoobenthos were established. Informational indices of the dominance structure, diversity and evenness of species were calculated. The macrozoobenthos of the arid water bodies and rivers included 24 taxa. In terms of abundance and biomass, the Chironomidae were predominant. The study revealed an interconnection between the level of macrozoobenthos biomass and water mineralization. This information can be used in assessing the fodder base for fish, the saprobity and the anthropogenic impact in the Aktobe Region, in performing an ecological analysis of the said region, as well as in establishing the condition of the Ural River ecosystem.

Key words: macrozoobenthos, biodiversity, dominance structure, habitation conditions, hydrochemical regime

MACROZOOBENTHOS DI CORSI D'ACQUA ARIDI DEL KAZAKISTAN: IL CASO DEL FIUME ILEK

SINTESI

Gli autori hanno studiato le caratteristiche quantitative, la composizione tassonomica e la struttura del macrozoobenthos del fiume arido Ilek (Kazakistan). L'argomento è rilevante per la conservazione della biodiversità globale. Nello studio hanno valutato la frequenza dei taxa, l'abbondanza, la biomassa e la composizione del macrozoobentos. Sono stati inoltre calcolati diversi indici: di dominanza, diversità e uniformità delle specie. È risultato che i*l macrozoobentos dei corpi idrici e dei fiumi aridi comprende 24 taxa. In termini di abbondanza e biomassa hanno prevalso i Chironomidi. Lo studio ha inoltre rivelato un'interconnessione tra il livello della biomassa del macrozoobentos e la mineralizzazione dell'acqua. Queste informazioni possono venir utilizzate per valutare la base di foraggio per il pesce, la saprofagia e l'impatto antropogenico nella regione di Aktobe, nell'effettuare un'analisi ecologica della regione, nonché nello stabilire le condizioni dell'ecosistema del fiume Ural.*

Parole chiave: macrozoobentos, biodiversità, struttura dominante, condizioni abitative, regime idrochimico

INTRODUCTION

The preservation of biodiversity is a global problem. In the conditions of intensifying processes of aridification in most regions of Kazakhstan and in other Asian countries, this problem is of a most acute nature (Alpeysov *et al.*, 2017). One of the approaches to addressing such environmental issues is the study of communities of aquatic organisms, including macrozoobenthos (Rosenberg & Gelashvili, 2013).

Kazakhstan is a terminal territory for the drainage of many inland basins of Central Asia. The intensifying desertification processes and increased use of water reservoirs for economic needs create a scarcity of water resources. As a result, Kazakhstan risks compromising the biodiversity of the hydrobionts living in the reservoirs and watercourses of its arid zones, which will result in the degradation of the ecosystems of internationally important transboundary watercourses and lead to a violation of the basin principle of their use.

The Aktobe Region is the second largest of Kazakhstan. It is located in the western part of the country and occupies more than 300,000 km^2. The region borders Russia in the north and Uzbekistan in the south. Its largest rivers (Emba, Or, Ilek, Irgiz, Turgai) originate in the mountains of Mugodzhary and belong to the basin of the Caspian Sea. Endorheic rivers and lakes drying up in the summer are characterized by brackish waters.

In scientific literature, the problem of studying the ecological state of rivers based on the structure and quantitative characteristics of macrozoobenthos is well covered (Hakiki *et al.*, 2017; Kenderov *et al.*, 2017) in connection with environmental conditions, including water mineralization (Zinchenko *et al.*, 2014; Zinchenko *et al.*, 2017a). Bioindication properties of macrozoobenthos allow an evaluation of water quality (Pawhestri *el al.*, 2015; Shitikov *et al.*, 2004). Specific features of the formation of bottom community of organisms in artificial reservoirs, represented by numerous and diverse insects (Bakanov, 2003; Furey *et al.*, 2006) as well as by Oligochaeta and molluscs (Yakovleva & Yakovlev, 2011), are considered separately. Fragmentary information on the macrozobenthos of the Ilek River is provided in the reports of the Kazakh Research Institute of Fishery (Kazakhstan, Almaty) on the monitoring research of fishery water bodies.

Currently, the biodiversity of watercourses with a high level of mineralization is markedly understudied (Gallardo *et al.*, 2014; Zinchenko *et al.*, 2017b). The available information on the structure and composition of the macrozoobenthos of the Irgiz River (Balymbetov & Grishaeva, 2008; Petrakov, 2015; Seitkasymova, 2016), Jai'yq River (a tributary of the Ilek River) (Kenzhebaev *et al.*, 2017; Pilin & Alpeisov, 2017) and other water bodies of the basin of the Ural River in the territory of Kazakhstan (Pilin, 2012; Pilin & Oskina, 2017) in condi-

Tab. 1: Collected hydrobiological data, 2015-2017.
Tab. 1: Zbrani hidrobiološki podatki v obdobju 2015-2017.

Waterbody	Station	Coordinates/ reference points	Number of collected samples								
			2015			2016			2017		
			A	B	C	A	B	C	A	B	C
Aktobe Reservoir	AR-1.1	050º11'58,5" N - 057º20'54,7" E	1	1	-	1	1	-	2	1	1
	AR-1.2	050º13'59,1" N - 057º20'32,4" E	-	-	-	1	1	-	1	1	1
	AR-1.3	050º14'56,8" N - 057º21'44,4" E	-	-	-	1	-	-	2	1	1
	AR-2	050º22'37,1" N - 057º29'54,5" E	1	-	-	1	-	-	1	1	1
	AR-3	050º07'45,8" N - 057º35'58,7" E	1	-	-	1	-	-	1	1	1
Sazda River	S-1	050 º23'93,1" N - 057 º15'58,2" E	1	1	-	3	1	-	-		
	S-2	050 º23'62,3" N - 057 º15'13,6" E	2	-	-	1	2	-	-		
Ilek River	I-1	050º18'45,3" N - 057º13'23,3" E	1	1	-	2	1	-	1	1	1
	I-2	050º16'52,9" N - 057º15'46,1" E	-	-	-	2	-	-	1	1	1
	I-3	050º15'16,7" N - 057º19'38,2" E	-	-	-	2	-	-	1	1	1
	I-4	050º17'40,4" N - 057º15'35,3" E	-	-	-	-	-	-	1	1	1
Aktobe City	AC-1	050º17'71,5" N - 057º13'75,8" E			2	-	-	-	-	-	1
Kargala River	K-1	050º20'06,6" N - 057º21'11,8" E	-			1	-	-	2	-	1

Note: A - quantitative samples of macrozoobenthos, B - qualitative samples of macrozoobenthos, C - samples of insect imagoes caught with light traps.

tions of aridification indicate insufficient coverage of this problem in literature.

The study of the modern macrozoobenthos of arid reservoirs and rivers of the Aktobe Region is of interest as a source of additional information for integrated environmental monitoring research and preservation of biodiversity in Kazakhstan. Investigation of the state of macrozoobenthos in the Ilek River, which flows on the territories of Kazakhstan and Russia, is especially important, as it affects the ecological interests of both countries.

The aim of this study was to examine the quantitative characteristics, taxonomic composition and structure of macrozoobenthos of the arid Ilek River (Kazakhstan).

MATERIAL AND METHODS

The hydrobiological research of the Ilek River, its tributaries (the rivers Sazda and Kargala) and the Aktobe Reservoir, which is fed by their waters, was carried out in the period between 2015 and 2017. In sampling macrozoobenthos for quantitative research, in which the density of distribution of organisms per unit of bottom area was relevant, 37 samples were collected using a Peterson bottom grab. An additional 18 samples were collected using a scraper net in sampling macrozoobenthos for quantitative research, in which the density of distribution of organisms per unit of bottom area was not relevant. To obtain more comprehensive information on the taxonomic composition of the Chironomidae (Diptera) and Trichoptera, the capture of insect imagoes with light traps was performed for 13 samples, using entomological scoop nets. The entire volume of hydrobiological material was collected from 13 stations (Table 1). The coordinates of the stations were determined by means of a GARMIN 64s GPS navigator.

To collect the hydrobiological material in the reservoir at a depth of over 0.8 m, we used the Petersen bottom grab with a bottom capture area of 0.025 m^2. For rivers with stony beds or bottoms overgrown with vegetation, a scraper net with netting made of gauze sieve with 10 holes per 1 cm^2 was used. The netting was stretched on a semi-circular metal frame with a diameter of 400 mm, the depth of the netting was 700 mm, the length of the handle 1,200 mm. Collection of samples by bottom grab and scraper net was carried out at least twice per each station. The macrozoobenthos samples were labelled and fixed with an aqueous solution of formaldehyde (10%).

For the capture of insect imagoes, an entomological scoop net made of gauze sieve with 0.25 mm wide holes at a quantity of 24 per 1 cm^2 was used in all reservoirs. The diameter of the scoop net was 300 mm, the depth of the netting 700 mm, the length of the handle 200 mm. Insects were collected from the scoop net after every 10 strokes and placed in 300 ml and 500 ml plastic containers (Zinchenko & Shitikov, 1999; Sharapova & Falomeeva, 2006; Krasheninnikov, 2011). When catching insects with light traps, 10 repetitions were made at each station. The macrozoobenthos samples were labelled and fixed with a solution of ethyl alcohol (70%) for further processing.

The taxonomic composition of the macrozoobenthos was determined using MBS-10 and MS-300 microscopes according to specific determinants (Tsalolikhin, 1995; Ivanov, 2011; Kenderov *et al.*, 2017; Krasheninnikov, 2011; Malicky, 1986; 2004; Morse, 2013; Olah & Ito, 2013). For each quantitative sample, the abundance and biomass were calculated for taxa adjusted to 1 m^2 of the water body bottom, followed by summation over groups (Oligochaeta, Chironomidae, Trichoptera, Crustacea). The organisms were weighed on torsion (from 0 to 1000 mg) and pharmacy scales. The frequency of occurrence was calculated as the ratio of the number of samples in which a certain species was present to the total number of samples.

To describe the structure of the macrozoobenthos, informational indices were calculated. The dominance index (Basyuni *et al.*, 2018) depended on the frequency of occurrence, abundance and biomass of the taxa according to Equation 1:

$$D_i = 100\ p_i\sqrt{N_iB_i}/\sqrt{N_sB_s}, \qquad (1)$$

wherein p_i is the frequency of occurrence of the taxon i; N_i is the abundance of the taxon i in the sample; B_i is the biomass of the taxon i in the sample; N_s is the total number of organisms in the sample; B_s is the total biomass of the organisms in the sample.

The diversity of communities that reflects the number of species and their share in the total quantitative characteristics was estimated according to the Shannon-Wiener index using Equation 2 (Basyuni *et al.*, 2018):

$$H = -\sum p_i lg_2 p_i, \qquad (2)$$

wherein H is the diversity index, bits/spec, bits/g; p_i is the specific abundance (or biomass) of the taxon i; $p_i = N_i/N_s$ or B_i/B_s; N_i is the number of each taxon i; N_s is the total number of all taxa; B_i is the biomass of each taxon i; B_s is the total biomass of all organisms.

The Pielou evenness index was calculated according to Equation 3 (Furey, 2006):

$$I = H/lg_2 S, \qquad (3)$$

wherein S is the number of taxa; $0 \leq I \geq 1$.

The calculations and statistical processing of the obtained data were carried out using Excel 2017 and STATISTICA 2015 programs. The data are presented as average values +/- standard deviations.

STUDY AREA

The study covered water bodies that belong to the ecosystem of the transboundary Ural River in the terri-

Tab. 2: The taxonomic composition of the macrozoobenthos of the Ilek River, its tributaries (the Kargala, the Sazda) and the Aktobe Reservoir, 2015-2017.
Tab. 2: Taksonomska sestava makrozoobentosa na reki Ilek, njenih pritokih (Kargala, Sazda) in v zadrževalniku Aktobe v obdobju 2015-2017.

Taxon Name	Ilek	Kargala	Sazda	Aktobe Reservoir
Vermes				
Annelida				
Oligochaeta				
Tubificidae				
Tubificidae gen. sp.	+	+	+	+
Naididae				
Naididae gen. sp.	-	-	+	+
Arthropoda				
Insecta				
Diptera				
Chironomidae				
Tanypus punctipennis Meigen, 1818	+	-	+	+
Ablabesmyia gr. *lentiginosa* Fries, 1823	-	-	-	+
Ablabesmyia gr. *monilis* Linne, 1758	-	-	-	+
Procladius sp.	-	-	-	+
Chironomini gen. sp.	+	+	+	+
Parachironomus gr. *pararostratus* Lenz, 1938	-	-	-	+
Cryptochironomus gr. *defectus* Kieffer, 1921	-	-	-	+
Lipiniella arenicola Shilova, 1961	+	+	+	+
Chironomus plumosus Linne, 1758	+	+	+	+
Limnochironomus sp.	-	-	+	+
Endochironomus sp.	+	-	+	+
Tanypus sp.	+	+	+	+
Diamesa sp.	-	-	-	+
Ceratopogonidae				
Ceratopogon sp.	+	+	+	+
Trichoptera				
Ecnomidae				
Ecnomus tenellus Rambur, 1842	+	+	-	+
Limnephilidae				
Limnephilus sp.	+	+	-	+
Limnephilus stigma Curtis, 1834	-	-	-	+
Odontoceridae				
Odontoceridae gen. sp.	+	-	-	+
Lepidostomatidae				
Lepidostomatidae gen. sp.	-	+	-	+
Leptoceridae				
Athripsoides sp.	-	+	-	-
Phryganeidae				
Phryganea sp.	+	-	+	-
Crustacea				
Amphipoda				
Gammaridae				
Dikerogammarus sp.	+	-	-	-
Note: »+« - taxon was found in the reservoir; »-« - taxon was not found in the reservoir.				

tories of Kazakhstan and Russia (Evseeva, 2010; Evseeva & Kushnikova, 2017), which is important for the basin approach in the use of this river (Sivokhip, 2016; Wolf *et al.*, 2003).

The Ilek River originates in the western slope of the Mugodzhary Mountains. Its length in the territory of the Aktobe Region is 257 km. The riverbed is meandering, with steep or abrupt banks (2-4 m), its width increasing downstream from 15 to 50 m (in some places, up to 170 m). The bottom is loamy, less often sandy-loamy with pebbles, in shallow water silty (Dzhubanova, 2008).

The Kargala River is the right tributary of the Ilek River, 114 km long and with a constant drainage. Its riverbed is meandering, well developed, its width expanding downstream from 20 to 200 m. In the upper and middle reaches, the banks are about 1-2 m high, sloping, while in the lower reaches they are 3-4 m high, steep, abrupt. The bottom of the reaches is stony or clayey, sometimes silty; it is stony or stony-sandy on slopes.

The Sazda River is the left tributary of the Ilek River, only 40 km long and with a constant drainage. Its riverbed widens downstream from 15 to 50 m. The banks are 2-4 m high, gently sloping, sometimes abrupt; in the estuary, they are reduced to 1-1.5 m. The bottom of the riverbed is sandy.

The Aktobe Reservoir stands out among the investigated water bodies. This is an artificial perennial reservoir with seasonal drops in the water level (Balymbetov & Grishaeva, 2004). The favourable conditions it provides for the development of hydrobionts are determined by various factors, including anthropogenic ones (hydrological regime, pollution of the environment, etc.), as well as internal processes of interaction among ecosystem components. The Aktobe Reservoir, which occupies an area of 3,570 hectares, is fed by the water from the Ilek River.

RESULTS

During the 2015-2017 research period, the depths of macrozoobenthos sampling sites varied from 0.2 to 0.8 m on the rivers Ilek, Kargala and Sazda, and from 0.5 to 3.2 m at the Aktobe Reservoir. The average water temperature in spring reached up to +21.2 °C in the rivers and up to +20.3 °C in the reservoir. In spring, the water was characterized by transparency to the bottom in sandy areas and by considerable muddiness in silty areas.

The most common bed types in the rivers are sand, gray silt and small pebbles. At the Aktobe Reservoir, the riverbed types include sand, gray, brown and black silt, stones and ground, densely overgrown with aquatic plants.

In the spring of 2017, the water in all the investigated reservoirs was characterized by a slightly alkaline reaction. The water mineralization in the rivers Ilek, Kargala and Sazda was up to 100-200 mg/dm^3. The water mineralization in the coastal zone of the Aktobe Reservoir did not exceed 100 mg/dm^3 (Erkeeva, 2017b).

During the 2015-2017observation period, the macrozoobenthos of the Ilek River, its tributaries (the Kargala and the Sazda) and the Aktobe Reservoir was represented by two families of Annelida (Oligochaeta) and nine families of Arthropoda (Insecta, Crustacea) (Table 2).

The Insecta class was the most diverse. It included two orders - Diptera with two families (Chironomidae, Ceratopogonidae) and Trichoptera with six families (Ecnomidae, Odontoceridae, Lepidostomatidae, Phryganeidae, Leptoceridae, Limnephilidae). The Chironomidae family had the highest number of identified invertebrate taxa.

The highest frequency of occurrence (81.5 %) in the examined rivers and the reservoir was recorded for Oligochaeta, which mainly included representatives of the Tubificidae family. The frequency of occurrence of Chironomidae larvae averaged 72 %. In terms of abundance and biomass, the Chironomidae were the dominant group: the highest percentages were recorded in the Aktobe Reservoir – 66.15 and 91.38%, respectively.

In the Ilek River, the maximum abundance of macrozoobenthos was recorded in 2016 – 420 spec/m^2 (Table 3). In 2015, the macrozoobenthos of the Sazda River had the largest biomass – 5.2 mg/m^2. In 2015 and 2017, the highest abundance of macrozoobenthos was ascertained in the Aktobe Reservoir – 912 spec/m^2 and 14.2 mg/m^2, respectively.

The dynamics of the Shannon-Wiener and Pielou indices (Table 4) showed that the maximum diversity and evenness of macrozoobenthos in the rivers and in the Aktobe Reservoir were recorded in the summers of 2015 and 2016.

Tab. 3: The abundance and biomass of the macrozoobenthos of the Ilek River, its tributaries (the Kargala, the Sazda) and the Aktobe Reservoir, 2015-2017.
Tab. 3: Abundanca in biomasa makrozoobentosa na reki Ilek, njenih pritokih (Kargala, Sazda) in v zadrževalniku Aktobe v obdobju 2015-2017.

Year	Ilek	Kargala	Sazda	Aktobe Reservoir
	Abundance (spec/m^2)			
2015	227*	-	120±23	912±97
2016	420±68	268*	184±42	710±63
2017	348±73	223*	-	817±92
Average	332±56	245±23	152±32	813±58
Biomass (g/m^2)				
2015	2.2*	-	5.2±0.9	12.6±2.2
2016	2.6±0.5	2.4*	4.6±1.0	10.2±1.8
2017	3.2±0.8	1.7*	-	14.2±3.2
Average	2.7±0.3	2.1±0.4	4.9±0.3	12.3±1.2
Note: * - the data were collected from a single station.				

DISCUSSION

In the studied rivers and reservoir, the following types of bed resulted the most common: gray silt, sand with gray silt deposits, and black silt with sapropel in areas with abundant vegetation. In the springs of the 2015-2017 period, the maximum density of invertebrates was observed for gray silt and sand with gray silt deposits: most often Diptera (Chironomidae, Trichoptera), less often Oligochaeta, and sporadically other representatives of the macrozoobenthos, for a total of 24 taxa.

In the previous period of study, from 2005 to 2009, a wider representation of benthic invertebrates was observed, namely 30 taxa. The macrozoobenthos included Oligochaeta, as well as Nematoda, Hirudinea, Hydracarina, larvae of Diptera (Chironomidae), Ephemeroptera, Trichoptera and Coleoptera, with the greatest diversity in the vegetation zone. On gray silt and silty sand, we found representatives of the order Trichoptera belonging to the families Lepidostomatidae, Ecnomidae, Leptoceridae and Odontoceridae. During the 2009-2012 (Smirnova, 2012; 2016) and 2015-2017 examination periods, we also observed representatives of other taxa of the Trichoptera order, including, in particular, *Ecnomustenellus; Limnephilus stigma; Limnephilus* sp.; *Athripsodes* sp.; *Phryganea* sp.; *Odontoceridae gen*. sp., and *Lepidostomatidae gen*. sp. In terms of species occurrence and quantitative characteristics, larvae of Diptera (Chironomidae) and Trichoptera were predominant, which is typical of arid rivers and reservoirs with variable filling levels (Kenzhebaev *et al.*, 2017; Pilin & Alpeisov, 2017; Pilin & Oskina, 2017). As a rule, the macrozoobenthos of brackish and highly mineralized rivers is represented by a taxonomically stable community of organisms that are resistant to changes in water salinity. Rivers in arid zones are characterized by certain species specificity; for example, Diptera (Chironomidae) are abundantly represented in the diverse silted biotopes of the Ilek River with its tributaries and the rivers of the saline lake Elton basin (Russia) (Orel (Zorina) *et al.*, 2014; Zinchenko, 2017), while Trichoptera (Malicky, 1986) are abundantly represented in the arid rivers of Iran and Afghanistan.

The study revealed an ambiguous relationship between quantitative characteristics of the macrozoobenthos in the Aktobe Reservoir and the influence of the Ilek River on its hydrological and hydrochemical conditions. For instance, a decrease in the water level in 2004 led to an increase in the total content of dissolved salts, whereas a reduction in its surface area caused the desiccation of the coastal zone and the death of shallow and coastal macrophytes, which constituted a biotope for mass representatives of macrozoobenthos. At the same time, in the composition of benthic invertebrates, the share of molluscs *Theodoxus pallasi* as well as that of the amphipod *Dikerogammarus aralensis* decreased. The decrease in the diversity of these groups of invertebrates led to a decrease in the total biomass of macrozoobenthos by an order of magnitude in comparison with the previous year (Balymbetov & Grishaeva, 2004).

Tab. 4: The dynamics of diversity and Evenness indices in the macrozoobenthos community of the Ilek River, its tributaries (the Kargala, the Sazda) and the Aktobe Reservoir, 2015-2017.
Tab. 4: Dinamika indeksov pestrosti in enakomernosti porazdelitve makrozoobentoške skupnosti v reki Ilek, njenih pritokih (Kargala, Sazda) in v zadrževalniku Aktobe v obdobju 2015-2017.

Year	Ilek	Kargala	Sazda	Aktobe Reservoir
Shannon-Wiener indices, bits/spec				
2015	0.7*	-	1.3±0.1	1.5±0.1
2016	1.3±0.03	1.1*	1.4±0.04	1.6±0.04
2017	0.5±0.03	0.7*	-	0.6±0.04
Pielou Evenness indices				
2015	0.8*	-	0.8±0.2	0.8±0.04
2016	0.8±0.02	0.8*	0.8±0.03	0.9±0.02
2017	0.4±002	0.6*	-	0.6±0.04
Note: * - the materials were collected from a single station.				

The natural hydrochemical background of the watercourses of the Aktobe Region of Kazakhstan is affected by anthropogenic factors, especially cattle grazing, melioration works, drainage regulation, exploitation of mineral deposits, etc. During the study period in May 2015, the depth of the Aktobe Reservoir was 0.5-0.8 m at the site of water sampling, whereas the water temperature was up to +21.2 °C. The water showed a slightly alkaline reaction and the concentration of dissolved oxygen was up to 10.3 mg/dm^3. During the post-flood period, the low concentration of carbon dioxide and low mineralization corresponded to low-mineralized waters (Petrakov, 2015).

In May 2017, the chemical composition of the Ilek River, its tributaries (the Sazda and the Kargala) and the Aktobe Reservoir was characterized by a slightly elevated level of hardness, in particular, 4.8, 4.9, 5.3 and 7.2 mg-eq/L, and an iron content of 0.13, 0.12, 0.22 and 0.40 mg/dm^3, respectively (Erkeeva, 2017a; 2017b). In the period of high water, the level of the Ilek River increased abnormally because of the large influx of melt water. For the first time in the last 25 years, the Aktobe Reservoir was filled to its maximum capacity. The flooding of coastal areas resulted in soil washout and destruction of the macrozoobenthos structure.

As the drainage volume of the Ilek River into the Aktobe Reservoir increased in May 2017, the water salinity dropped to 100 mg/dm^3, whereas its average value in spring during the 2004-2008 (Balymbetov & Grishaeva,

2004; 2008) and 2011-2016 (Petrakov, 2015; Grishaeva & Erekeeva, 2017) study periods was 550 mg/dm^3. In May 2017, the minimum abundance and biomass of the macrozoobenthos over the periods of 2004-2008 (Balymbetov & Grishaeva, 2004; 2008) and 2015-2016 were recorded. The dominant group in the composition of the macrozoobenthos was Chironomidae (D_{Ch} = 79%). Between 2015 and 2017, despite a decline in the biomass of the macrozoobenthos, the Aktobe Reservoir was mesotrophic-eutrophic, the Ilek River and Kargala River were oligotrophic, the Sazda River mesotrophic.

Similar results were obtained from studies of the macrozoobenthos of the saline rivers of the Prieltonie, an arid zone in the south of Russia, where Chironomidae larvae formed the basis of the benthic zoocoenosis. Its quantitative characteristics consistently changed under the influence of hydrological and hydrochemical regimes of the watercourses. At the same time, the detected patterns of change in the structure of the aquatic ecosystem depended not only on the faunistic composition of the hydrobionts, but also on the type of water body, water expenditure, flowage, turbidity, flow velocity and other hydrological, hydrophysical and hydrochemical features (Choi1 *et al.*, 2013; Gallardo *et al.*, 2014; Zinchenko *et al.*, 2017).

The small depths of rivers in the arid zone result in the instability of their functioning under conditions of seasonal and climatic fluctuations. As extreme habitats, they are unique and represent hydro-ecosystems of the highest biological productivity in the dry landscapes of the intracontinental arid zones of Eurasia (Gallardo *et al.*, 2014; Zinchenko *et al.*, 2014), including Kazakhstan, Southern Russia, Central Asian countries, East and Northeast China, Korea, Iran, and Afghanistan (Choi *et al.*, 2013; Malicky, 1986), all located far from the oceans.

CONCLUSIONS

In the spring-summer periods during the 2015-2017 time frame, the macrozoobenthos of the investigated rivers and the Aktobe Reservoir included 24 taxa consisting of three groups: Anellida (Oligochaeta), Crustacea (Amphipoda), Insecta (Diptera, Trichoptera). The highest frequency of occurrence was observed for the Oligochaeta (81.5%) and Diptera (Chironomidae) (72%). The maximum values with regard to the abundance and biomass of the Diptera (Chironomidae) (664 spec/m^2 and 8.2 g/m^2, respectively), as well the highest diversity (1.6±0.04 bits/spec) and evenness (0.9 ± 0.02) of species were observed in the Aktobe Reservoir. During the observation period, the trophic level of the reservoir was characterized as mesotrophic-eutrophic. The value of the biomass of river zoobenthos characterized the Ilek and Kargala Rivers as oligotrophic, and the Sazda River as a mesotrophic watercourse.

In general, the Chironomidae larvae were dominant in the benthic community of invertebrates of the investigated rivers and reservoir – the value of their dominance index reached 79%. The diversity and evenness of zoobenthos species were at a low level, which is typical of water bodies and watercourses of arid zones with high anthropogenic impact.

An ambiguous relationship was established between the biomass of macrozoobenthos and the water salinity of the Aktobe Reservoir, which depended on the volume of river drainage. The decrease in the biomass of macrozoobenthos with an increase in the river drainage into the reservoir may be due to the destruction of existing biotopes – ground and aquatic vegetation.

The obtained hydrobiological data indicate a typically low level of fodder base for bottom-feeders and a low trophicity that is characteristic of arid watercourses. A gradual reduction in the species diversity of zoobenthos, the predominance of the larvae of secondary aquatic insects under conditions of an unstable hydrological regime, and anthropogenic impact are leading to a degradation of aquatic ecosystems. The loss of species diversity results in a reduced functionality of the ecosystem, an invasion of new species and a significant change in the biomass production.

The theoretical significance of the obtained information about the structure of the macrozoobenthos of the Ilek River is related to the progressive desertification of the territory of Kazakhstan, a Central Asian country. Desertification is a major global ecological and socio-economic problem. The study of the condition of the macrozoobenthos of water bodies and watercourses of arid zones should be continuous, as the data obtained could importantly contribute to the formation of a global database on the status of the biodiversity of aquatic ecosystems.

The practical significance of the present research results lies in the possibility of their application to the development of a scientific foundation for a rational use and protection of biological resources in arid countries.

MAKROZOOBENTOS ARIDNIH VODNIH TELES V KAZAHSTANU: PRIMER REKE ILEK

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POVZETEK

Članek obravnava kvantitativne značilnosti, taksonomsko sestavo in strukturo makrozoobentosa na primeru aridne reke Ilek (Kazahstan). Pričujoča tematika je pomembna z vidika problematike ohranjanja globalne biodiverzitete. Avtorji so raziskovali frekvenco pojavljanja taksonov, abundanco, biomaso in strukturo makrozoobentosa. Izračunali so dominanco, pestrost in enakomernost pojavljanja. Makrozoobentos aridnih vodnih teles in rek je sestavljalo 24 taksonov, med katerimi so v abundanci in biomasi prevladovale ličinke trzač (Chironomidae). Raziskava je pokazala povezavo med stopnjo biomase makrozoobentosa in mineralizacijo. Ti izsledki so lahko uporabni za krmo za ribe, za ugotavljanje saprobnih razmer in antropogenih vplivov v regiji Aktobe, pri ekoloških analizah omenjene regije in tudi za opredelitev ekološkega stanja v uralskem rečnem ekosistemu.

Ključne besede: makrozoobentos, biodiverziteta, dominanca, okoljske razmere, hidrokemični režim

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MISCELLANEA

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PREGLED PLEISTOCENSKE FAVNE IN ANALIZA UGRIZOV NA KOSTEH V JAMAH BELE VODE NAD GORENJO TREBUŠO IN SMOGANICA NAD MOSTOM NA SOČI

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IZVLEČEK

V prispevku smo podali zgodovinski pregled raziskav jam Bele vode nad Gorenjo Trebušo in Smoganica nad Mostom na Soči. S preučitvijo fosilnega gradiva iz jame Bele vode smo ovrednotili prvotno študijo določitve vrste jamskega medveda iz leta 1895 ter taksonomsko opredelili nove najdbe ostankov jamskih medvedov in navadnega jelena. V jami Smoganica smo poleg kosti jamskega medveda potrdili tudi prisotnost fosilnih ostankov tura ali bizona in konja. Primerjalno smo analizirali tudi možnost nastanka lezij na najdenih kosteh, ki po obliki in glede podobne razporeditve po značilnem vzorcu 1 + 2 spominjajo na luknje, odkrite na kosti s paleolitskega najdišča Divje babe I, in potrdili domnevo, da so nastale kot posledica grizenja jamskega medveda.

Ključne besede: jama Bele vode, jama Smoganica, jamski medved, zobje, ugrizne kostne lezije, koščena piščal

RASSEGNA DELLA FAUNA PLEISTOCENICA E DEI SEGNI DI MORSI EVIDENZIATI SULLE OSSA FOSSILI NELLE GROTTE DI BELE VODE VICINO A TRIBUSSA E SMOGANICA VICINO A SANTA LUCIA D'ISONZO

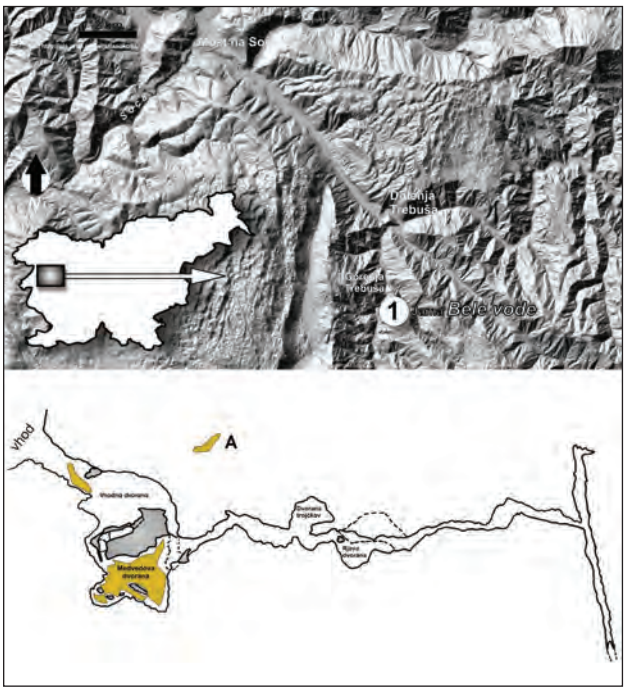
SINTESI

Nel contributo gli autori passano in rassegna la storia delle ricerche paleontologiche nelle grotte Bele vode vicino a Tribussa e Smoganica vicino a Santa Lucia d'Isonzo. Con l'analisi del materiale fossile della grotta Bele vode hanno rivalutato la determinazione dell'orso delle caverne proposta nell'anno 1895, e definito le categorie tassonomiche dei neo rinvenuti resti di orsi delle caverne e del cervo nobile. Nella grotta Smoganica, oltre ai reperti ossei dell'orso delle caverne, hanno confermato la presenza di resti fossili di uro o di bisonte, e di cavallo. Hanno inoltre eseguito l'analisi comparativa per verificare la possibilità di formazione di lesioni sulle ossa rinvenute e confermato l'ipotesi che i fori sono da attribuire ai morsi lasciati sulle ossa dall'orso delle caverne, che per la loro forma e la distribuzione secondo il tipico schema 1 + 2 mostrano una marcata somiglianza con i fori presenti sulle ossa rinvenute nel sito paleolitico Divje babe I.

Parole chiave: grotta Bele vode, grotta Smoganica, orso delle caverne, denti, lesioni ossee da morso, flauto d'osso

UVOD

Jama Bele vode nad potokom Trebuščica nad Gorenjo Trebušo (Medvedova jama), kat. št. JZS 2966, in jama Smoganica na pobočju Drobočnika nad Mostom na Soči (Jama pod Smoganico), kat. št. JZS 823, sta poleg jam Divje babe I in II na Cerkljanskem in Idrijskem ter v Posočju zaenkrat edini znani jami, v katerih so bili odkriti fosilni ostanki pleistocenske favne. Prve najdbe iz Belih vod so bile znane že konec 19. stoletja (Marchesetti, 1895), iz Smoganice pa v tridesetih letih 20. stoletja (Jelinčič, 1956, 571). Nekaj fosilnih kosti, ki so bile iz jam pobrane v preteklosti, so v zasebnih zbirkah, nekaj pa so jih že pred desetletji predali Tolminskemu muzeju. V letih 2016 in 2017 so tolminski jamarji pri raziskovanju obeh jam ponovno našli mesta prvotnega odkritja kosti. Nove najdbe so predali Tolminskemu muzeju. Ker so pleistocenski kostni ostanki v tem delu Slovenije redki in je sedaj v obeh jamah znana tudi mikrolokacija najdišč, smo poskušali zbrati vse znane najdbe in jih preliminarno paleontološko opredeliti. Za najdbe iz jame Bele vode smo z analizo preverili tudi prvotno določitev vrste medveda, ki je bila opravljena v 19. stoletju.



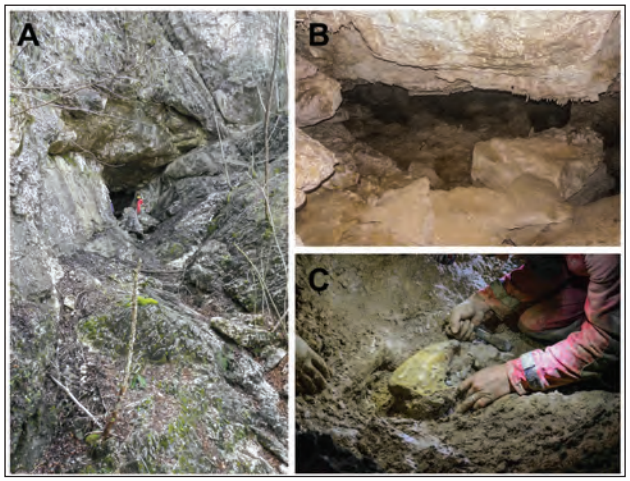
Sl. 1: Položaj jame Bele vode (1) pri Gorenji Trebuši (zgoraj). Tloris jame Bele vode z označenim območjem, kjer so bili odkriti ostanki pleistocenske favne. A – razprostranjenost fosilonosnih jamskih sedimentov, ki jih je največ zlasti v Medvedovi dvorani (tloris jame po Francetu Habetu in Petru Habiču, (Kataster JZS) risba: Matija Križnar).

Fig. 1:Location of the Bele vode cave (1) in the vicinity of Gorenja Trebuša. Ground plan of the Bele vode cave showing the marked fossil bearing sediments. A – distribution of fossil bones within Pleistocene cave sediments mostly restricted on the Medved hall/Medvedova dvorana (Cave ground plan by France Habe and Peter Habič, adapted drawing: Matija Križnar).

Jama Bele vode (Medvedova jama)

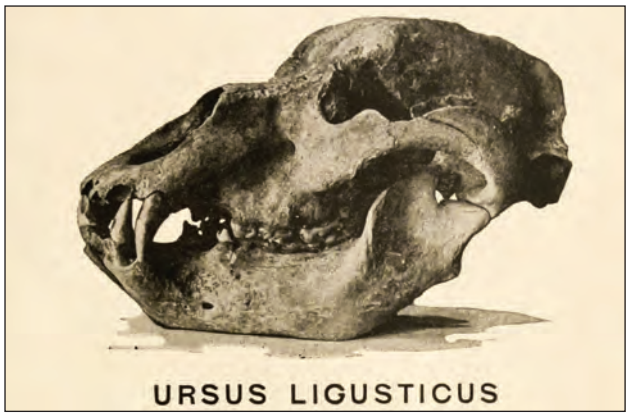
Okoli 40 višinskih metrov nad cesto iz Gorenje Trebuše proti Vojskarski planoti je pod skalno steno v obliki slapišča občasen izvir potoka Bele vode, ki se prek lehnjakastih pragov, širokih do 7 metrov, spušča v dolino, tam pa se izlije v potok Trebuščica (slika 1). Pod isto skalno steno, le nekaj metrov nad izvirom, je na nadmorski višini 375 metrov velik vhod v jamski sistem (sliki 1 in 2A). Ob večjem deževju priteče voda na prosto tudi skozi jamski vhod, v sušnih obdobjih pa ostaja v manjših kotlicah v vhodnem delu jame. Izvir pod jamskim vhodom je le odvod vode iz spodnjih etaž jamskega sistema, kjer z vodo zapolnjeni rovi otežujejo nadaljnje raziskovanje jame. Jama skupne dolžine 233 metrov je po 23 metrih višinske razlike med vhodom in jamskimi rovi oblikovana v dveh etažah. Takoj za vhodom se po dobrih 5 metrih glavni rov začenja dvigovati. Glineno-ilovnati sedimenti, ki jih meteorna voda izpira iz zgornje etaže jame, se ob vhodu v jamo ujamejo v nekajmetrsko kotanjo pod kapom vhoda. Rovi zgornje etaže so danes suhi, dno je prekrito s plastjo sige in glineno-ilovnatimi sedimenti. Ti rovi so delno zasigani. Po večini jamskih sten je množica kotlic, ki jih je oblikovala hitro tekoča in vrtinčasta voda. Zgornji suhi rovi in z vodo napolnjeni spodnji rovi so med seboj povezani z nekaj manjšimi brezni oz. navpičnimi rovi. Spodnja etaža se na koncu raziskanega jamskega sistema konča s sifonskim rovom.

Takoj za vhodom v jamo je v desni skalni steni le nekaj metrov širok prehod, skozi katerega je mogoče obiti glavni rov in priti v zgornje etaže. Rov se nato nekoliko razširi in dvigne (približno 10 x 5 m^2 površine in do 3 m višine). Na tleh je odložena mokra ilovica s kosi apnenca, odpadlega z jamskih sten (slika 2B). Na več mestih je bila ilovica že preložena in izkopana (sekundarno mesto). Mestoma kapljajoča voda odkriva do nekaj centimetrov velike drobce fosilnih kosti, ob robovih pa se med kosi skal ter grušča najdejo tudi nekoliko večji fragmenti. V letih 2016 in 2017 sta tolminska jamarja Jani Kutin in Nejc Maver prve kosti in nekaj zob našla že v kotanji med sedimenti, naplavljenimi iz jame, takoj pod kapom vhoda v jamo. V nadaljevanju jame sta kosti opazila le v stranskem rovu neposredno za vhodom in iz ilovice pobrala fragmente kosti, kjer jih siga ni zlepila z gruščem. Ob tem sta našla še skoraj celo lobanjo, ki so jo kasneje odkopali pod vodstvom arheologa Miha Mlinarja iz Tolminskega muzeja. Lobanjo je muzej skupaj s preostalimi kostmi, najdenimi v jami, tudi prevzel v hrambo (slika 2C).



Sl. 2: Jama Bele vode. A – vhod v jamo; B – pogled na jamske sedimente v Medvedovi dvorani; C – izkopavanje lobanje jamskega medveda (glej tudi tablo 1). Fotografije: Jani Kutin.
Fig. 2: The Bele vode cave. A – cave entrance; B – the Medved hall (Medvedova dvorana) with fossil bearing cave sediments; C – excavation of cave bear skull (see Plate 1). Photos: Jani Kutin.

Najdišče fosilnih medvedovih kosti iz jame Bele vode je znano že od konca 19. stoletja dalje. Kosti je leta 1894 odkopal tržaški arheolog Carlo Marchesetti in leto pozneje o najdbah iz te takrat imenovane Jame pri Trebuši tudi objavil prispevek (Marchesetti, 1895). Poleg objave podatkov o fosilnih kosteh pleistocenskih živali iz Postojnske jame, kjer je leta 1821 raziskoval Guiseppe de Volpi (Habe, 1968), iz Križne jame po poročilih Dominika Bilinecka leta 1847 (Križnar, 2017)



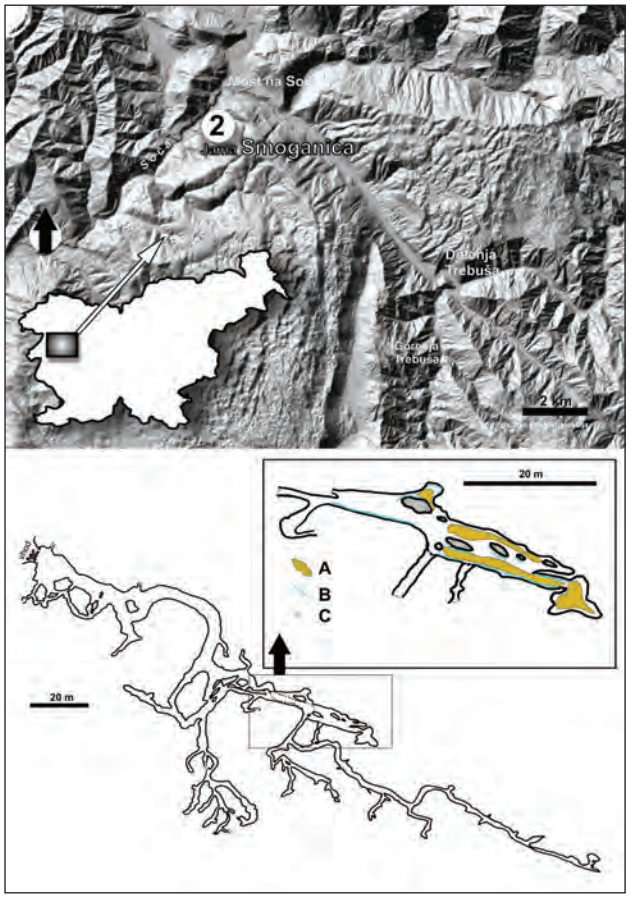
Sl. 3: Lobanja jamskega medveda** Ursus ligusticus **iz jame Bele vode (it. Caverna di Tribussa), kot jo je leta 1895 prikazal in določil Carlo Marchesetti.
Fig. 3: Cave bear skull of** Ursus ligusticus **from the Bele vode cave (Caverna di Tribussa), represented and determinated by Carlo Marchesetti, 1895.

ter iz Mokriške jame, kjer sta kosti jamskega medveda našla in izkopavala Johann Pezhar (leta 1837) in Henrik Freyer (leta 1838) (Božič, 2013; Križnar, 2014), je to bila ena prvih objav, ki vključuje najdišča z ozemlja današnje Slovenije, za katera se omenjajo pleistocenski fosilni ostanki. Marchesetti je članek iz leta 1895 vnovič objavil leta 1907 (Marchesetti, 1907). Izkopane kosti je na podlagi merskih primerjav z jamskim medvedom *Ursus spelaeus* pripisal starejši vrsti medveda, in sicer drugi vrsti *Ursus ligusticus* (slika 3), katerega taksonomski status še ni bil revidiran.

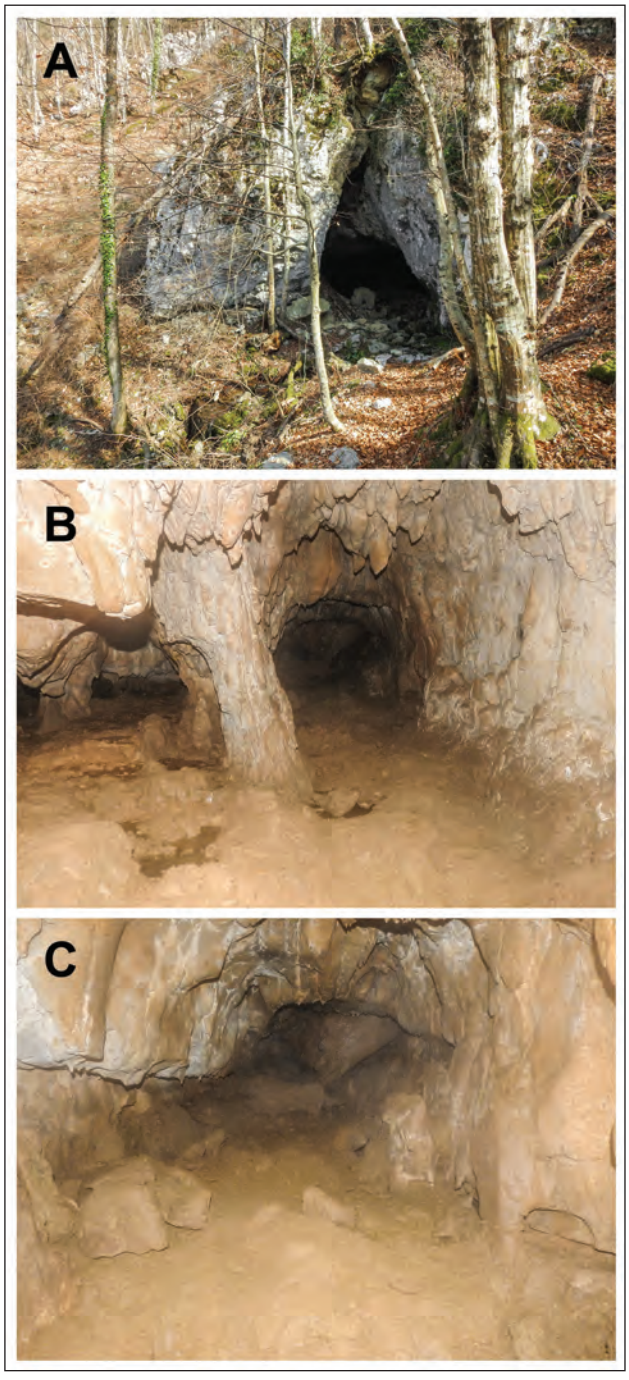
Smoganica (Jama pod Smoganico)

Jama Smoganica spada med izvirne jame. Velik vhod vanjo se odpira na pobočju Drobočnika nad Mostom na Soči na nadmorski višini 480 metrov (sliki 4 in 5A). Izoblikovana je v apnenčevi breči, nastala pa je v freatičnih razmerah. Jamski sistem tvori preplet manjših rovov, ki so se razvili znotraj breče v vseh smereh. Oblikovanje jame lahko opredelimo kot poligenetsko, saj je njene dele že povsem preoblikovala voda, ki pronica s površja in polzi po jamskih stenah (Knez *et al.*, 2005). Kljub razvejanosti in prepletu rovov pa je v grobem mogoče zgornje, manj mokre rove ločiti od spodnjih, po katerih teče voda, ki se iz zaledja jame pretaka skozi jamske rove ponovno na površje, od tod pa po strmi strugi odteka proti hudourniškemu potoku Lisičnik in nato proti Soči. Med zgornjo in spodnjo etažo jame je več prehodov v obliki manjših brezen ali poševnih rovov. Smoganica je dolga 492 metrov, višinska razlika med najnižjim in najvišjim rovom je 15 metrov.

Nahajališče kosti v jami Smoganica so leta 1924 odkrili člani ilegalnega planinskega kluba Krpelj, ki so v Posočju in na Idrijskem prvi raziskovali tudi jamski svet. Ko so zaznali, da se za jame na tamkajšnjem območju zanimajo Italijani, so kot zavedni Slovenci sami najprej začeli raziskovati Smoganico (Rovšček, 2015, 43). Leta 1956 je član društva Zorko Jelinčič ob odkritju »čre*pinje*« jamskega medveda zapisal: » … *Pač mu je bila usodna ona skala. Končno smo staknili v gornji, suhi jami, kjer je potoček tekel že pred davnimi desettisočletji, preden si je izdolbel strugo ca. 5 m globlje, pod plastjo kapnika in sige, v debeli naplavini ilovice tudi pravo ležišče ali pokopališče medvedov brlogarjev.*« (Jelinčič, 1956, 571) Tolminska jamarja Jani Kutin in Nejc Maver sta leta 2016 jamo večkrat pregledala, da bi našla nahajališče kosti. V spodnji etaži, skozi katero se prevaja manjši potok, sta našla le nekaj drobcev, ki jih je voda zajela nekje globlje v jami in jih na svoji poti odložila blizu izhoda iz jame. V zgornji, bolj suhi etaži pa sta našla rov, ki so ga Krpljarji prepoznali kot »ležišče ali pokopališče medvedov brlogarjev«. Gre za ozek, le nekaj več kot meter širok in od 0,5 do 2 metrov visok rov. Ta se odpira nad breznom, ki povezuje zgornjo in spodnjo etažo (slika 5B) in se konča s podorom, skozi katerega je mogoče zlesti še nekaj metrov naprej v jamo (slika 5C). Ali je ta podor morda

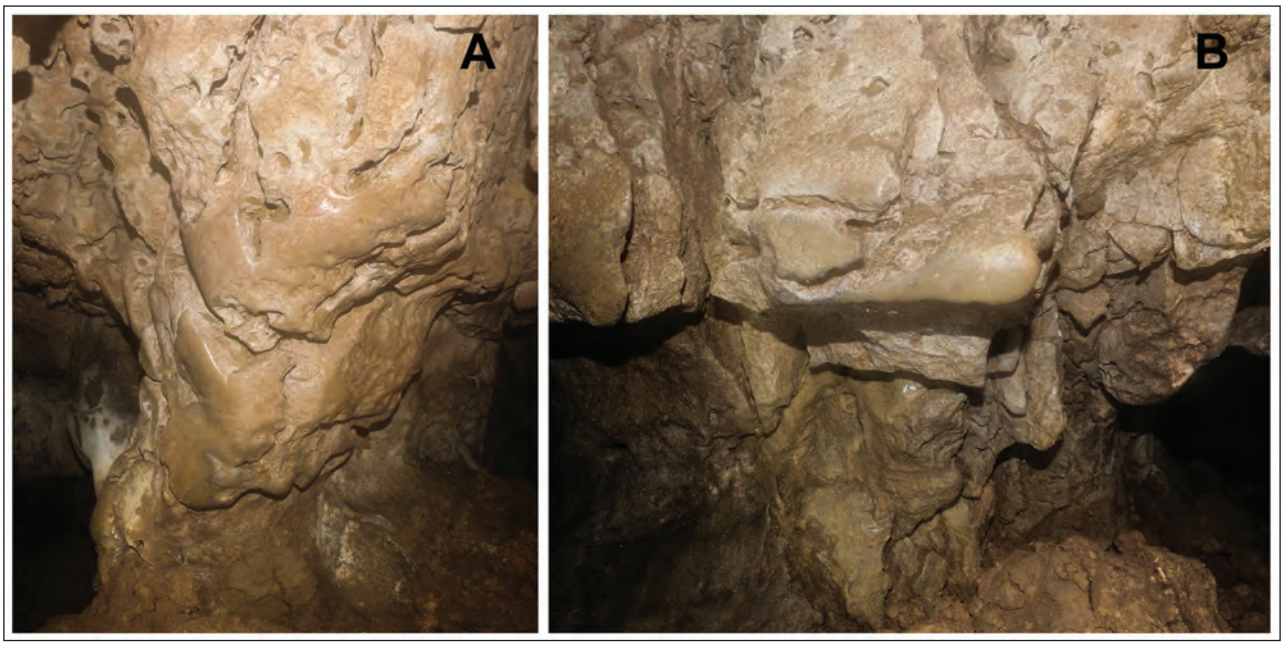


Sl. 4: Položaj jame Smoganica (2) nad dolino Soče (zgoraj). Tloris jame Smoganica z označenimi območji pojavljanja fosilonosnih plasti in obrusov; A – razprostranjenost plasti s fosilnimi ostanki, B – dokumentirani in opazni obrusi na jamskih stenah (nastali ob obiskih jamskih medvedov), C – podor v jamskem rovu (glej tudi sliko 5C). Tloris jame po Umbertu Mikolicu in Giorgiu Colombettu, risba: Matija Križnar).
Fig. 4: Location of the Smoganica cave (2) above the Soča River valley. Ground plan of the Smoganica cave; A – distribution of fossil bones within Pleistocene cave sediments, B – walls brushed by cave bears, C – collapsed walls/ceiling in cave tube (see Figure 5C). (Cave ground plan Umberto Mikolic and Giorgio Colombetta, adapted drawing Matija Križnar).



Sl. 5: Jama Smoganica nad dolino reke Soče. A – jamski vhod, B – pogled na rove z ostanki fosilnih kosti, C – rov, ki se konča z večjim podorom. Fotografije: Pavel Jamnik.
Fig. 5: The Smoganica Cave above the Soča River valley. A – cave entrance, B – part of the cave with fossil remains, C – Cave tube with collpased walls and ceiling on the end. Photos: Pavel Jamnik.

zapolnil staro povezavo rova s površjem, ni mogoče presoditi, so pa tudi v tem delu za njim še fosilne kosti. Ker je rov s kostmi precej oddaljen od vhoda in je dostop do njega otežen, se zdi, da so medvedi morda imeli drugo, krajšo pot in za dostop niso uporabljali današnjega vhoda. Jamska tla v rovu so zapolnjena z ilovico, ki leži na plasti sige. Kot je videti, je bila ilovica skoraj po celi dolžini okoli 10 metrov dolgega rova že precej prekopana. Kjer je bila plast sige odstranjena ali razbita, je pod njo plastovito odložena ilovica skoraj brez grušča. Kosti in zobje ležijo v ilovici, ki je pod odstranjeno sigo. Nekaj kosti je tudi v ilovici na začetku rova, nad



Sl. 6: A, B: Obrusi na površini jamskih sten v jami Smoganica kot posledica obiskovanja jamskega medveda. Fotografije: Pavel Jamnik.
Fig. 6: A, B: Cave walls with brush marks, probably made by cave bears in the Smoganica cave. Photos: Pavel Jamnik.

breznom, kjer spodaj sige ni opaziti. Na jamskih stenah po celi dolžini rova so številni medvedovi obrusi (slika 6), zaglajene skalne stene, ki so v medvedovih brlogih nastale, ko so se medvedi drgnili ob kamnite izbokline in si tako lajšali srbenje. Številni medvedovi obrusi so tudi v dostopnem rovu pred breznom, prek katerega iz smeri današnjega vhoda vstopimo v rov s kostmi. Tam na jamskih tleh ni več ilovnatega sedimenta, so pa ravno obrusi dokaz za prisotnost medvedov na obeh straneh rovov nad breznom.

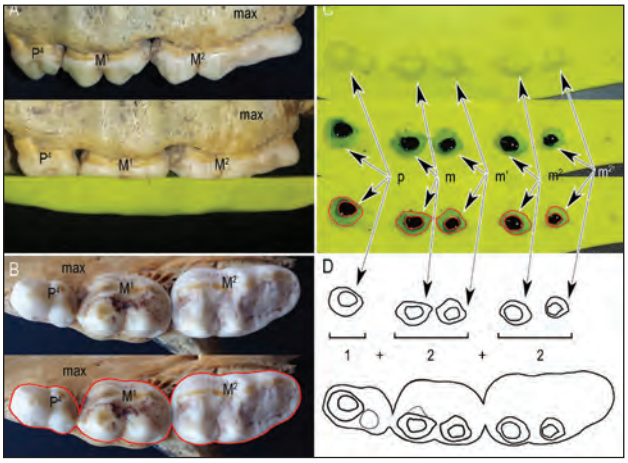
MATERIAL IN METODE

Kosti s sledmi ugrizov

Med nabranimi, celimi in fragmentiranimi kostnimi ostanki smo v jami Bele vode našli tudi nekaj kosti s sledmi ugrizov v obliki jamic ali krožnih poškodb, pri katerih kostna stena ni bila predrta v celoti. Take lezije smo našli na kosteh, ki pripadajo jamskemu medvedu, in sicer na štirih rebrnih fragmentih (slike 8–11), na ledvenem vretencu (slika 12), na desni petnici (slika 13) in na levi nadlahtnici (slika 14). V nekaj primerih lahko opazimo, da si po tri jamice neenakomerno sledijo v navidezni liniji, kar pomeni, da eni sledita dve med seboj nekoliko zbližani (1 + 2).

Da bi pojasnili možnost za nastanek okroglih jamic oz. lezij na kosteh iz jame Bele vode, smo poskušali z analizo načina ugrizov jamskega medveda in domnevnega nastanka sledi na kosteh odgovoriti na vprašanje, ali perforativne lezije na kosteh lahko naredi jamski medved s premolarji in molarji. Iz analize smo izključili vse druge zveri, saj je bilo najdišče fosilnih kosti v jami Bele vode brlog jamskega medveda in med najdbami fosilnih kostnih ostankov ni bila dokazana navzočnost drugih zveri in glede na mesto najdbe tudi ne prisotnost kamenodobnega človeka.

Za primerjalno analizo smo imeli na razpolago dve fosilni lobanji z najdišča Križna jama (paleontološka zbirka Prirodoslovnega muzeja Slovenije), tri spodnje čeljustnice, ki ustrezajo velikosti vzorčnih lobanj povprečnega odraslega jamskega medveda, in manjšo lobanjo rjavega medveda, vključno s spodnjima čeljustnicama (Veterinarska fakulteta Univerze v Ljubljani). Izmerili smo dolžino lobanj, tj. projekcijo razdalje med rostralnim koncem interincizivnega šiva (*prosthion*) in sredinsko točko zunanje zatilnične štrline (*inion*) na osnovno ploskev. Domnevne odtise zobovja smo na vzorčnih kosteh dokazovali s prileganjem lezij na grizne površine oz. vrške zobnih grbic (slike 8–14). Izdelali smo odtis ličnikov zgornje čeljustnice jamskega medveda, na podlagi katerega smo izrisali shemo vrškov grbic na griznih površinah (slika 7), in z zobovjem jamskega oz. rjavega medveda rekonstruirali posamezne lezije. Vzorce ugrizov smo na slikah primerjali s shemo in tako morfološko ocenjevali predvsem medsebojni položaj, obliko, velikost in globino posameznih poškodb.



Sl. 7: Ličniki zgornje čeljustnice jamskega medveda. A – lateralni pogled in izdelava odtisa, B – grizne površine in obris, C – odtisi grbic in izohiptični prikaz globine odtisov, D – shema razporeditve odtisov posameznih grbic »1 + 2 + 2« na zgornjih ličnikih. Okrajšave: max – zgornja čeljustnica; P⁴ – četrti premolar; M¹ – prvi molar; M² – drugi molar; p, m, m', m², m²' – oznake odtisov grbic ustreznih ličnikov. Fotografije: Matjaž Uršič.
Fig. 7: Cheek teeth of the cave bear upper jaw. A – lateral view and tooth print, B – cheek teeth's occlusal surfaces and their contour, C – the order of imprints of tooth tubercles with their depth contour lines, D – schematic diagram of the upper jaw cheek teeth and their tubercles arrangement "1 + 2 + 2". Abbreviations: max – maxilla; P⁴ – the fourth premolar; M² – the first molar; M² – the second molar; p, m, m', m², m²' – the marks indicate tooth prints of the corresponding cheek teeth. Photos: Matjaž Uršič.

REZULTATI IN RAZPRAVA

Osnovne funkcionalne in morfološke značilnosti zobovja jamskega medveda

Zobovje je skupaj z drugimi deli žvekalnega aparata namenjeno jemanju in mehanični drobitvi hrane. Ker obstajajo med obliko zobovja in vrsto hrane tesni vzajemni odnosi, se je zobovje pri razvoju živalskih vrst po obliki prilagajalo predvsem načinu prehranjevanja. Tako v grobem lahko razlikujemo med zobovjem mesojedov (*carnivora*), vsejedov (*omnivora*) in rastlinojedov (*herbivora*). Sesalci imajo zobe v zgornji in spodnji čeljusti, in sicer štiri vrste zob, ki opravljajo različno funkcijo (Rigler, 2000; Nickel *et al*., 1979).

Sekalci I (*dentes incisivi*) so pri mesojedih namenjeni sekanju, paranju in strganju tkiv od kosti, lahko tudi čiščenju dlake in odstranjevanju na kožuhu sprijetih tujkov. Podočniki, tudi grabilci C (*dentes canini*), se pri zbliževanju čeljusti in škarjastem ugrizu, značilnem za mesojede, nekoliko prekrižajo. Gre za koničaste, enokoreninske zobe, ki so pri mesojedih izraziti in dobro razviti. Z njimi lahko plenu povzročijo smrtonosne vbodne rane, prav tako grabijo, držijo in trgajo plen. Hkrati so podočniki opora pri ohranjanju položaja jezika v ustni votlini. Zobni lok za podočniki zapolnjujejo ličniki iz skupine predmeljakov ali premolarjev P (*dentes premolares*), ki so pri mesojedih sicer najštevilnejši zobje, prisotni tako v mlečnem kot tudi v stalnem zobovju, pri jamskem medvedu pa so se med filogenetskim razvojem skoraj povsem izgubili. Živali jih uporabljajo za držanje, glodanje, lomljenje in drobljenje. Sledijo ličniki iz skupine meljakov oz. kočnikov ali molarjev M (*dentes molares*), ki izrastejo le enkrat. Potegnjeni so globlje v ustno votlino in so navadno zunaj pogleda, za ustno režo. Razporeditev ličnikov s svojimi vrški nekoliko spominja na škarje z ostrim nazobčanim rezilom (Nickel *et al*., 1979; Rigler, 2000; Evans & de Lahunta, 2013; Singh, 2018).

Pri jamskem medvedu se je med filogenetskim razvojem v stalnem zobovju v obeh čeljustnicah ohranil le četrti, tj. zadnji premolar P4, v zgornji čeljustnici sta od molarjev zrasla samo dva, v spodnji pa trije. Zgornji ličniki imajo pri medvedu na nebnem odseku le rahlo grbičasto in izravnano grizno ploskev (Vila Taboada *et al*., 2001), kar mu omogoča predvsem zvečenje in dodatno drobljenje.

Morfološke značilnosti žvekalnega aparata jamskega medveda, obsežne grizne ploskve molarjev, vključno z izgubo premolarjev in s podaljšanjem brezzobničnega roba tako v zgornji kot tudi v spodnji čeljustnici, ter izrazitost žvekalne muskulature kažejo na način njihovega hranjenja. Raziskave kažejo, da je bil sicer precejšen delež njihove prehrane rastlinskega izvora (Kurten, 1976; Bocherens *et al*., 1994; Stiner *et al*., 1998; Vila Taboada *et al*., 2001; Fernández-Mosquera *et al*., 2001), kljub temu pa zobje predvsem v zgornji čeljustnici razvojno še vedno do neke mere ohranjajo lastnosti zverskega zobovja. Značilna oblika sekalcev, veliki podočniki in izrazitejši vrški na grbicah zgornjih ličnikov kažejo značilnosti bunodontnega oz. prehodnega buno-sekodontnega tipa. Spodnji ličniki (premolar in molarji) s svojimi številnimi neizrazitimi grbicami in obsežnimi griznimi ploskvami predstavljajo izrazitejše zobovje bunodontnega tipa (Vila Taboada, *et al*., 2001), kar je sicer značilnost omnivorov. Izraženost vrškov je odvisna tudi od vrste in načina prehrane ter starosti osebka, kar se odraža predvsem v okluzalni obrabi zobovja (Stiner, 1999; Baryshnikov 1998; Jones & Desantis 2016).

Ostanki pleistocenske favne

Marchesetti (Marchesetti, 1907) je pri uvrščanju ostankov jamskega medvedov v vrsto *Ursus ligusticus* upošteval zgolj kondilobazalno dolžino lobanje, ne pa tudi zob in drugih parametrov, ki jih danes uporabljamo za določevanje vrst jamskih medvedov (Rabeder *et al*., 2004). Njegova primerjava (z objavljenih fotografij) lo-

Tabla 1: Kostni ostanki fosilne favne iz jame Bele vode. *Ursus* ***cf.*** *ingressus****: 1 – čeljust mladega osebka, 2 – podočnik (C), 3 – čeljust mladega osebka z neizraslim podočnikom, 4 – čeljust mladega osebka z izraslim spodnjim prvim molarjem (M), 5 – skupek kostnih fragmentov in zob, vezanih s karbonatnim vezivom, 6 – plečnica jamskega medveda z vidnimi poškodbami/ugrizi (puščice);*** *Cervus elaphus****: 7 – distalna prstnica (parkeljnica). 1, 2, 3: zbirka Tolminskega muzeja; 4, 6: zbirka Janija Kutina; 5, 7: zbirka Nejca Mavra. Merila 1, 3, 6 – 10 cm, 2, 4, 5, 7 – 1 cm. Predstavljeno fosilno gradivo ni inventarizirano. Fotografije: Matija Križnar.***

Plate 1: Bone remains of fossil fauna from Bele vode cave. *Ursus* ***cf.*** *ingressus****: 1 – lower jaw of young specimen, 2 – canine (C), 3 – lower jaw of juvenile specimen with canine, 4 – lower jaw of juvenile specimen with first molar (M1), 5 – bone fragments and teeth aggregate in carbonate sediment, 6 – scapula with visible marks/bite (arrows);*** *Cervus elaphus****: 7 – distal phalanx. (1, 2, 3: Collection Tolminski muzej; 4, 6: Collection Jani Kutin; 5, 7: Collection Nejc Maver), Scale bar 1, 3, 6 – 10 cm, 2, 4, 5, 7 – 1 cm. The inventory of presented fossil material has not been taken. Photos: Matija Križnar.***

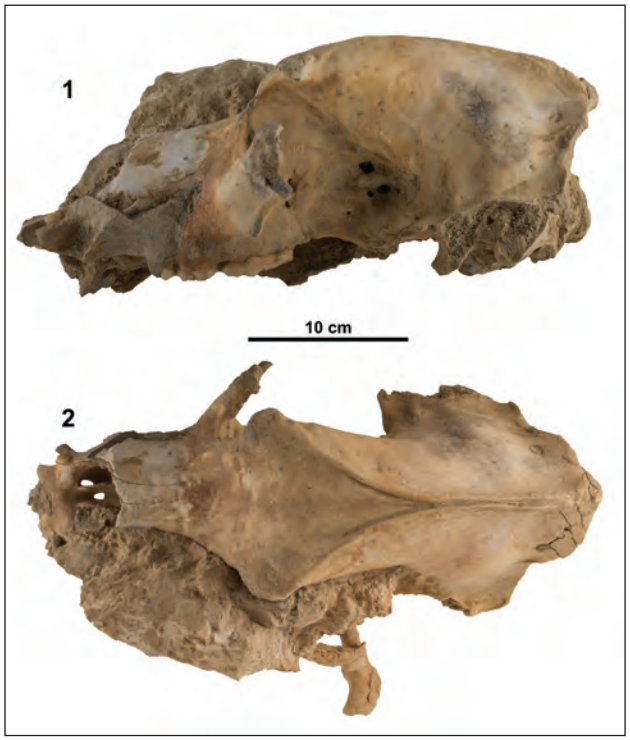


Tabla 2: Lobanja jamskega medveda** (Ursus **cf.** ingressus) **iz jame Bele vode (iz zbirke Tolminskega muzeja). 1 – pogled s strani (desna), 2 – pogled od zgoraj. Fotografiji: Matija Križnar.
Plate 2: Cave bear skull** (Ursus **cf.** ingressus)**, the Bele vode cave (Collection Tolminski muzej). 1 – lateral view (right side), 2 – dorsal view. Photos: Matija Križnar.

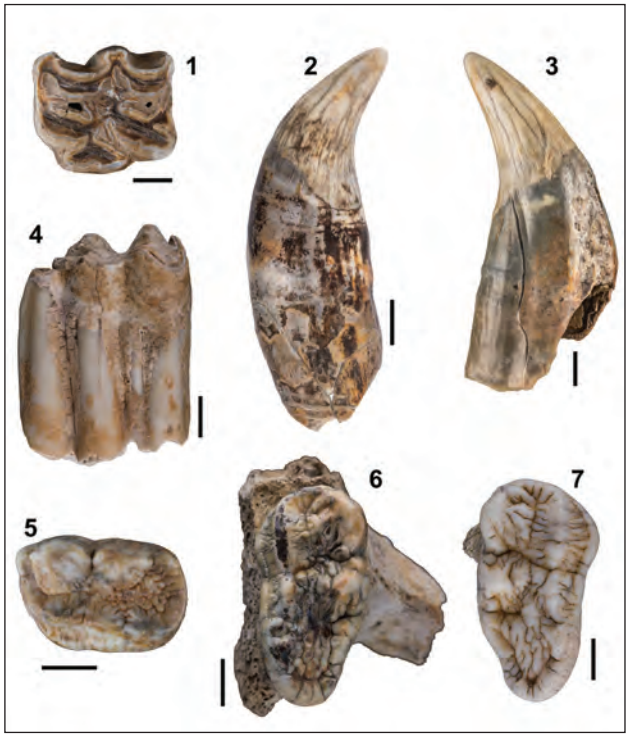
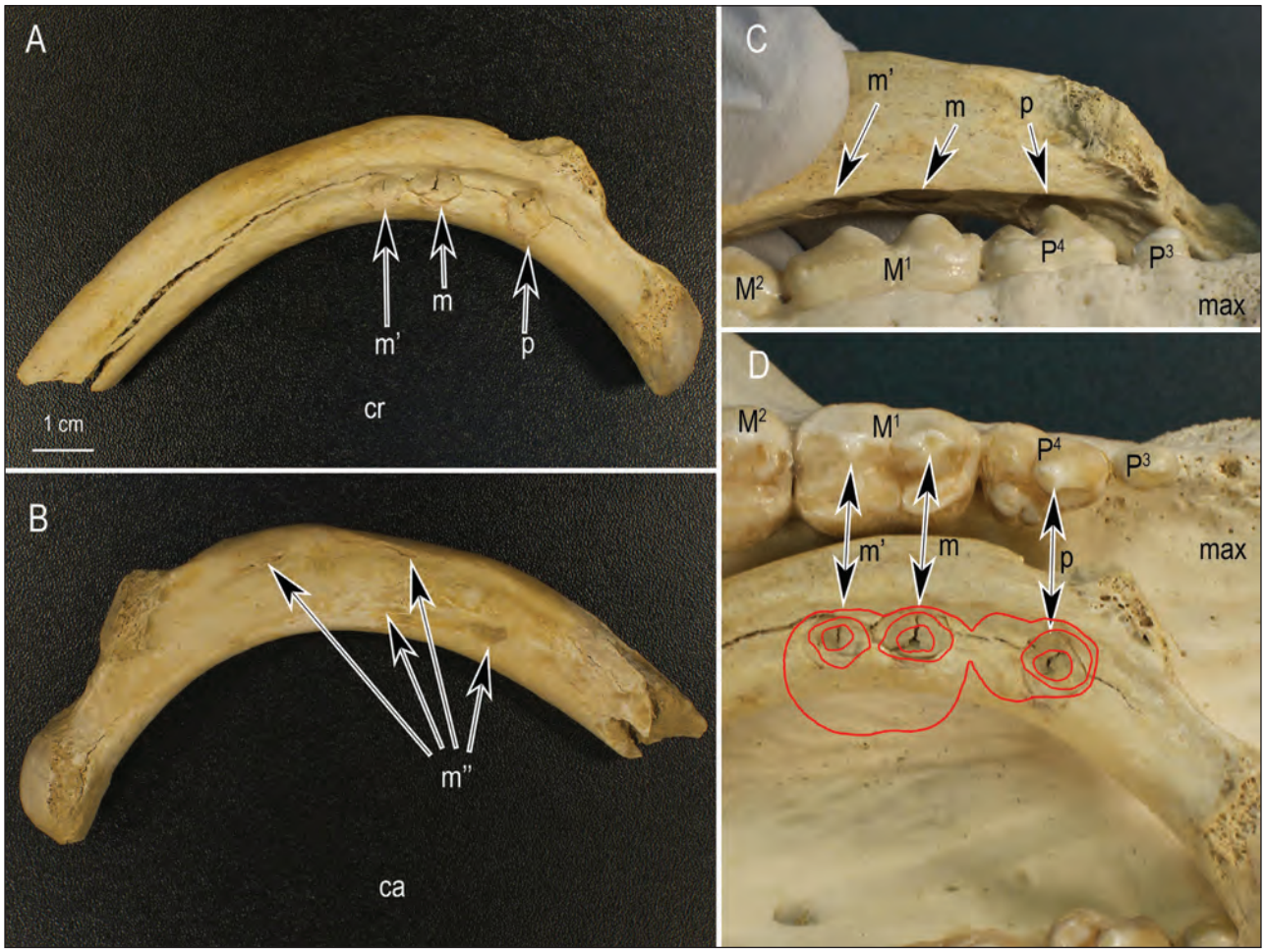


Tabla 3: Kostni ostanki fosilne favne iz jame Smoganica.** Equus ferus caballus**: 1 – zgornji levi premolar (P); Bos primigenius seu Bison priscus: 4 – spodnji molar (M_3); Ursus ingressus: 2, 3 – podočnika (C), 5 – zgornji molar (M^1), 6, 7 – zgornja molarja (M^3). (1, 4–7: zbirka Tolminskega muzeja, 2: zbirka Nejca Mavra, 3: zbirka Bruna Blažina). Merila 1 cm. Predstavljeno fosilno gradivo ni inventarizirano. Fotografije: Matija Križnar.
Plate 3: Bone remains of fossil fauna from the Smoganica cave.** Equus ferus caballus**: 1 – Upper left molar (P^3); Bos primigenius seu Bison priscus: 4 – Lower molar (M_3); Ursus ingressus: 2, 3 – canine (C), 5 – Upper molar (M^1), 6, 7 – Upper molar (M^3). (1, 4–7: collection Tolminski muzej, 2: collection Nejc Maver, 3: collection Blažina), Scale bar 1 cm. The inventory of presented fossil material has not been taken. Photos:Matija Križnar.

banj jamskih medvedov *Ursus ligusticus* in *Ursus spelaeus* je dokaj nazorna, a brez pregleda zob in dodatnih morfometričnih podatkov vrste ni mogoče opredeliti oziroma potrditi. Med Marchesettijevima predstavljenima lobanjama je več razlik, ki bi jih lahko pripisali različnim dejavnikom: (1) dokaj izrazit spolni dimorfizem pri jamskem medvedu – ta lahko pri rjavem medvedu *Ursus arctos* dokazano vpliva na razlike celo v 20 % do 30 %, analogno pa tudi pri jamskem medvedu *Ursus spelaeus* sensu stricto (Baryshnikov *et al*., 2003; Grandal d'Anglade, 2001; Weinstock, 2001); (2) razlike med lobanjama so lahko tudi ontogenetsko pogojene, pri čemer imajo mlajši osebki drugače oblikovano lobanjo z značilnimi morfometričnimi podatki, kar pomeni, da bi lahko Marchesettijeva lobanja medveda vrste *Ursus ligusticus* pripadala mlajšemu ali neodraslemu osebku, verjetneje drugi vrsti jamskega medveda (Toškan, 2007); (3) za potrditev, da lobanja, ki jo je preučeval Marchesetti, res pripada novi vrsti *Ursus ligusticus,* bi bilo treba primerjalno analizirati še druge vrste oz. podvrste jamskih medvedov *Ursus deningeri*, *Ursus spelaeus ladinicus*, *Ursus spelaeus eremus* in *Ursus ingressus* kakor tudi tudi nekatere bolj vzhodne, kot so *Ursus kudarensis*, *Ursus kanivetz* in *Ursus rossicus* (Rabeder & Hofreiter, 2004; Rabeder *et. al*, 2004; Baryshnikov & Puzachenko, 2011). Morfotipi slednjih so bili na podlagi novih raziskav mlajših pleistocenskih jamskih medvedov prepoznani v preteklih dveh desetletjih, a je njihov taksonomski status še vedno nedorečen.

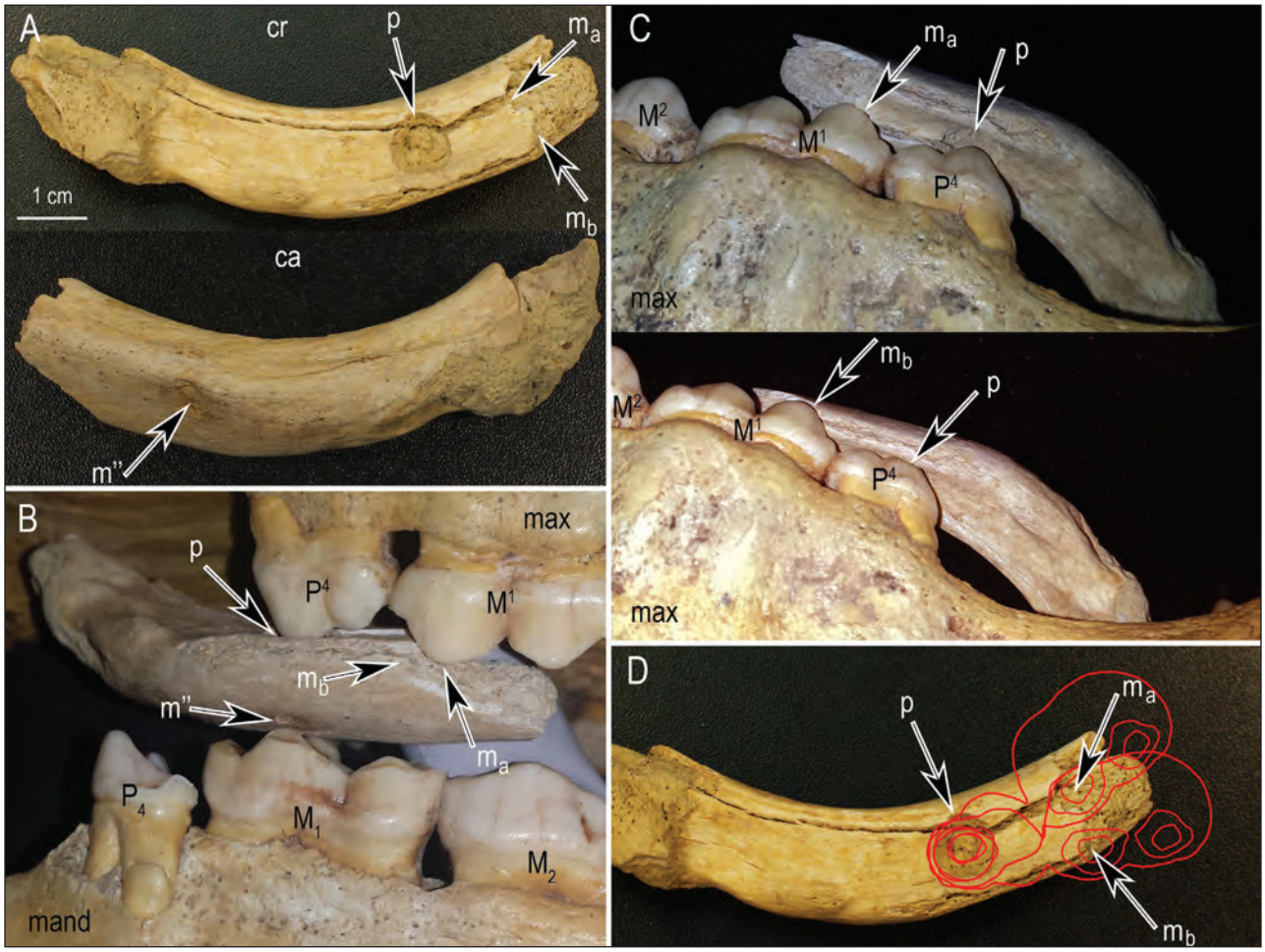
Prisotnost ostankov mladih in manjših jamskih medvedov kaže, da je bila Medvedova dvorana v jami Bele vode občasno brlog samic in da je bila v tistem času prehodnost jame drugačna. Bolj zaščiten vhodni del je bil primernejši za bivanje. Pregled sedimentov je pokazal, da je po odložitvi kosti prišlo do delnega premika kostnih ostankov in kasneje do ponovne sedimentacije. Mnoge kosti in kostni fragmenti so vezani v peščen se-



Sl. 8: Dorzalni fragment desnega rebra jamskega medveda. A – kranialni (cr) pogled, B – kavdalni (ca) pogled, C – rekonstrukcija medvedjega ugriza, D – prikaz skladnosti odtisov z grbicami na P^4 in M^1 jamskega medveda. Okrajšave: max – zgornja čeljustnica; P^3 – tretji premolar; P^4 – četrti premolar; M^1 – prvi molar; M^2 – drugi molar; p, m, m', m'' – oznake odtisov ustreznih grbic na ličnikih. Fotografije: Jasna Šporar in Matjaž Uršič.
Fig. 8: Dorsal fragment of the right cave bear rib. A – cranial (cr) view, B – caudal (ca) view, C – reconstruction of the bear bite, D – shows the matching of imprints with the cave bear P4 and M1 teeth tubercles. Abbreviations: max – maxilla; P^3 – the third premolar; P^4 – the fourth premolar; M^1 – the first molar; M^2 – the second molar; p, m, m', m'' – the marks indicate tooth prints corresponding to cheek teeth. Photos: Jasna Šporar and Matjaž Uršič.

diment z močnim karbonatnim vezivom. Čeprav premik kosti in zob znotraj jame ni bil izrazit, pa ta dislokacija kaže na kasnejše izpiranje ob prisotnosti vodnega toka. Ker v nadaljevanju jame v večini rovov ni najti fosilnih kosti, najdene so bile le v omenjenem stranskem rovu ob vhodu, domnevamo, da je bila v jami voda že v času, ko so vanjo zahajali medvedi. Vlažna jama je bila sicer za brlog manj primerna, a izbor take jame za jamskega medveda ni bil nič nenavadnega. Verjetno je iskati enega od vzrokov za izbiro takega brloga v večji populaciji medveda v določenem obdobju. Vodoravnih jam na tem območju sicer ni veliko, v bližini se nahaja še Hvalova jama (kat. št. 1862), v kateri pa raziskav oziroma odkritij pleistocenske favne še ni bilo.

Med gradivom je tudi manjša lobanja, ki jo hrani Tolminski muzej in pripada starejšemu osebku (tabla 2). Na podlagi dimenzij, tj. dolžine zgornjega M^2 (44,5 mm) in skupne razdalje od P^4 do M^2 v zgornji čeljustnici (91 mm), bi jo lahko pripisali vrsti *Ursus ingressus*. Stranski profil lobanje je zelo podoben omenjeni vrsti (glej Rabeder *et al.*, 2004; Rabeder & Hofreiter, 2004). Na vrsto *Ursus ingressus* kažejo morfološke značilnosti (zobne grbice, dimenzije in oblika zob) nekaterih molarjev (zgornji in spodnji M2). Preostali kostni ostanki kažejo na znatno prisotnost mlajših in nedoraslih osebkov. Preliminarno smo zbrano gradivo jamskih medvedov iz jame Bele vode uvrstili v vrsto *Ursus* cf. *ingressus* (Rabeder *et al.*, 2004) (tabla 1/1–6 in tabla 2).



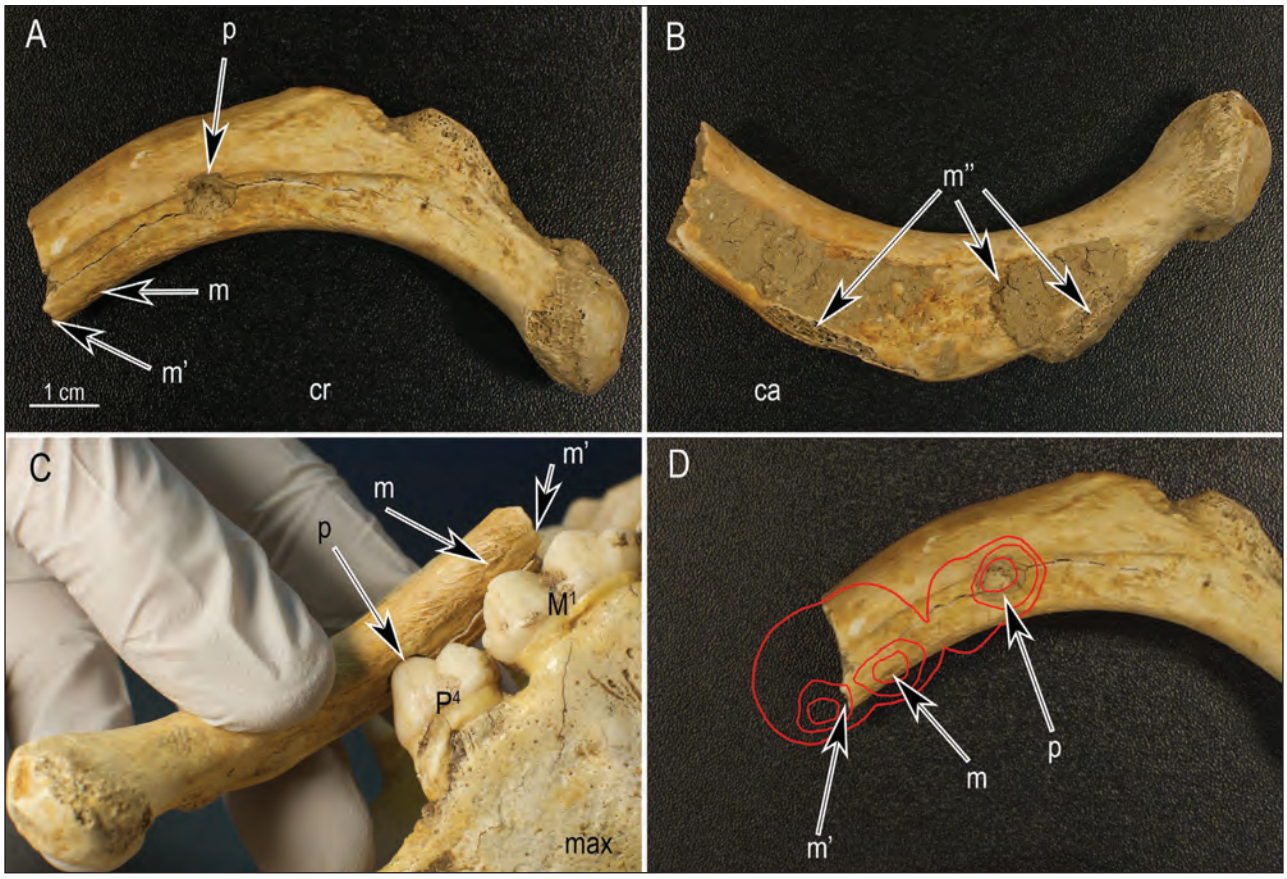
Sl. 9: Dorzalni fragment levega rebra jamskega medveda. A – kranialni (cr) in kavdalni (ca) pogled, B in C – rekonstrukcije ugrizov s čeljustnicama jamskega medveda, D – prikaz ujemanja griznih lezij z vrški zobnih grbic jamskega medveda. Okrajšave: max – zgornja čeljustnica; mand – spodnja čeljustnica; P^4 oz. P_4 četrti premolar; M^1 oz. M_1 – prvi molar; M^2 oz. M_2 – drugi molar; p, m_a, m_b, m'' – oznake griznih lezij glede na ustrezne grbice ličnikov. Fotografije: Jasna Šporar in Matjaž Uršič.
Fig. 9: Dorsal fragment of the left cave bear rib. A – cranial (cr) and caudal (ca) view, B and C – bite reconstructions with the cave bear's jaws, D – the matching of the imprints with the cave bear's teeth tubercle cusps. Abbreviations: max – maxilla; mand – mandible; P^4 or P_4 – the fourth premolar; M^1 or M_1 – the first molar; M^2 or M_2 – the second molar; p, m_a, m_b, m'' – marks indicate lesions corresponding to the cheek teeth tubercles. Photos: Jasna Šporar and Matjaž Uršič.

V Medvedovem rovu je bila najdena tudi distalna prstnica (parkeljnica) jelena, ki morfološko ustreza navadnemu jelenu *Cervus elaphus* (tabla 1/7). Slednji je v Sloveniji zastopan tako med pozno pleistocensko favno kot tudi v mnogih holocenskih najdiščih (Pohar, 1994). Skromni ostanek navadnega jelena bi lahko v Bele vode vnesle tudi različne pleistocenske zveri.

Najdeni fosilni ostanki favne iz Smoganice večinoma pripadajo jamskemu medvedu (tabla 3/2–3, /5–7). Med ostanki so bili prepoznani tudi redki ostanki konja in goveda oz. bizona. Delni pregled gradiva jamskega medveda iz Smoganice je pokazal, da večji del kosti in zob spada k mladim osebkom. Dimenzije in morfološke značilnosti zobnih kron (zobnih grbic), predvsem zgornjih in spodnjih M2, kažejo na razvitejšo vrsto *Ursus ingressus* (Rabeder & Hofreiter, 2004). Fosilne ostanke jamskega medveda umeščamo v vrsto *Ursus ingressus* (Rabeder, Hofreiter, Nagel & Withalm, 2004).

Domnevamo, da so jamski medvedi jamo uporabljali kot prezimovalni brlog oz. za kotenje mladičev, kar potrjuje predvsem prisotnost kostnih najdb zgolj v enem delu jame. O dolgotrajnosti obstoja brloga pričajo številni obrusi na nekaterih jamskih stenah (slika 6).

Poleg kosti jamskega medveda so bili v Smoganici



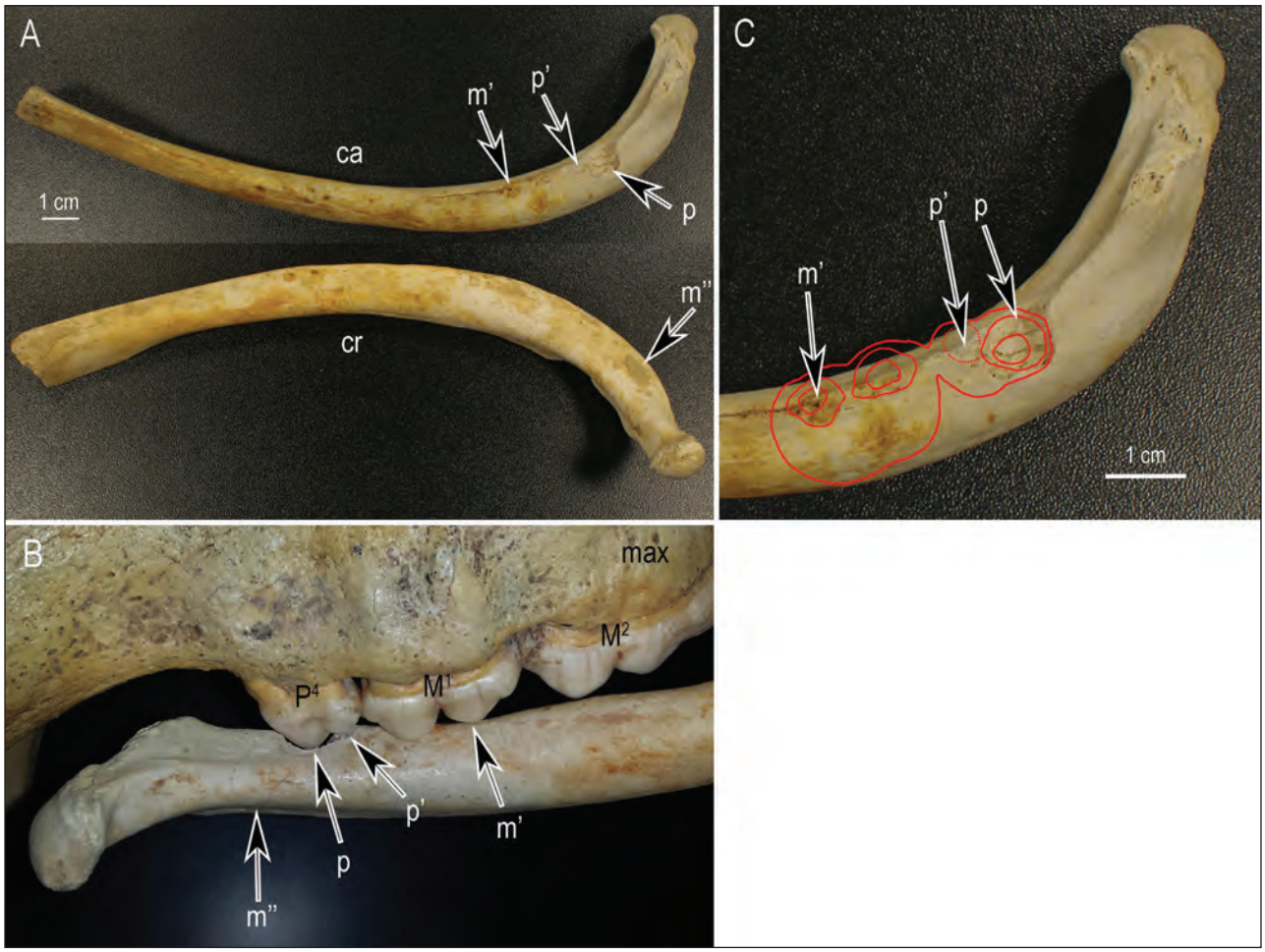
Sl. 10: Dorzalni fragment desnega rebra jamskega medveda. A – kranialni pogled (cr), B – kavdalni pogled (ca) z C – rekonstrukcijo ugriza, D – prikaz sovpadanja griznih lezij z grbicami P^4 in M^1 jamskega medveda. Okrajšave: max – zgornja čeljustnica; P^4 – četrti premolar; M^1 – prvi molar; M^2 – drugi molar; p, m, m', m'' – grizne lezije povzročene z ustreznimi grbicami ličnikov. Fotografije: Jasna Šporar in Matjaž Uršič.
Fig. 10: Dorsal fragment of the right cave bear rib. A – cranial view (cr), B – caudal view(ca), C – bite reconstruction of the cave bear cheek teeth, D – shows the matching of the lesions with the cave bear P^4 and M^1 teeth tubercles. Abbreviations: max – maxilla; P^4 – the fourth premolar; M^1 – the first molar; M^2 – the second molar; p, m, m', m'' marks indicate lesions corresponding to the cheek teeth tubercles. Photos: Jasna Šporar and Matjaž Uršič.

najdeni še ostanki bovidov in konja. Bovidu pripadajo trije zobje iz spodnje čeljustnice: sekalec ter ličnika P_3 in M_3 (tabla 3/4). Taksonomija fosilnih ostankov rodu *Bos* in *Bison* temelji na morfometričnih podatkih kosti, zato so zobje manj uporabni za natančno določevanje vrst. Zob M_3 lahko pripada tako turu *Bos primigenius* kot stepskemu bizonu *Bison priscus*, zato smo jih pripisali obema vrstama *Bos primigenius seu Bison priscus*. Ostanki turov oz. bizonov so na pleistocenskih najdiščih v Sloveniji redki (Rakovec, 1973; Pohar, 1994).

V Smoganici je bil najden še ostanek P^4 iz zgornje leve čeljustnice konja *Equus ferus caballus* (tabla 3/1), ki morfološko ustreza zobovju pleistocenskih konj. Ostanke konja so v jamo lahko zanesli tudi kateri od večjih plenilcev (jamski lev ali jamska hijena), so pa tudi v drugih slovenskih najdiščih najdbe ostankov pleistocenskih konj dokaj redke (Rakovec, 1958; Pohar, 1994).

Morfološka analiza in rekonstrukcije ugrizov

Lobanji jamskega medveda, ki sta nam služili za primerjavo, sta bili po velikosti primerljivi. V dolžino sta merili 42 cm, medtem ko je bila dolžina lobanje rjavega medveda občutno krajša, le 30 cm. Pri jamskem medvedu so bili ohranjeni vsi izrasli ličniki in podočniki, od sekalcev pa le tretji v eni od spodnjih čeljustnic. Slednji je enostaven z dvorežnjasto krono. Izraziti podočniki so enostavni, veliki in ostrostožčaste oblike. Spodnji so nekoliko večji. Od bolj kompliciranih ličnikov so v zgornji čeljustnici razvojno edini ostali četrti predmeljak P^4 in dva le v trajnem zobovju navzoča meljaka M^1 in M^2. Izrazitost sekodontnega grebena se kaže na ličnem (bukalnem) odseku, tj. lateralnem delu grizne (okluzalne) površine. Na ličnem odseku vsakega ličnika sta po dve izrazitejši stožčasti

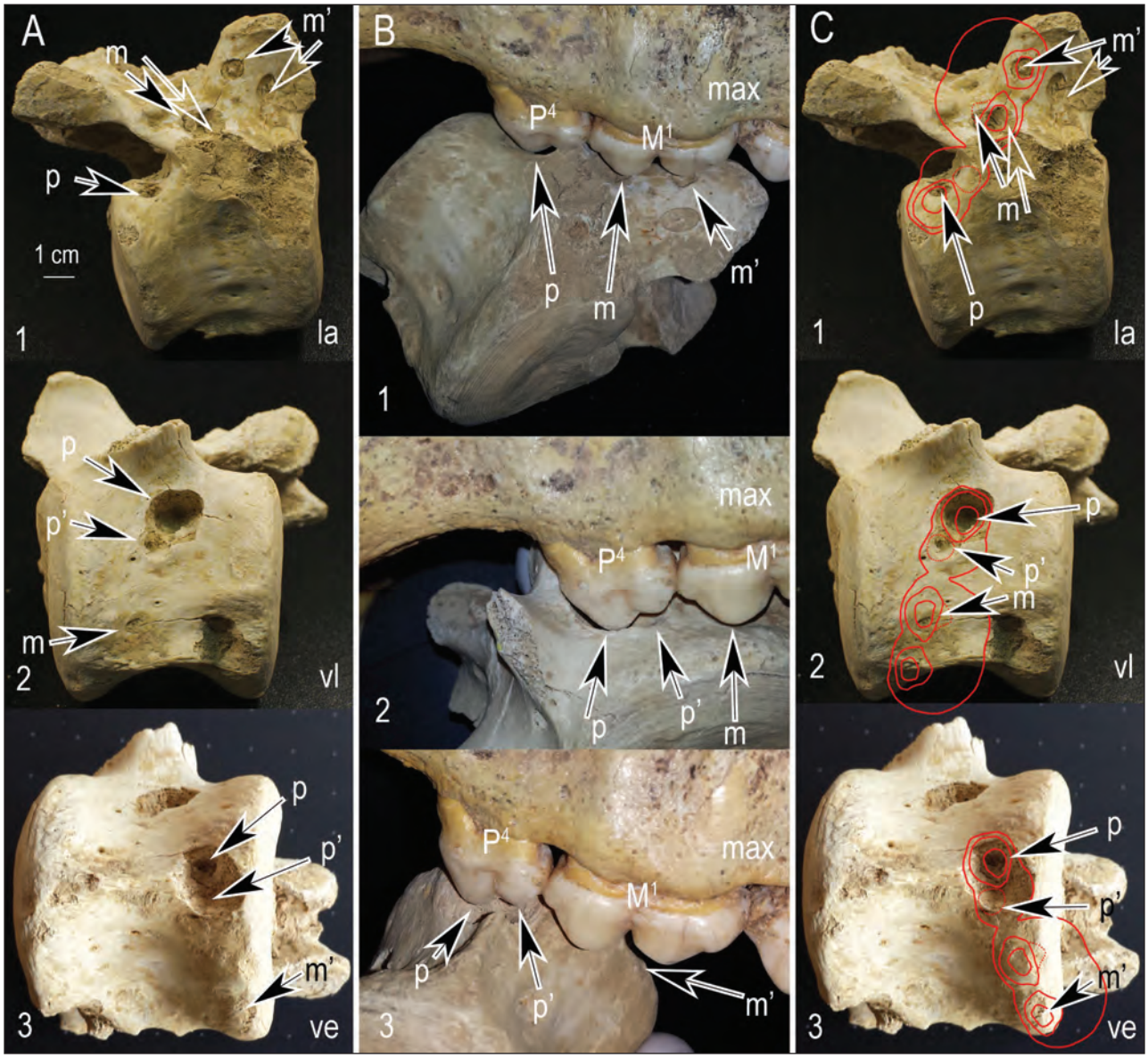


Sl. 11: Koščeni del, domnevno drugega sternalnega rebra jamskega medveda. A – kavdalni (ca) in kranialni (cr) pogled, B – rekonstrukcija griznih lezij, C – prikaz ujemanja lezij z vrški grbic na P⁴ in M¹. Okrajšave: max – zgornja čeljustnica; P⁴ – četrti premolar; M¹ – prvi molar; M² – drugi molar; p, m, m', m'' – oznake griznih lezij glede na vrške ustreznih grbic ličnikov. Fotografije: Jasna Šporar in Matjaž Uršič.
Fig. 11: A bony part probably of the right second sternal cave bear rib. A – caudal (ca) and cranial (cr) view, B – reconstruction of bite lesions, C – shows the matching of the cave bear P⁴ and M¹ teeth tubercles with the bite lesions. Abbreviations: max – maxilla; P⁴ – the fourth premolar; M¹ – the first molar; M² – the second molar; p, m, m', m'' –indicate lesions corresponding to the cheek teeth tubercles. Photos: Jasna Šporar and Matjaž Uršič.

grbici z vzdolžno nekoliko sploščenima vrškoma. V spodnji čeljustnici so izrasli štirje ličniki: premolar P_4 in trije molarji M_1, M_2 in M_3.

Vršek na sprednji zgornječeljustnični grbici premolarja je znatno višji od vrška kavdalne grbice, medtem ko sta na obeh molarjih sprednja vrška ličnega odseka le neznatno višja (slika 7A). Zobni lok je v okviru ličnikov zgornje čeljustnice le rahlo ukrivljen. Odtisi vrškov obeh molarjev so v zobnem loku postavljeni skoraj premočrtno (slika 7/C, /D). Manjše odstopanje se kaže le pri premolarju P^4, tj. četrtem ličniku. Ta ustreza lomilcu ali deraču (*dens sectorius*) (Rigler, 2000; Nickel *et al.*, 1979) in je rahlo rotiran (slika 7/B, /D), zato je vršek njegove izrazitejše sprednje grbice nekoliko zamaknjen proti mediani ravnini, kar krivuljo zobnega loka v tem delu nekoliko poudari. Opazna je značilna anizognatija. Spodnječeljustnični zobni lok je ožji kot zgornječeljustnični. Vrški ličnega odseka grizne ploskve zgornječeljustničnih ličnikov tako pri zapiranju čeljusti s svojim grebenom zdrsnejo čez ustnično oz. lično ploskev ustreznih zob v spodnji čeljustnici, ob tem pa se medialni nebni odsek grizne ploskve zgornjih ličnikov prileže ličnemu odseku spodnjih griznih ploskev ličnikov. V spodnji čeljustnici so zlasti molarji drobnogrbičasti in z obsežnimi griznimi ploskvami.

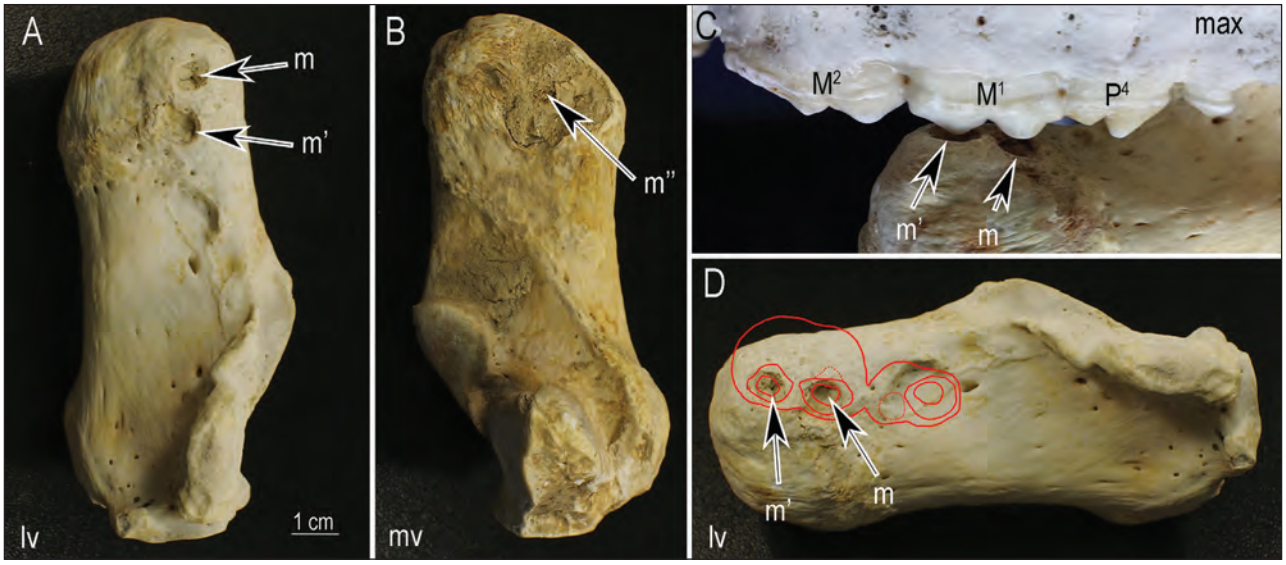
Tri jamice p, m, m‘ (slika 8) na fragmentu desnega rebra so kranialno na telesu v višini rebrnega kota: dor-



Sl. 12: Ledveno vretence jamskega medveda, primerjalno peto ali šesto. A – lateralni (la), ventrolateralni (vl) in ventralni (ve) pogled, B – rekonstrukcije ugrizov, C – shematski prikazi skladnosti posameznih lezij z grbicami P⁴ in M¹ jamskega medveda. Okrajšave: max – zgornja čeljustnica; P⁴ – četrti premolar; M¹ – prvi molar; M² – drugi molar; p, p', m, m' – grizne lezije, povzročene z ustreznimi grbicami ličnikov P⁴ in M¹. Fotografije: Jasna Šporar in Matjaž Uršič.
Fig. 12: A cave bear's lumbal vertebre comparatively the fifth or the sixth. A – lateral (la), ventrolateral (vl) and ventral (ve) view, B – reconstruction of bites, C – schemes shows the matching of the cave bear P⁴ and M¹ teeth tubercles with the adequate bite lesions. Abbreviations: max – maxilla; P⁴ – the fourth premolar; M¹ – the first molar; M² – the second molar; p, p', m, m' – marks indicate lesions corresponding to tubercles of the cheek teeth P⁴ and M¹. Photos: Jasna Šporar and Matjaž Uršič.

zalna jamica p je neposredno ventralno od rebrne grbice, ventolateralno pa sta druga ob drugi dve jamici m in m' (slika 8/A, /C, /D). Primerjava kaže, da je jamica p odtis večjega vrška na rostralni grbici P⁴ zgornje čeljustnice, m in m' pa sta domnevno nastali kot odtisa obeh vrškov grbic na M¹.

Razdalje med jamicami ustrezajo razdaljam med vrški zobnih grbic medveda. Rekonstrukcija ugriza prikazuje, da sta pri tem ugrizu udeležena oba zoba, tj. P⁴ in M¹ zgornje čeljustnice (slika 8C), shema (slika 8D) pa dokazuje popolno skladnost oz. prileganje jamic tudi na vrške grbic P⁴ in M¹ hipotetično sorazmerno velikega



Sl. 13: Desna petnica jamskega medveda. A – lateralni pogled (lv), B – medialni pogled (mv), C – rekonstrukcija ugriza v petnično grčo (zobovje rjavega medveda), D – prikaz ujemanja ugriznih odtisnih lezij z grbicama M¹ zgornje čeljustnice jamskega medveda. Okrajšave: max – zgornja čeljustnica; P⁴ – četrti premolar; M¹ – prvi molar; M² – drugi molar; m, m' – ugrizna odtisa, povzročena z grbicama M¹. Fotografije: Jasna Šporar in Matjaž Uršič.
Fig. 13: A cave bear's right calcaneus. A – lateral view (lv), B – medial view (mv), C – reconstruction of a brown bear's bite into a calcaneal tuber, D – the matching of the bite impressions with the cave bear's upper jaw M¹ teeth tubercles. Abbreviations: max – maxilla; P⁴ – the fourth premolar; M¹ – the first molar; M² – the second molar; m, m' – bite impressions of M¹ teeth tubercles. Photos: Jasna Šporar and Matjaž Uršič.

jamskega medveda. V rebrnem žlebu so zaznavne le abrazije m‟ (slika 8B) zaradi delovanja antagonistov spodnje čeljustnice.

Leziji m_a in m_b (slika 9) sta domnevno povzročila ugriza z vrškom sprednje grbice na M^1 zgornje čeljustnice, medtem ko se je sprednja grbica na P^4 ob tem le rahlo zasukala znotraj iste jamice p. Na nasprotni strani je na kraniolateralnem delu telesa odrgnina m‟ (slika 9/A, /B). Sprednja grbica na M^1 zgornje čeljustnice je med grizenjem zaporedoma povzročila nastanek obeh lezij m_a in m_b ter ob domnevnem hkratnem pritisku antagonista M_2 spodnje čeljustnice tudi frakturo ventralnega dela telesa. Odrgnina m‟ je posledično nastala zaradi pritiska vrška grbice na M_1 v spodnji čeljustnici (slika 9B). Iz slike (slika 9/B, /C, /D) je prav tako razvidno, da se grbice zob prilegajo na grizne poškodbe.

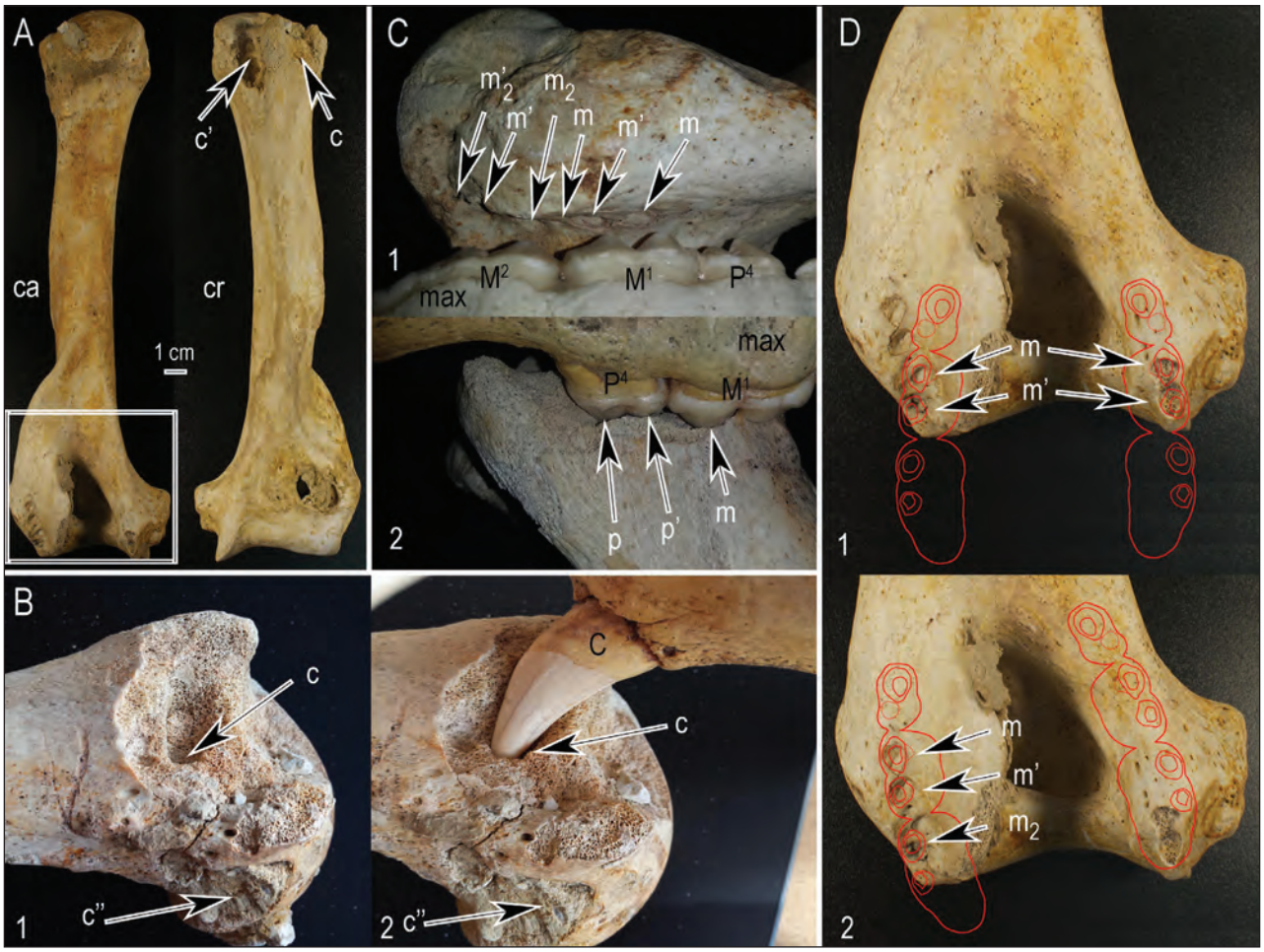
Pri rekonstrukciji gre za dva domnevno zaporedna ugriza ob rahlem premiku rebra, kar potrjujeta leziji m_a in m_b na robu frakture. Vršek sprednje grbice na P^4 pri obeh zaporednih ugrizih ostaja znotraj jamice p.

Pri analizi dorzalnega fragmenta koščenega dela desnega rebra (slika 10) predstavlja odtis grbice na P^4 jamica p na kranialni strani rebrnega telesa ventralno ob rebrnem kotu, opazna odrgnina m na medialni strani, lezija m‘ na robu frakture in odlom (slika 10/A, /C, /D) pa so nastali kot posledica delovanja sile M^1 ob učinkovanju antagonistov spodnje čeljustnice. Oznake smiselno ustrezajo posameznim grbicam ličnikov P^4 in M^1. Odrgnine m‟ na nasprotni, kavdalni strani (slika 10B) so lahko posledica delovanja ličnikov v spodnji čeljustnici. Hkrati shema griznih površin (slika 10D) dokazuje izrazito sovpadanje lezij na grbice ličnikov.

Enotna lezija p in p‘ na kavdalni strani telesa, ventralno ob rebrnem kotu, po vsej verjetnosti drugega desnega sternalnega rebra (slika 11), je domnevno posledica odtisa obeh grbic na P^4 zgornje čeljustnice. Odrgnino m‘ je povzročil vršek kavdalne grbice na M^1, vršek sprednje grbice pa ni dosegel kostne površine. M_1 spodnje čeljustnice je na kranialni strani v višini rebrnega kota pri ugrizu povzročil zaznavno odrgnino m‟. Prileganje posameznih zobnih grbic na lezije je izrazito (slika 11C).

Ledveno vretence (slika 12). Tri jamice m‘, m in p oblikujejo navidezno kavdoventralno potekajočo linijo na desni strani vretenca (slika 12/A1, /B1 in /C2). Domnevno so se med ugrizom odtisnili sprednja grbica na P^4, lezija p in obe grbici na M^1, leziji m in m‘ leve zgornje čeljustnice, pri tem pa vršek kavdalne grbice na P^4 ni dosegel površine vretenca (slika 12B1).

Dve globlji poškodbi, ena na levi lateralni strani telesa (slika 12/A2, /B2 in /C2), druga pa kavdalno na ventralnem grebenu (slika 12/A2, /B3 in /C2), lahko pojasnimo kot domnevna odtisa obeh grbic p in p‘ na P^4 zgornje čeljustnice. Vrška grbic na M^1 sta zaradi zaobljenosti vretenčnega telesa povzročila le neznatni odrgnini m oz. m‘. Preostale odrgnine in lezije so nastajale



Sl. 14: Leva nadlahtnica jamskega medveda. A – kavdalni (ca) in kranialni (cr) pogled, B – poškodovan proksimalni okrajek (1) in domnevni nastanek lezije s podočnikom jamskega medveda (2), C – rekonstrukcija nastanka lezij na nadčvršu (1) in rekonstrukcija poškodbe večje grbice z zgornječeljustničnimi ličniki (2), D – prikaz skladnosti posameznih lezij z grbicami jamskega medveda pri dveh načinih ugriza. Okrajšave: max – zgornja čeljustnica; P⁴ – četrti premolar; M¹ – prvi molar; M² – drugi molar; c, c'', p, m, m', m'' – grizne lezije. Fotografije: Jasna Šporar in Matjaž Uršič.

Fig. 14: A cave bear's left humerus. A – caudal (ca) and cranial (cr) view, B – damaged proximal epiphysis (1) and reconstruction of the lesion with a cave bear's canine tooth (2), C – reconstruction of bite lesions on the epicondile (1) and reconstruction of the edge of damage on the great tubercle (2) with bear upper jaw teeth set, D – the matching of the bite lesions with the cheek teeth tubercles of a cave bear's upper jaw at two bite variants. Abbreviations: max – maxilla; P⁴ – the fourth premolar; M¹ – the first molar; M² – the second molar; c, c'', p, m, m', m'' – bite lesions. Photos: Jasna Šporar and Matjaž Uršič.

pri dodatnem grizenju, nekatere tudi zaradi delovanja antagonistov v spodnji čeljustnici. Sheme na sliki 12C kažejo, da se obravnavane lezije izrazito prilegajo na posamezne zobne grbice.

Jamici m in m' na lateralni strani petnične grče (slika 13) se popolnoma prilegata zobovju vzorčne lobanje rjavega medveda. Nastali sta kot domnevna odtisa obeh grbic na M^1 zgornje čeljustnice. Lezija m'' na nasprotni medialni strani petnične grče (slika 13B) je verjetna posledica delovanja antagonista v spodnji čeljustnici. Razvidno je, da se leziji m in m' popolnoma ujemata tudi z grbicama na M^1 sorazmerno velikega jamskega medveda (slika 13D).

Pri levi nadlahtnici (slika 14) so jamice m, m' in m_2, m_2', ki so lateralno na stranskem nadčvršu, domnevno posledica odtisov grbic na ličnikih M^1 (m, m') oz. M^2 (m_2, m_2') leve zgornje čeljustnice (slika 14C1), kar potrjuje tudi enotna oz. združena lezija m in m' oz. m_2 na sredinskem nadčvršu (slika 14D/1, /2), ki predstavlja sočasno nastalo poškodbo z M^1 (slika 14D1) ali, kar je manj verjetno, z M^2 v nasprotni, desni čeljustnici (slika 14D2). Razdalja med poškodbami na obeh nadčvrših primerjalno ustreza širini zgornječe-

ljustničnega zobnega loka sorazmerno velikega jamskega medveda v višini obeh zgornjih molarjev M^1 (slika 14D1). Pri obgrizenem proksimalnem okraju lahko grizni poškodbi c in c' (slika 14A) na mestu večje grbice oz medgrbičnega žleba po obliki, globini in skladnosti pripišemo podočniku, kar potrjuje tudi poškodba c'' na kavdolateralnem delu vratu in glave (slika 14B2), ki je domnevno nastala kot posledica delovanja antagonista v spodnji čeljustnici. Distalni obrobni del lezij p, p' in m na večji grbici reliefno ustreza odtisom ličnikov zgornje čeljustnice (slika 14C2).

S prileganjem poškodb na vrške zobnih grbic in s slikovno analizo ugotavljamo, da gre za grizne poškodbe, kjer sodelujejo ličniki zgornje čeljustnice jamskega medveda. Vrška grbic na M^1 sta bližje drug drugemu, vršek sprednje večje grbice na P^4 pa je nekoliko odmaknjen in zamaknjen z linije grbic na M^1, kar pri popolnem odtisu predstavlja razporeditev jamic 1 + 2.

Razdalje med jamicami oz. griznimi lezijami predvsem na rebrnih fragmentih, ledvenem vretencu in petnici (slika 8–13) povsem ustrezajo razdaljam med posameznimi grbicami na P^4 oz. M^1 zgornje čeljustnice. Ličniki v spodnji čeljustnici delujejo le kot podlaga, saj so vrški grbic na obsežnejših griznih ploskvah manj izraziti in agresivni ter posledično povzročijo le manj zaznavne odrgnine (abrazije). Nekateri ugrizi po razmerju med odtisi ustrezajo velikosti vzorčne lobanje jamskega medveda, na petnici (slika 13), enem izmed rebrnih fragmentov (slika 8) in nadlahtičnih nadčvrših (slika 14D) pa je grizne poškodbe povzročila manjša žival, po vsej verjetnosti manjši jamski medved, katerega lobanja je bila po velikosti primerljiva vzorčni lobanji rjavega medveda, ki smo jo uporabili za rekonstrukcijo. Makroskopsko gre namreč za zelo podobno zobovje. P^4 in M^1 zgornjih čeljustnic sta v višini ustne reže in sta po funkciji in položaju namenjena drobljenju hrane. Rostralno se namreč nahaja brezzobnični rob (*diastema*). Opravljena primerjava kaže, da pri nastanku večine griznih lezij na preučevanih kosteh sodelujeta prav P^4 in M^1. Razdalje med lezijami, če jih primerjamo z oddaljenostjo posameznih vrškov na grbicah, kažejo, da M^2 zgornje čeljustnice ni pogosteje sodeloval pri nastanku odtisnih poškodb na analiziranih fragmentih, seveda pa ga, čeprav je pomaknjen relativno v ozadje ustne votline, ni mogoče povsem izključiti. Rekonstrukcija nastanka poškodb na nadlahtničnem nadčvršu pri eni od variant nakazuje prav možnost soudeležbe sprednje grbice na M^2 (slika 14D2).

Na cevastih kosteh so izpostavljeni predvsem okrajki oz. epifize, ki jih pod tanko površinsko kompakto zapolnjuje predvsem gobasta kostnina. Spongiozni epifizni deli kosti so mehkejši in zato dovzetnejši za nastanek griznih lezij v obliki jamic z vgreznjeno kompakto (Diedrich, 2015). Podobne grizne lezije se pri kostnih najdbah lahko pojavljajo tudi na kosteh pretežno gobaste notranjosti, kot je v našem primeru vretenca ali fragmentov reber in petnične grče.

Poznane so tudi kosti s poškodbami oz. luknjami na diafizah, npr. stegnenica mladega jamskega medveda (Turk, 1997; Turk *et al*. 1995, 2001, 2003, 2014), in druge naluknjane diafize (Brodar, 1985; Diedrich, 2015), a jamic ali lukenj na tršem, votlem, cevastem telesu nadlahtnice v našem primeru ni bilo.

Predpostavljamo, da lahko podobne lezije tako po velikosti kot tudi obliki nastanejo tudi na diafizah dolgih cevastih kosti, ko zveri z ličniki, premolarji ali molarji prebijejo kompakto na diafizah. Menimo, da se večina takih griznih poškodb lahko pojavi predvsem na juvenilnih kosteh oz. kosteh mlajših živali. Zakostenele adultne kosti s tršo diafizno steno so proti takim poškodbam odpornejše, obenem pa močnejše sile točkovnih pritiskov vrškov zobnih grbic na kompakto diafize večinoma rezultirajo v njihovi fragmentaciji predvsem zaradi debelejše stene, večje trdote in posledične krhkosti adultnih kosti (Diedrich, 2015).

V jami Bele vode je bilo tudi nekaj ostankov kosti z večinoma po tremi neenakomerno razporejenimi jamicami (1 + 2). Po takem razporedu izstopata predvsem ugriza na fragmentu rebra (slika 8) in nadčvršu nadlahtnice (slika 14). V obeh primerih gre za razpored, ki zbuja zanimanje zaradi podobnosti z razporedom lukenj v specifični kostni najdbi z najdišča Divje babe I, ki je bila po obsežnih in večstranskih analizah interpretirana kot neandertalčeva koščena piščal. Tudi sicer se razpored odtisnih jamic 1 + 2, lahko tudi 2 + 2, pojavlja pri vseh tistih ugrizih medveda, pri katerih gre za hkraten odtis dveh sosednjih ličnikov zgornje čeljustnice. V takih primerih kot je v naši analizi, nadlahtnice (slika 14/A1, /D1, /D2), enega rebrnega fragmenta (slika 8) in ledvenega vretenca (slika 12), so razdalje med jamicami vedno ustrezale razdaljam med vrški grbic ustreznih ličnikov (P^4 in M^1).

Pri dokazovanju namenske izdelave koščene piščali oz. izključevanju možnosti nastanka lukenj z ugrizi so avtorji izhajali tudi iz njihovega razporeda (Turk, 1997; Turk *et al*. 1995, 2001, 2003, 2014). Že pred najdbo iz Divjih bab je po preučitvi preluknjanih kosti s paleolitskih najdišč prevladala razlaga, da so luknje nastale ob ugrizu s podočniki (Brodar: 1985). Morda je bil prav poudarek na podočnikih kot možnih povzročiteljih razlog, da je bila nekoliko zanemarjena možnost nastanka lukenj oz. poškodb z živalskim grizenjem s premolarji in molarji. Poškodbe na kosteh, ki so jih povzročili podočniki (grabilci), so redke, saj zveri z njimi plen predvsem grabijo (Rigler 2000). Take lezije se lahko pojavljajo na delih kosti, ki so manj podvrženi drobljenju oz. fragmentaciji in so jih povzročili koničasti vrški, lahko sočasno ob grizenju. Na preučevanih kosteh jih pripisujemo le lezijam na proksimalnem okrajku nadlahtnice (slika 14/A, /B). Pričakovano je pojavnost takih griznih lezij manj pogosta, saj podočniki niso namenjeni drobljenju ali mletju.

Možnosti, da bi luknje na kosteh nastajale tudi ob ugrizu z drugimi zobmi in ne le s podočniki, pa se je avtor zavedal že od začetka preučevanja lukenj na kosti iz Divjih bab, saj je zapisal, da »*tako predrejo kosti zveri predvsem z derači*« – torej enem izmed ličnikov – »*in ne*

s podočniki, kot se običajno misli« (Turk,1997: 71). Na možnost luknjanja in poškodovanja kosti s premolarji in molarji, še zlasti na vzorec razporeditve takih poškodb, je bilo opozorjeno tudi na primeru recentne, največ nekaj sto let stare svinjske kosti iz rudarskega naselja na Pokljuki, ki ima razpored poškodb povsem identičen, kot je razpored lukenj na stegnenici iz Divjih bab (Jamnik, 1999). Prav tako je C. G. Diedrich (Diedrich, 2015) nastanek takih lezij na juvenilnih kosteh kakor tudi same luknje na koščeni neandertalčevi piščali pripisal premolarjem zobovja hiene. I. Turk je Diedrichu v odgovoru očital precej netočnosti v navajanju dejstev z najdišča, kar zadeva način ugriza pa zapisal, da mora biti zob za predrtje kosti oster in šiljast (angl. *pointy*), saj bi bilo kost s topim zobom težje prebosti (Turk *et al*., 2016: 404); celovitejša predstavitev argumentov (Turk *et al*., 2018).

Na podlagi naše analize lezij na najdenih kosteh, načina in možnosti grizenja jamskega medveda menimo, da bi luknje v razporedu, kot so na stegnenici iz Divjih bab, lahko povzročil tudi jamski medved s predmeljaki (premolarji) in meljaki (molarji). Vsekakor bi bilo omenjeno domnevo vredno tudi podrobneje preučiti.

ZAKLJUČKI

Jami Bele vode in Smoganica sta poleg Divjih bab I in II edini jami v zahodnem delu Slovenije, v katerih je bila doslej najdena pleistocenska favna. V jami Bele vode smo z analizo vnovič ovrednotili prvotno določitev vrste medveda. Marchesetti je leta 1895 najdene kosti pripisal vrsti *Ursus liguisticus*. Zaradi več nejasnosti Marchesettijevi umestitvi ne moremo povsem pritrditi in zaenkrat preliminarno zbrane ostanke jamskih medvedov iz jame Bele vode pripisujemo vrsti *Ursus* cf. *ingressus*. Od drugih živalskih vrst je bila v jami Bele vode poleg kosti medveda najdena le še prstnica navadnega jelena (*Cervus elaphus*).

V jami Smoganica smo z analizo fosilnih kostnih ostankov potrdili prisotnost jamskega medveda *Ursus ingressus* ter ostanke bovidov, tura (*Bos primigenius*) ali stepskega bizona (*Bison priscus*) in konja (*Equus ferus caballus)*. V fosilnem gradivu je tudi več kosti s sledmi ugrizov. Na podlagi morfološke primerjave med zobnimi grbicami ličnikov ter poškodbami na teh kosteh in njihovo medsebojno razporeditvijo z rekonstrukcijami posameznih ugrizov jamskega medveda potrjujemo domnevo, da so lezije na kosteh iz jame Bele vode z vzorčnim razporedom 1 + 2 nastale kot posledica odtisov treh grbic zaporednih ličnikov zgornje čeljustnice. Pri takem ugrizu je namreč razporeditev lezij vedno ustrezala medgrbični razdalji na ustreznem ličniku, običajno na M^1 zgornje čeljustnice, oz. razdalji med ustreznima grbicama dveh sosednjih ličnikov, navadno med zgornječeljustničnima P^4 in M^1.

REVIEW OF PLEISTOCENE FAUNA AND THE ANALYSIS OF BONE BITE MARKS IN THE CAVES BELE VODE NEAR GORENJA TREBUŠA AND SMOGANICA NEAR MOST NA SOČI

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SUMMARY

The paper presents a historical overview of the discovery and research of the Bele vode cave in the vicinity of Gorenja Trebuša (Fig.1) and the Smoganica cave at Most na Soči (Fig. 4) in the western part of Slovenia. One of the first paleontological finds from Bele vode cave dates back to the end of the 19th century. The first Pleistocene mammal bones were excavated by Carlo Marchesetti (1895) and determinated as a new species of bear Ursus ligusticus *(Fig. 3). At the Bele vode cave most of fossil bones were discovered in the small hall, mostly in cave clay and partly as bone breccia. After examining the pictures taken by Marchesetti and new cave bear remains from the Tolmin Museum collection (Plate 1, 2), the bones of the cave bear are attributed to the species (*Ursus cf. ingressus*).*

The finds of fossil bones, mostly of the cave bear from the Smoganica cave (Fig. 4) have been known since the 1930s. Most of the fossil bones were found in the small cave tube (Fig. 5). Cave bear bones and teeth probably belong to Ursus ingressus*, a few bone finds belong to other mammals, such as Pleistocene horse (*Equus ferus*) and the aurochs (*Bos primigenius*) or steppe bison (*Bison pricus*) (Plate 3). In addition, the cave bear used the cave as a den, signs of wear and scratches on walls are still visible (Fig. 6).*

The examination of cave bear bones collection revealed some bone specimens with very distinctive perforative or circular bite lesions (Figs. 8–14). The position of some lesions is arranged in pattern 1 + 2. It is a quite similar alignment to the puncture holes on the femur body found in Divje babe I which is interpreted as a Neanderthal bone flute.

In the study, the possibility of the formation and alignment of bone lesions from fossil material was morphologically analyzed. A morfological comparison was made between the alignment of cave bear cheek teeth tubercles and the alignment of bite lesions on the bones. The reconstruction of cave bear bites confirms the assumption that lesions on the bones from the Bele vode cave arranged according to the 1 + 2 pattern are the result of the cave bear upper jaw cheek teeth tubercles cusp bite impressions. The performed comparison shows that the biting lesions on the examined bones are mainly caused by the bite action of the upper P^4 and M^1 cheek teeth (Figs. 8–14). In such a bite, the alignment of the bone lesions and distances beetwen them always correspond to the intertubercular distance often on the upper yaw M^1 cheek tooth or the distance between the corresponding teeth tubercles of two adjacent cheek teeth, mainly upper P^4 and M^1. Otherwise, the layout of bone lesions in the pattern distribution 1 + 2, as well as 2 + 2, can occur in all those cases of the bear bites where of the two adjacent upper jaw cheek teeth tubercles act simultaneously, like in the rib fragment (Fig. 8) and in the epicondyle of the humerus (Fig. 14) or lumbal vertebre (Fig. 12). The distances between all these bite lesions are the same as the distances between both tooth tuberceles of M^1 or between P^4 and M^1 teeth tuberceles of the adequately large cave bear upper jaw.

We assume that such lesions and perforations could also occur on the diaphyses on the compact, hollow, and tubular body of long, especially juvenile bones. Fully ossified, adult bones with a thicker and solid wall are more resistant to such injuries and the pressure of the P^4 and/or M^1 teeth tubercles cusps on such bone largely cause the fragmentation of bone wall. Therefore large expressive canine teeth are not likely to form the bone lesions in the layout pattern distribution 1 + 2.

Key words: Bele vode cave, Smoganica cave, cave bear, teeth, bite bone lesions, bone flute

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OCENE IN POROČILA

RECENSIONI E RELAZIONI

REVIEWS AND REPORTS

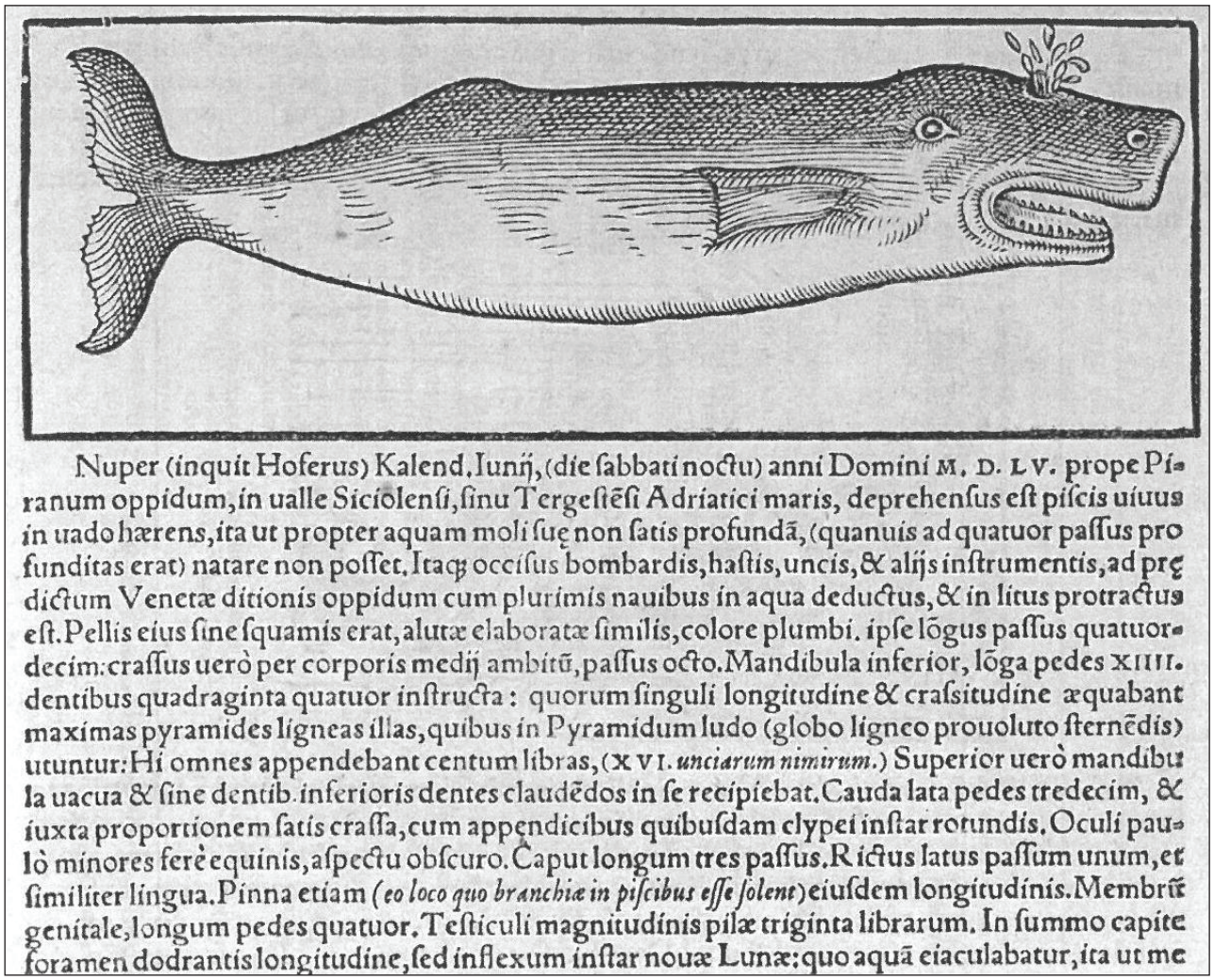
Book review: LA BIOLOGIA MARINA A TRIESTE E NELL'ALTO ADRIATICO
Autori: Nicola Bettoso & Giuliano Orel
Editore: Circolo di Cultura Istro-Veneto "Istria", 120 pp.

La presente monografia sulla biologia marina a Trieste e nell'Alto Adriatico non è solo un lavoro originale sull'evolversi di questa scienza nella regione dell'Adriatico settentrionale, ma è pure un contributo che getta luce sugli albori delle scienze naturali marine. Non a caso Trieste, con i suoi dintorni, è considerata la culla delle scienze naturali marine, poiché i primi lavori pionieristici furono pubblicati proprio in questa zona. Leggendo la monografia possiamo così acquisire nozioni nuove sui quattro secoli in cui le scienze naturali si sono evolute nella nostra area geografica. Anche se già Aristotele e Plinio il Vecchio dedicarono spazio nelle loro opere alla vita nel mare, il profondo interesse odierno e lo sviluppo delle scienze marine sono nati e cresciuti solo grazie ad un intenso traffico marittimo e alla scoperta di nuovi ambienti. Nel vero senso del concetto, la ricerca della vita nel mare iniziò solo dopo il XV secolo, mentre il termine *biologia*, come ci insegnano gli autori, è entrato nell'uso moderno dal 1802. Sebbene la ricerca degli organismi marini si sia da allora estesa a tutte le parti del mondo, molti studiosi considerano la spedizione scientifica *Challenger*, svoltasi tra il 1872 e il 1876, come momento d'inizio della biologia marina quale disciplina scientifica. Fino a quel momento le conoscenze sul mare rimasero molto limitate, mentre della vita nelle profondità marine non si sapeva quasi nulla. A quel tempo era comune e diffuso il pensiero che non ci fosse vita negli ambienti profondi. E proprio riguardo alla scoperta del mondo degli abissi, gli autori ci spiegano che gli inizi furono tutt'altro che accurati e coerenti, come ad esempio per il misterioso organismo chiamato *Bathybius haeckelii*. Quando il famoso T.H. Huxley, uno dei più grandi difensori di Darwin in quei tempi turbolenti, ottenne dalla spedizione Challenger alcuni campioni dai mari profondi, denominò erroneamente la massa gelatinosa come *B. haeckelii*, ossia "*vivente nel profondo*". Più tardi si scoprì che non era un essere vivente, ma un precipitato di $CaSO_4$. Gli autori della monografia raccontano numerosi episodi interessanti di questo tipo, associati a vari ricercatori attivi a Trieste o nell'Adriatico settentrionale. Nel libro così leggiamo come il famoso studioso Lazzaro Spallanzani descrisse vividamente la sua esperienza con una torpedine e le scosse da essa ripetutamente inflittegli.

Particolarmente produttiva dal punto di vista scientifico e divulgativo per l'Alto Adriatico fu la scuola di Chioggia, dove a quel tempo operavano grandi nomi dell'ittiologia, quali Giandomenico Nardo, Fortunato Naccari, lo zoologo Giuseppe Olivi e molti altri. Giuseppe Olivi diventò famoso in tutta Europa con il suo ampio lavoro intitolato "*Zoologia Adriatica*" (1792), che incoraggiò molti altri ricercatori all'esplorazione del mare. La scuola di biologia marina di Trieste ebbe un'importanza crescente a partire dal XIX secolo, quando l'Adriatico settentrionale cominciò ad attrarre molti naturalisti provenienti da tutta Europa, compresa la lontana Svezia. La nascita del Museo zoologico di Trieste contribuì certamente ad aumentarne la fama. Fra i più celebri naturalisti di Trieste di quel tempo ricordiamo Simeone Adamo de Syrski, Carl Friedrich Wilhelm Claus, Adolf Stossich ed Eduard Heinrich Graeffe. Alla fine del secolo si arrivò alla fondazione della Stazione zoologica di Rovigno, in cui si dedicò alla scienza anche il padre della moderna planctologia, Adolf Steuer. Gli autori naturalmente non dimenticano di menzionare anche Aristocle Vatova, uno dei pionieri della bionomia moderna, che ha gettato le basi per la comprensione delle comunità bentoniche anche fuori dal Nord Adriatico.

Oltre ai ricercatori più importanti e famosi di Trieste, gli autori hanno reso omaggio anche allo zoologo e ittiologo sloveno, il prof. Miroslav Zei. Pure il prof. Zei è stato legato strettamente a Trieste, poiché nacque nella vicina Aurisina (Nabrežina), dove oggi ha sede il Laboratorio di biologia marina dell'Istituto Nazionale di Oceanografia e Geofisica Sperimentale.

Proseguendo nella lettura della monografia, non possiamo liberarci della sensazione che Trieste abbia



Nuper (inquit Hoferus) Kalend. Iunij, (die ſabbati noctu) anni Domini M. D. LV. prope Piranum oppidum, in ualle Siciolenſi, ſinu Tergeſtēſi Adriatici maris, deprehenſus eſt piſcis uiuus in uado hærens, ita ut propter aquam moli ſuę non ſatis profundā, (quanuis ad quatuor paſſus profunditas erat) natare non poſſet. Itaq; occiſus bombardis, haſtis, uncis, & alijs inſtrumentis, ad prę dictum Venetæ ditionis oppidum cum plurimis nauibus in aqua deductus, & in litus protractus eſt. Pellis eius ſine ſquamis erat, alutæ elaboratæ ſimilis, colore plumbi. ipſe lōgus paſſus quatuordecim: craſſus uerò per corporis mediį ambitū, paſſus octo. Mandibula inferior, lōga pedes XIIII. dentibus quadraginta quatuor inſtructa: quorum ſinguli longitudine & craſsitudine æquabant maximas pyramides ligneas illas, quibus in Pyramidum ludo (globo ligneo prouoluto ſternēdis) utuntur: Hi omnes appendebant centum libras, (XVI. *unciarum nimirum.*) Superior uerò mandibula uacua & ſine dentib. inferioris dentes claudēdos in ſe recipiebat. Cauda lata pedes tredecim, & iuxta proportionem ſatis craſſa, cum appendicibus quibuſdam clypei inſtar rotundis. Oculi paulò minores ferè equinis, aſpectu obſcuro. Caput longum tres paſſus. Rictus latus paſſum unum, et ſimiliter lingua. Pinna etiam (*eo loco quo branchiæ in piſcibus eſſe ſolent*) eiuſdem longitudinis. Membrū genitale, longum pedes quatuor. Teſticuli magnitudinis pilæ triginta librarum. In ſummo capite foramen dodrantis longitudine, ſed inflexum inſtar nouæ Lunæ: quo aquā eiaculabatur, ita ut me

Illustrazione medievale di un capodoglio a Pirano, arenato nelle saline di Sicciole il 1° giugno 1555. Fu dipinto nel 1555 dal famoso erudito Konrad Gessner (1516-1565), autore della celebre monografia "Historia animalium", considerata quale base della moderna zoologia.
Srednjeveška ilustracija kita glavača iz Pirana, ki je 1. junija 1555 nasedel v Sečoveljskih solinah. Narisal jo je leta 1555 sloviti Konrad Gessner (1516 – 1565), avtor odmevnega dela „Historia animalium", ki ga smatrajo za temelj sodobne zoologije.

fatto la parte del leone nell'evolversi della biologia e dell'ecologia del mare, e in parte anche dell'oceanografia. Gli autori forniscono una moltitudine di dati e informazioni interessanti, mentre raccontano la storia della crescita delle scienze naturali nella nostra regione con descrizioni concise e comprensibili, che aumentano il valore della narrazione. Avrebbero forse potuto dedicare qualche riga anche ad altre figure importanti di questa disciplina scientifica, che hanno contribuito anch'esse allo studio del Nord Adriatico, come ad esempio Freyer, Frauenfeld, Trois, Perugia e altri. Ma ci auguriamo che questa lacuna venga riempita da future monografie di questo tipo.

Non possiamo infine ignorare che un tale contributo alla storia delle scienze naturali nel Golfo di Trieste e nel più ampio Alto Adriatico poteva venir portato a termine solo da fervidi amanti del mare, quali sono il prof. Giuliano Orel, ricercatore, bentologo e per lungo tempo docente presso l'Università di Trieste, e il suo fedele allievo, il dott. Nicola Bettoso, oggi rinomato ricercatore, che mantiene viva l'eredità degli studiosi eruditi della scuola di scienze naturali di Trieste. Maestri delle parole scritte, nella pubblicazione hanno riportato alla memoria ciò che troppo spesso dimentichiamo, ossia che il Golfo di Trieste non è solo Barcolana, architettura austroungarica e capitale del caffè. Ma è pure un

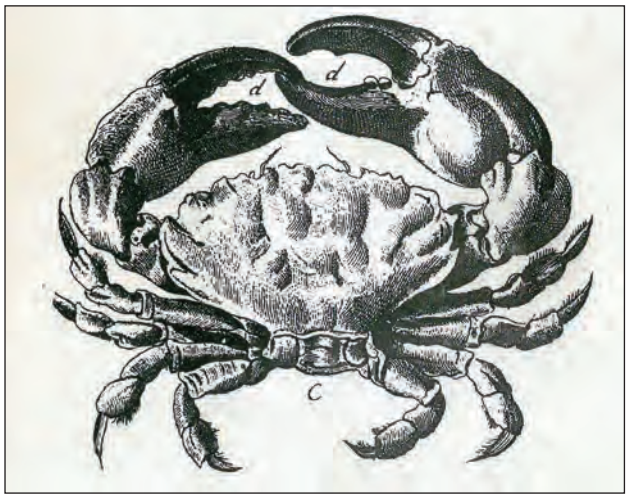


Illustrazione del granchio *Xantho poressa****, estratta dalla famosa monografia "Zoologia Adriatica" (1792) scritta da Giuseppe Olivi, uno dei più eminenti rappresentanti della scuola di scienze naturali di Chioggia.***
Ilustracija rakovice *Xantho poressa* ***iz odmevne monografie "Zoologia Adriatica" (1792), ki jo je napisal Giuseppe Olivi, eden od najodmevnejših predstavnikov naravoslovne šole iz Chioggie.***

monumento straordinario, in quanto culla delle scienze del mare. Ci sentiamo di raccomandare la lettura della monografia a tutti i ricercatori, studenti e appassionati che sono attratti dal Golfo di Trieste e dall'Adriatico settentrionale. Ci congratuliamo infine con entrambi gli autori per l'interessante e prezioso contributo alla divulgazione delle scienze naturali dell'area adriatica. Vorremmo concludere con un pensiero speciale scritto dagli autori nel libro (ma in un contesto diverso): »*Non esistono risorse ittiche proprie di un unico stato italiano, sloveno o croato: l'Adriatico è uno*!«.

Lovrenc Lipej & Martina Orlando-Bonaca
Stazione di biologia marina di Pirano,
Istituto nazionale di biologia

IN MEMORIAM

IN MEMORY OF MARK HINES (1950-2018)

Mark E. Hines passed away on March 11, 2018 at the age of 67. He spent his early years in California and then later moved with his family to Connecticut where he finished high school. Mark attended the Ohio State University, where he received a BSc in microbiology in 1973. In 1978, he received a MSc in microbiology from University of Connecticut. After receiving his PhD in microbiology from the University of New Hampshire in 1981, Mark accepted a research position at the Departments of Microbiology and Earth Sciences at the University of New Hampshire where he remained for fifteen years. In 1996 he moved to the University of Alaska at Anchorage where he became an Assistant Professor (1997) and then (2000) a tenured Professor in the Department of Biological Sciences. Mark took a faculty position as an Associate Professor in the Biology Department at the University of Massachutts Lowell in 2002. In 2004 Mark became Department Chair, a position he held for 10 years. In 2005, he became a Professor and in 2012 he was made Dean of the Kennedy College of Sciences for 4 years.

His research involved understanding the roles of microorganisms in the cycling of elements, in particular during the latter part of his career he focused on mercury in marine and lacustrine sediments, soils, and wetland peats. He also worked in high latitude environments looking at factors influencing the methylation and demethylation of mercury in soils, freshwater and marine sediments as well as in mines. He made a notable contribution, along wth J.P. Megonigal and P.T. Visscher, in the preparation of the comprehensive chapter »Anaerobic metabolism: Linkages to trace gases and aerobic processes« for Volume 8 Biogeochemistry (ed. W.H. Schlesinger) in Treatise on Geochemistry (eds. H.D. Holland and K.K. Turekian). Over the years, Mark served on numerous editorial boards, committees, working groups, review panels and workshops.

Mark was a member of the American Society for Microbiology, the American Society of Limnology and Oceanography, the American Geophysical Union, the American Association for the Advancement of Science, the Society of Wetland Scientists and the International Society for Environmental Biogeochemistry (ISEB). He was a long-time member of the International Scientific Committee of ISEB.

I first met Mark in 1987 at the ISEB Symposium in Nancy (France) and we became close collaborators and friends. In 1992, we first studied the anaerobic microbial processes of the degradation of sedimentary organic matter in coastal marine areas, the Gulf of Trieste (northern Adriatic Sea) as an example. We continued with the methylation of mercury and demethylation of methylmercury in surface sediments of the Gulf of Trieste (1999) and the Grado and Marano Lagoon (2009) which has been severely contaminated by mercury originating from the Idrija mine, the second largest mercury mine, which was in operation for nearly 500 years (till 1995). The main conclusion of this research was the importance of demethylation in reducing methylmercury concentrations in the gulf including biota (fish, mussels) used by humans. My memory of Mark include many wonderful occasions over the last thirty years including samplings, laboratory work, workshops, trips, parties, dinners, skiings…. In particular, I remember the work we did together to organize the much lauded workshop »Mercury in the Adriatic« in 2001 in Piran, Slovenia, which dealt primarily with Hg cycling in the Hg contaminated northern Adriatic, which greatly contributed to the understanding of mercury cycling in the northern Adriatic.

Mark loved research, teaching and mentoring students, and easily made friends where-ever he went. He was at home at all parts of the world. He was a great collaborator and friend. From my part, I shall miss him greatly. A special issue of the journal Aquatic Geochemistry will be devoted to his memory.

Jadran Faganeli
Marine Biology Station Piran,
National Institute of Biology

Mark's bibliography related to the northern Adriatic Sea

Hines, M.E., J. Faganeli & R. Planinc (1997): Sedimentary anaerobic microbial biogeochemistry in the Gulf of Trieste, northern Adriatic Sea: Influences of bottom water oxygen depletion. Biogeochem., 39, 65-86.

Hines, M.E., M. Horvat, J. Faganeli, J.-C. Bonzongo, T. Barkay, E.B. Major, K.J. Scott, E., A, Bailey, J.J. Warwick & W.B. Lyons (2000): Mercury biogeochemistry in the Idrija River, Slovenia, from above the mine into the Gulf of Trieste. Environ. Res., 83, 129-139.

Hines, M.E., M. Horvat & J. Faganeli (2001): Workshop on mercury in the Idrija Rregion and the Northern Adriatic. Portorož 2001, RMZ – Mat. & Geoenviron., 48, 1-255.

Bonzongo, J.-C., W.B. Lyons, M.E. Hines, J.J. Warwick, J. Faganeli, M. Horvat, T. Barkay, E.B. Major, K.J. Scott, E.A. Bailey, P. J. Lechner & J.R. Miller (2002): Mercury in surface waters of three mine-dominated river systems: Idrija river, Slovenia, Carson river, Nevada and Madeira river, Brazilian Amazon. Geochem. Expl. Environ. Anal., 120, 111-120.

Horvat, M., V. Jereb, V. Fajon, M. Logar, J. Kotnik, J. Faganeli, M.E. Hines & J.-C. Bonzongo (2002): Mercury distribution in waters, sediment and soil in the Idrijca and Soča river systems. Geochem. Expl. Environ. Anal., 2, 287-296.

Hines, M.E., J. Faganeli, I. Adatto & M. Horvat (2006): Microbial mercury transformations in marine, estuarine and freshwater sediments downstream of the Idrija mercury mine. Appl. Geochem., 21, 1924-1939.

Hines, **M.E.,** E. Poitras, S. Covelli, J. Faganeli, A. Emili, S. Žižek & M. Horvat (2012): Mercury methylation and demethylation in Hg-contaminated lagoon sediments (Marano & Grado Lagoons, Italy). Estuar. Coast. Shelf Sci., 113, 85-96.

Baldi, F., D. Marchetto, M. Gallo, R. Fani, I. Maida, S. Covelli, V. Fajon, S. Zizek, M. Hines & M. Horvat (2012): Chlor-alkali plant contamination of Aussa River sediments induced a large Hg-resistant bacterial community. Estuar. Coast. Shelf Sci., 113, 96-104.

Baldi, F., D. Marchetto, M. Gallo, R. Fani, I. Maida, M. Horvat, V. Fajon, S. Zizek & M. Hines (2012): Seasonal mercury transformation and surficial sediment detoxification by bacteria of Marano and Grado lagoons. Estuar. Coast. Shelf Sci., 113, 105-115.

Faganeli, J., M.E. Hines, S. Covelli, A. Emili & M. Giani (2012): Mercury in lagoons: An overview of the importnace of the link between geochemistry and biology. Estuar. Coast. Shelf Sci., 113, 126-132.

Hines, M.E., S. Covelli, J. Faganeli & M. Horvat (2017): Controls on microbial mercury transformations in contaminated sediments downstream of the Idrija mercury mine (West Slovenia) to the Gulf of Trieste (northern Adriatic). J. Soils Sediments, 17, 1961-1971.

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:
Beli morski volk *(Carcharodon carcharias)* je še eden izmed najbolj pogosto izbranih vsebin dokumentarnih filmov o življenju v morju. Po eni strani strah in trepet iz globin, po drugi pa utelešenje superplenilca že od nekdaj privlači gledalce tovrstnih dokumentarcev. (Foto: B. Furlan)
Sl. 1: V zadnjih desetletjih smo priča vse pogostejšemu upadu populacij morskih psov. Kot kažejo vesti iz turških morij, se ogroženi beli morski volk v vzhodnem Sredozemskem morju še vedno pojavlja. (Foto: B. Furlan)
Sl. 2: V Sredozemsko morje počasi, a vztrajno prihajajo nove in nove vrste lesepskih selivk. Ena takih je tudi bradač vrste *Parupeneus forsskali*, o katerem poročajo tudi iz tunizijskih voda. (Foto: B. Furlan)
Sl. 3: Zaradi višjih temperatur morja se v zadnjih desetletjih pogosto dogaja, da v severnejših delih Sredozemskega morja naletimo na toploljubne vrste. To velja tudi za črnuha (*Centrolophus niger*). (Foto: B. Mavrič)
Sl. 4: Ker je beli morski volk (*Carcharodon carcharias)* zelo redka in ogrožena vrsta morskih psov v Sredozemskem morju, so zapisi o opazovanju ali ulovu še toliko dragocenejši za ihtiološko znanost. (Foto: B. Furlan)
Sl. 5: Regrat (*Taraxacum officinale*) je uporaben tudi kot indikator za ugotavljanje stopnje kromosomskih anomalij v območjih, onesnaženih s težkimi kovinami. (Foto: B. Bakan)
Sl. 6: Morska papiga (*Sparisoma cretense*) je ena izmed najbolj barvitih sredozemskih ribjih vrst. Nekoč se je pojavljala le v južnih predelih Sredozemskega morja, v zadnjem času pa vse več virov poroča o pojavljanju te vrste v severnih predelih. (Foto: B. Furlan)

INDEX TO IMAGES ON THE COVER

FRONT COVER:
The great white shark *(Carcharodon carcharias)* is one of the most common protagonists of documentaries presenting the life in seas and oceans. It is the terror of the oceanic depths, and at the same time the epitome of super predator, forever attracting lovers of documentaries about marine life. (Photo: B. Furlan)
Fig. 1: Over the past decades, we have witnessed a drastic decline in shark populations. However, in certain areas, such as the Turkish seas, the endangered great white shark seems to be still present. (Photo: B. Furlan)
Fig. 2: New Lessepsian migrants are slowly, but persistently moving into the Mediterranean Sea. One such fish species is also the Red Sea goatfish *Parupeneus forsskali*, which has been recently reported along the Tunisian coasts. (Photo: B. Furlan)
Fig. 3: The increasing sea temperatures in the past decades have resulted in certain thermophile fish species spreading their areas of distribution northward. Such is, for example, the case of rudderfish (*Centrolophus niger*). (Photo: B. Mavrič)
Fig. 4: Since the great white shark (*Carcharodon carcharias)* is a rare and endangered large shark in the Mediterranean Sea, its sighting or capture constitutes an event of which the world of ichthyology deserves to be informed. (Photo: B. Furlan)
Fig. 5: The common dandelion (*Taraxacum officinale*) has proved to be a useful indicator in establishing the level of chromosomal aberration in wild plants in areas polluted by heavy metals. (Photo: B. Bakan)
Fig. 6: The Mediterranean parrotfish (*Sparisoma cretense*) is one of the most vividly coloured Mediterranean fish species. In the past it was mainly present in the southern sectors of the Mediterranean Sea, while nowadays there is an increasing number of records confirming its occurrence in the northern sectors as well. (Photo: B. Furlan)

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VSEBINA / *INDICE GENERALE / CONTENTS*

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