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EDITORIAL

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EDITORIAL

ANNALES – A JOURNAL SPECIALIZED IN SHARK RESEARCH

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The story of sharks in the world's oceans started nearly 400 million years ago. Since their first appearance, sharks have occupied a wide range of habitats as a result of their diverse morphological or behavioural adaptations to their environment. Sharks are one of the success stories of evolution, because of their life-history characteristics as k-selected species (large maximum body size, slow growth, late maturity and long lifespan). However, due to these same life-history characteristics, many shark species are now considered vulnerable, threatened or endangered.

The Mediterranean region, where sharks display their diversity with 49 species, is known as an important habitat for cartilaginous fish and considered a unique breeding ground for several shark species, *e.g.* the great white shark, *Carcharodon carcharias*. Unfortunately, most of the major environmental impacts of fishing recorded around the world take place in the Mediterranean, one of the remarkable localities of shark occurrence. There is evidence that the sharks of the Mediterranean region are decreasing in number, diversity and range due to intensive fishing activities, and the loss of large predatory sharks is a very special concern.

Any conversation about sharks can easily get stuck at the issue of the dangers of sharks. Only a few decades ago "merciless sharks are dangerous creatures of the ocean" was a deep-rooted prejudice; but things have changed and now the question is "are sharks dangerous or endangered?" Therefore, in-depth research on the life-history of sharks is inevitable and necessary for a better understanding of these magnificent and fragile predators, as well as for finding a reasonable answer to the question above.

The study of sharks is surely one of the most outstanding jobs in modern world. At first sight, studying these proven predators can be seen as an unreasonable effort by many. They have sharp teeth and strong jaws! That's right. Many of them can grow bigger and stronger than us! That's right too. Frankly, many shark species have the capacity to harm humans. Still, in order to understand them and reveal the hidden stories of their biology and ecology, shark researchers around the world should get closer to these animals. Observation and data collection is a daily routine of any shark researcher. And when the survey is completed, the researcher should write and publish the story about the sharks they studied in the wilderness, in a natural history museum, under a microscope, or elsewhere.

For the last 25 years, the Annales natural history series journal has been generously providing space to shark researchers for sharing their findings with the scientific community. With an increasing momentum since 1999, a total of 80 articles dealing with sharks, skates and rays have been published in the pages of this remarkable journal specialized in shark research, by many authors from the countries in and beyond the Mediterranean region. Let's take a closer look now at some facts and figures about this elasmobranch publication.

From the west to the east of the Mediterranean, researchers from Spain, Morocco, France, Tunisia, Algeria, Italy, Croatia, Slovenia and Turkey – Christian Capapé, Alessandro De Maddalena, Alen Soldo, Antonio Celona, Marco Zuffa, Tiziano Storai, Joan Barrull, Isabel Mate, Farid Hemida, Mohamed Nejmeddin Bradaï, Olivier Guélorget, Jeanne Zouali, Jean Pierre Quignard, Néjia Mnasri, Olfa El Kamel, Moncef Boumaiza, and many others – have enriched the contents of the journal with their contributions on several aspects of elasmobranch research. Based on the information on study localities stated in the materials and methods sections, the geographical distribution of these contributions is as follows (Fig. 1): 36 out of 80 articles presented the results of studies carried out in central Mediterranean, 31 in eastern Mediterranean, and 13 in the western parts of the basin. Articles covering the entire Mediterranean or its western and central parts together are listed under more than one geographical location. The complete list of contributing authors, with the full titles of their articles can be seen in Table 1. The diversity of the subjects is impressive.

When speaking of the sharks and rays of the Mediterranean Sea, researcher Christian Capapé is one of the first names that springs to mind. Since Dr. Capapé's efforts on Mediterranean elasmobranchs go back many years, he has been one of the major contributors to Annales. Publications by Dr. Capapé and European and Maghrebi colleagues are definitely a source of inspiration for who wants to be a shark researcher or needs detailed information on these enigmatic predators, and will be remembered as remarkable milestones of elasmobranch research in western and central Mediterranean.

Alessandro De Maddalena, curator of the Italian White Shark Data Bank, has invested much time and energy in gathering available data on the Mediterranean great whites since the 1990s. Not only the white shark, but several other species have been the focus of his research for the last 20 years. Moreover, Dr. De Maddalena's contributions to Annales are not only limited to words; since he is a renowned illustrator of marine life, sharks in particular, his

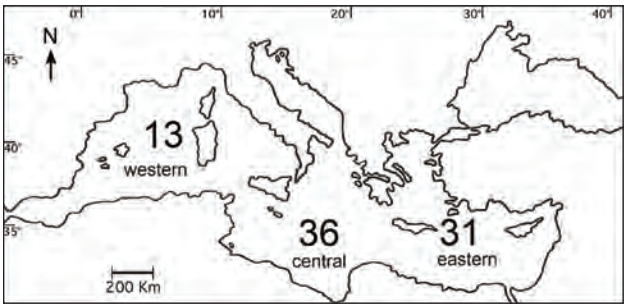

Fig. 1: Geographical coverage of elasmobranch articles published in the Annales natural history series between 1999 and 2016. The numbers on the map indicate the number of articles per zone of the Mediterranean region. The eastern region includes the Aegean, Marmara and Black Seas; the central region includes the Ionian and Adriatic Seas
Sl. 1: Geografska pripadnost prispevkov o ribah hrustančnicah, ki so bili objavljeni v znanstveni reviji Annales med leti 1999 in 2016. Številke na zemljevidu označujejo število prispevkov na posamezni predel Sredozemskega morja. Vzhodni predel vključuje Egejsko, Marmarsko in Črno morje; osrednji predel pa Jonsko in Jadransko morje.

illustrations have enriched the contents of many articles appearing in the journal, from scientific and artistic perspectives.

The chronology of elasmobranch research in Turkish waters can be divided into two distinct eras: the first, which lasted until the late 1990s, was characterised by a paucity of elasmobranch-specific studies. Since sharks and rays were at the time considered as "pests" with no commercial value, the clear scientific neglect of shark- and ray-specific studies of Turkish waters resulted in a remarkable gap of knowledge about them. Following the foundation of the Ichthyological Research Society in early 2000, a non-governmental and non-profit organization dedicated to elasmobranch research, research efforts in the mentioned field increased considerably. The publication of nearly three dozen shark-specific articles in Annales by Hakan Kabasakal and his colleagues between 2002 and 2016, significantly improved our knowledge about sharks found in Turkish waters and in the broader area of eastern Mediterranean. An increased number of shark-related studies and publications associated with the mentioned area can be considered as the hallmark of the second era: the rise of elasmobranch research in Turkey.

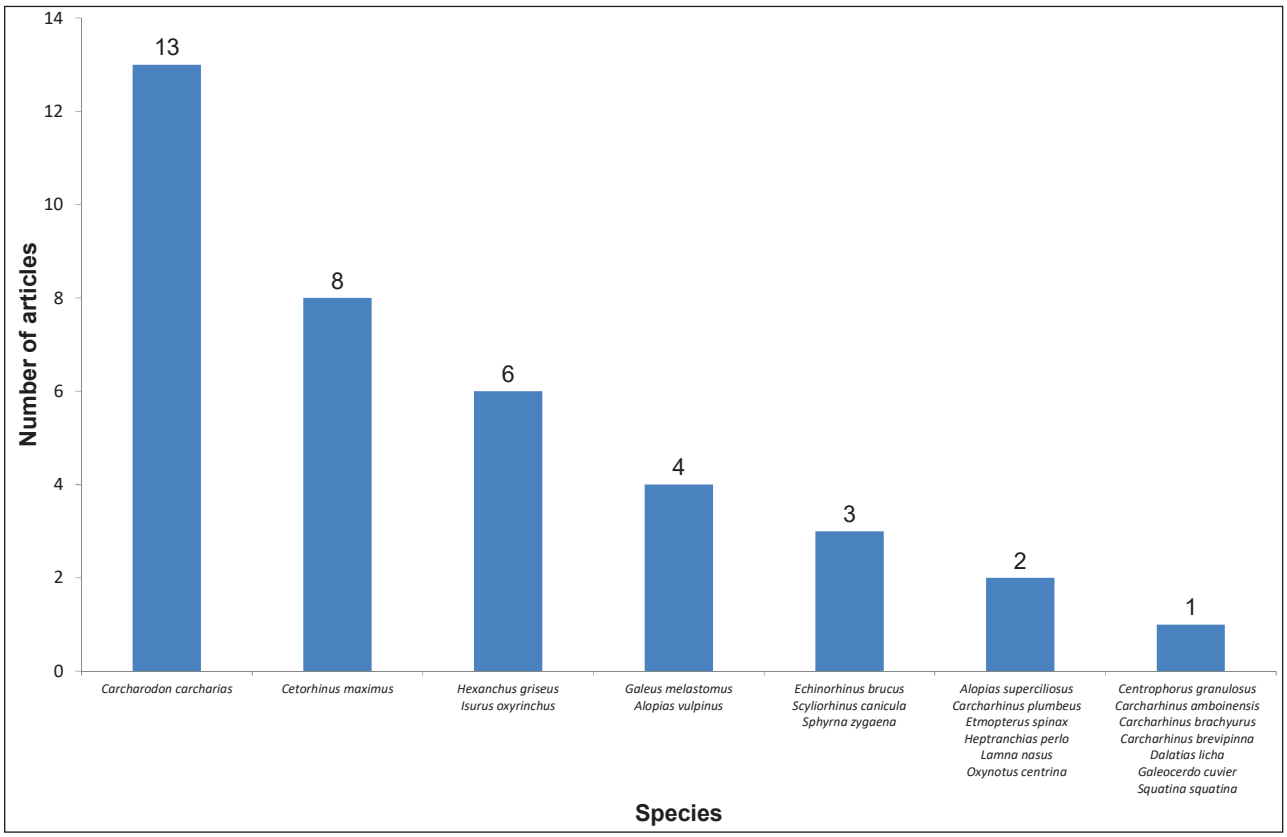

Fig. 2: Number of articles per sharks and elasmobranchs species. Different shark species with the same number of citations in the articles are listed under the same column.
Sl. 2: Število znanstvenih prispevkov glede na posamezne vrsto morskih psov. Različne vrste morskih psov z enakim številom prispevkov so navedene pod stolpiči.

Fifty-six out of 80 articles dealt with the occurrence, distribution or status of sharks, rays and skates in the Mediterranean and adjacent seas, greatly improving our understanding of the current status and distribution ranges of Mediterranean elasmobranchs, and of the first records of new arrivals to the area. Biological aspects of elasmobranchs (e.g. reproduction, feeding and stomach contents) and morphology were another two topics featured in the publications (23 out of 80 articles). Some interesting, but rarely published topics were shark attacks, post-release behaviour, photographic analysis of largest specimens, and analysis of newspaper reports (1 article per topic). Again, articles covering more than one topic are listed under each separate topic, based on the keywords defined in the article. With regard to the numerical distribution of articles per species (Fig. 2), the great white shark, *Carcharodon carcharias*, is the "top star," with 13 out of 80 articles dealing with several aspects of this master predator of the silent world. It is followed by the basking shark, *Cetorhinus maximus* (8 articles), sixgill shark, *Hexanchus griseus*, and shortfin mako shark, *Isurus oxyrinchus* (6 articles per species). Skates and rays appeared in 14 out of 80 articles.

The journal also published some very interesting articles on several other endangered shark species of the Mediterranean. Among these were papers dealing with the status of the angel shark, *Squatina squatina*, in the Sea of Marmara, with the Marmaric occurrence and new maximum depth record (1214 m) of the bramble shark, *Echinorhinus brucus*, a rare deep sea shark supposed to be extinct in the eastern Mediterranean until this publication, and with the first record of the pigeye shark, *Carcharhinus amboinensis*, and the second record of the tiger shark, *Galeocerdo cuvier*, in the Mediterranean Sea.

Drastic reductions in the stocks of traditional commercially important sea fishes mean that elasmobranchs are currently seen as new opportunities for fisheries development. As already mentioned, elasmobranchs are the success story of the evolution because of their life-history characteristics. However, sharks, skates and rays are nowadays swimming along the edge of the knife, and most species are struggling to survive. Dangerous monsters of old are now considered endangered. A closer examination of the elasmobranch publications in Annales reveals that 4 of the mentioned species are presently considered "critically endangered," 3 are "endangered," 6 are "nearly threatened," 1 is "threatened," and 5 species are considered "vulnerable." Eight of the species dealt with are now considered "data deficient" and six are of "least concern," and it can be expected that any changes in the conservation status of these species may only be for the worse if the current targeted and untargeted fishing pressure on them continues. Throughout the long-lasting publication effort of Annales, contributing authors have passionately called attention to the alarming status of elasmobranchs.

With the hard efforts of contributing authors, Annales, a journal specialized in research of sharks and their relatives, has reached a privileged milestone in its long-lasting editorial journey. Last but not least, I have to mention the names of the editors, Lovrenc Lipej, editor in chief, and Martina Orlando-Bonaca, and extend my sincere thanks on behalf of the contributing authors for their editorial assistance, which has not diminished over the years. And finally, the supportive efforts of Patricija Mozetič, former editor of the journal, will always be remembered with appreciation. As time passes by, new generations of researchers will hopefully continue the endeavours of studying elasmobranchs and add new publications into the pages of Annales, which will always welcome them.

Tab. 1: The complete list of contributing authors with the full titles of their articles on sharks and other elasmobranch species, published in the scientific journal Annales.
Tab. 1: Popoln seznam vseh znanstvenih prispevkov o morskih psih in drugih ribah hrustančnicah z navedenimi naslovi in avtorji, ki so bili objavljeni v znanstveni reviji Annales.

No	Title	Date	Authors	Country Origin of Authors	Marine Area
1	New record and some morphological data of the basking shark, *Cetorhinus maximus* (Gunnerus, 1765), in the eastern Adriatic	1999	Alen Soldo Melita Peharda Vlado Onofri Nikša Glavič Pero Tutman	Croatia	Adriatic (Central Mediterranean) Sea
2	Records of the sandbar shark *Carcharhinus plumbeus* (Nardo, 1827) in the Gulf of Trieste (Northern Adriatic)	2000	Lovrenc Lipej Tihomir Makovec Alen Soldo Valter Žiža	Slovenia Croatia	Adriatic (Central Mediterranean) Sea

3	First record of a tiger shark *Galeocerdo cuvier* (Peron & le Seur, 1822) in the Italian waters	2000	Antonio Celona	Italy	Central Mediterranean Sea
4	Il disegno della superficie ventrale delle pinne pettorali dei selachi come carettere diagnostico per il riconoscimento delle specie	2000	Alessandro De Maddalena	Italy	Mediterranean Sea and Atlantic
5	Occurrence of the basking shark, *Cetorhinus maximus* (Gunnerus, 1765), in the waters off Piran (Gulf of Trieste, Northern Adriatic)	2000	Lovrenc Lipej Tihomir Makovec Martina Orlando Valter Žiža	Slovenia	Adriatic (Central Mediterranean) Sea
6	Historical and contemporary presence of the great white shark, *Carcharodon carcharias* (Linnaeus, 1758), in the northern and central Adriatic Sea	2000	Alessandro De Maddalena	Italy	Adriatic (Central Mediterranean) Sea
7	An analysis of the photographic evidences of the largest great white sharks *Carcharodon carcharias* (Linnaeus, 1758), captured in the Mediterranean Sea with considerations about the maximum size of the species	2001	Alessandro De Maddalena Marco Zuffa Lovrenc Lipej Antonio Celona	Italy Slovenia	Mediterranean Sea
8	Morphometrics of neonate velvet belly, *Etmopterus spinax* (Linnaeus, 1758)	2001	Alessandro De Maddalena Luigi Piscitelli	Italy	Central Mediterranean Sea
9	First confirmed record of angular rough shark *Oxynotus centrina* (Linnaeus, 1758) predation on shark egg case of small-spotted catshark *Scyliorhinus canicula* (Linnaeus, 1758) in Mediterranean waters	2001	Joan Barrull Isabel Mate	Spain	Western Mediterranean Sea
10	In relation to the captures of a great white shark, *Carcharodon carcharias* (Linnaeus, 1758), and a shortfin mako, *Isurus oxyrinchus* Rafinesque, 1809, in the Messina Strait	2001	Alessandro De Maddalena	Italy	Central Mediterranean Sea
11	On the capture of a young porpeagle, *Lamna nasus* (Bonnaterre, 1788), in the western Adriatic Sea	2001	Mario Marconi Alessandro De Maddalena	Italy	Central Mediterranean Sea
12	Preliminary observations on abnormal abundance of *Cetorhinus maximus* (Gunnerus, 1765) in middle and northern Adriatic Sea	2001	Marco Zuffa Alen Soldo Tiziano Storai	Italy Croatia	Adriatic (Central Mediterranean) Sea

13	Presence of the great white shark, *Carcharodon carcharias* (Linnaeus, 1758) in the Catalonian Sea (NW Mediterranean): Review and discussion of records, and notes about its ecology	2001	Joan Barrull Isabel Mate	Spain	Western Mediterranean Sea
14	Due catture di squalo bianco, *Carcharodon carcharias* (Linneo, 1758) avvenute nelle acque di Marzamemi (Sicilia) negli anni 1937 e 1964	2002	Antonio Celona	Italy	Central Mediterranean Sea
15	Elasmobranch species of the seas of Turkey	2002	Hakan Kabasakal	Turkey	Eastern Mediterranean, Aegean, Marmara and Black seas
16	Morphometrics of young kitefin sharks, *Dalatias licha* (Bonnaterre, 1788), from northeastern Aegean Sea, with notes on its biology	2002	Hakan Kabasakal Elif Kabasakal	Turkey	Northern Aegean Sea
17	Presence of atypical characteristics in a specimen of small-spotted catshark *Scyliorhinus canicula* (Linnaeus, 1758) caught in the Mediterranean	2002	Joan Barrull Isabel Mate Manuel Bueno	Spain	Western Mediterranean Sea
18	Stomach contents of the longnose spurdog, *Squalus blainvillei* (Risso, 1826) from the north-eastern Aegean Sea	2002	Hakan Kabasakal	Turkey	Northern Aegean Sea
19	Capture of a female basking shark *Cetorhinus maximus* (Gunnerus, 1765), from southern Turkey	2002	Hakan Kabasakal	Turkey	Eastern Mediterranean
20	Historical and contemporary records of sharks from the Sea of Marmara, Turkey	2003	Hakan Kabasakal	Turkey	Sea of Marmara
21	Records of basking sharks, *Cetorhinus maximus* (Gunnerus, 1765) (Chondrichthyes: Cetorhinidae) off the Maghrebin shore (southern Mediterranean):	2003	Christian Capapé Farid Hemida Jalil Bensaci Béchir Saïdi Mohamed Nejmeddin Bradaï	France Algeria Tunisia	Western Mediterranean Sea
22	Effects of reproductive factors on interrelationships between three deep water sharks from northern Tunisia (central Mediterranean)	2003	Christian Capapé Olivier Guélorget Christian Reynaud Adam Marquès Jean Luc Bochereau Jeanne Zouali	France Tunisia	Central Mediterranean Sea
23	Status of sharks in the Mediterranean	2003	Alen Soldo	Croatia	Mediterranean Sea

24	Historical records of the great white shark, *Carcharodon carcharias* (Linnaeus, 1758) (Lamniformes: Lamnidae), from the Sea of Marmara	2003	Hakan Kabasakal	Turkey	Sea of Marmara
25	Sharks captured off Pescara (Italy, western Adriatic Sea)	2003	Gianluca Cugini Alessandro De Maddalena	Italy	Adriatic (Central Mediterranean) Sea
26	A gravid female bramble shark, *Echinorhinus brucus* (Bonnaterre, 1788), caught off Elba Island (Italy, northern Tyrrhenian Sea)	2003	Alessandro De Maddalena Marco Zuffa	Italy	Thyrrenian (Central Mediterranean) Sea
27	Records of the bluntnose sixgill shark, *Hexanchus griseus* (Bonnaterre, 1788) (Chondrichthyes: Hexanchidae) in the Mediterranean Sea: A historical survey	2003	Christian Capapé Olivier Guélorget Joan Barrull Isabel Mate Farid Hemida Rabea Seridji Jalil Bensaci Mohamed Nejmeddin Bradaï	France Spain Algeria Tunisia	Mediterranean Sea
28	On a great white shark, *Carcharodon carcharias* (Linnaeus, 1758), trapped in a tuna cage off Libya, Mediterranean Sea	2004	Txema Galaz Alessandro De Maddalena	Spain Italy	Central Mediterranean Sea
29	*Cetorhinus maximus* (Gunnerus, 1765) (Lamniformes, Cetorhinidae) in the Gulf of Antalya in 1987: A summary of the previous records of the species from Turkish coastal waters in the Mediterranean	2004	Hakan Kabasakal	Turkey	Eastern Mediterranean
30	Sharks captured by commercial fishing vessels off the coast of Turkey in the northern Aegean Sea	2004	Hakan Kabasakal Elif Kabasakal	Turkey	Northern Aegean Sea
31	Observations on biometrical parameters in elasmobranch species from Maghrebin waters: A survey	2004	Christian Capapé Jean Pierre Quignard Olivier Guélorget Mohamed Nejmeddin Bradaï Abderrahman Bouaïn Jamila Ben Souissi Jeanne Zaouali Farid Hemida	France Algeria Tunisia	Central and Western Mediterranean
32	Two large shortfin makos, *Isurus oxyrinchus*, Rafinesque, 1809, caught off Sicily, western Ionian Sea	2004	Antonio Celona Luigi Piscitelli Alessandro De Maddalena	Italy	Central Mediterranean Sea

33	The elasmobranch species from the Bahiret el Biban (southern Tunisia, central Mediterranean): A survey	2004	Christian Capapé Olivier Guélorget Jean Pierre Quignard Amor el Abed Jamila Ben Souissi Jeanne Zaouali	France Tunisia	Central Mediterranean Sea
34	Catture ed awistamenti di mòbula, *Mobula mobular* (Bonnaterre, 1788) nelle acque dello Stretto di Messina	2004	Antonio Celona	Italy	Central Mediterranean Sea
35	On the recent occurrence of elasmobranch species in Tunis southern lagoon (northern Tunisia, central Mediterranean)	2004	Hamadi Mejri Jamila Ben Souissi Jeanne Zaouali Amor el Abed Yvan Vergne Olivier Guélorget Christian Capapé	France Tunisia	Central Mediterranean Sea
36	On the occurrence of the pelagic stingray, *Dasyatis violacea* (Bonaparte, 1832), in the Gulf of Trieste (northern Adriatic)	2004	Borut Mavrič Radoš Jenko Tihomir Makovec Lovrenc Lipej	Slovenia	Agriatic (Central Mediterranean) Sea
37	Sexual dimorphism in small-spotted catshark, *Scyliorhinus canicula* (L., 1758), from the Edremit Bay (Turkey)	2004	Zeliha Aka Erdoğan Hatice Torcu Dilek Türker Çakın Vedrana Nerlovič Jakov Dulčič	Turkey Croatia	Northern Aegean Sea
38	Occurrence of hammerhead sharks (Chondrichthyes: Sphyrnidae) in waters off Sicily (central Mediterranean): Historical and Recent Data	2005	Antonio Celona Alessandro De Maddalena	Italy	Central Mediterranean Sea
39	On the occurrence of the porpeagle, *Lamna nasus* (Bonnaterre, 1788) (Chondrichthyes: Lamnidae), off Italian coasts (northern and central Mediterranean Sea): A historical survey	2005	Tiziano Storai Antonio Celona Marco Zuffa Alessandro De Maddalena	Italy	Central Mediterranean Sea
40	Photographic evidence of the occurrence of bramble shark, *Echinorhinus brucus* (Bonnaterre, 1788) (Squaliformes: Echinorhinidae) from the Sea of Marmara	2005	Hakan Kabasakal M. İdil Öz S. Ünsal Karhan Ziya Çaylarbaşı Umut Tural	Turkey	Sea of Marmara
41	Pontic occurrence of the bluntnose sixgill shark, *Hexanchus griseus* (Bonnaterre, 1788) (Chondrichthyes: Hexanchidae)	2005	Hakan Kabasakal	Turkey	Black Sea
42	First record of the pigeye shark, *Carcharhinus amboinensis* (Müller & Henle, 1839)	2005	Alessandro De Maddalena Gianfranco Della Rovere	Italy	Central Mediterranean Sea

43	Shark chumming in the eastern Adriatic	2005	Alen Soldo Richard Peirce	Croatia United Kingdom	Adriatic (Central Mediterranean) Sea
44	The Gulf of Gabès (central Mediterranean): Nursery area for the sandbar shark, *Carcharhinus plumbeus* (Nardo, 1827) (Chondrichthyes: Carcharhinidae)	2005	Mohamed Nejmeddin Bradaï Béchir Saïdi Abderrahman Bouaïn Olivier Guélorget Christian Capapé	Tunisia France	Central Mediterranean Sea
45	Distribution and biology of the bluntnose sixgill shark, *Hexanchus griseus* (Bonnaterre, 1788) (Chondrichthyes: Hexanchidae), from Turkish waters	2006	Hakan Kabasakal	Turkey	Eastern Mediterranean, Aegean, Marmara and Black seas
46	Quignard skates and rays (Chondrichthyes) from waters off the Languedocian coast (southern France, northern Mediterranean): a historical survey and present status	2006	Christian Capapé Olivier Guélorget Yvan Vergne Adam Marques Jean Pierre Quignard	France	Western Mediterranean Sea
47	Biological observations on the black torpedo, *Torpedo nobiliana* Bonaparte, 1835 (Chondrichthyes: Torpedinidae), from two Mediterranean areas	2006	Christian Capapé Olivier Guélorget Yvan Vergne Jean Pierre Quignard Mohamed Mourad Ben Amor Mohamed Nejmeddin Bradaï	France Tunisia	Central and Western Mediterranean
48	Evidence of predatory attack on a bottle nose dolphin, *Tursiops truncatus* by a great white shark *Carcharodon carcharias* in the Mediterranean Sea	2006	Antonio Celona Alessandro De Maddalena Giorgia Comparetto	Italy	Central Mediterranean
49	On a rare skate, the speckled ray, *Raja polystigma* Regan, 1923 (Chondrichthyes: Rajidae) captured off the coast of Languedoc (southern France, northern Mediterranean)	2006	Christian Capapé Olivier Guélorget Yvan Vergne Jean Pierre Quignard	France	Western Mediterranean Sea
50	Incidental captures of thresher sharks (Lamniformes: Alopiidae) from Turkish coastal waters	2007	Hakan Kabasakal	Turkey	Eastern Mediterranean, Aegean, Marmara and Black seas
51	Sizes of eight oviparous elasmobranch species hatched in two Mediterranean areas: A survey and recent data	2007	Christian Capapé Mohamed Ben Salem Mohamed Mourad Ben Amor	France Tunisia	Central and Western Mediterranean
52	Diet of the marbled electric ray, *Torpedo marmorata* (Chondrichthyes: Torpedinidae) off the Languedocian coast (southern France, northern Mediterranean)	2007	Christian Capapé Séverine Crouzet Céline Clément Yvan Vergne Olivier Guélorget	France	Western Mediterranean

53	First record of *Carcharhinus brachyurus* (Gunther, 1870) (Chondrichthyes: Carcharhinidae) from Sardinian waters (central Mediterranean)	2007	Tiziano Storai Luca Zinzula Benedetto Cristo Brett Human	Italy Sultanate of Oman	Central Mediterranean Sea
54	Two recent records of the great white sharks, *Carcharodon carcharias* (Linnaeus, 1758) (Chondrichthyes: Lamnidae), caught in Turkish waters	2008	Hakan Kabasakal	Turkey	Aegean and Marmara seas
55	New biological data on the eagle ray, *Myliobatis aquila* (Chondrichthyes: Myliobatidae), off the Languedocian coast (southern France, northern Mediterranean)	2008	Christian Capapé Yvan Vergne Jean Pierre Quignard Christian Reynaud	France	Western Mediterranean Sea
56	Note on a sharpnose sevengill shark, *Heptranchias perlo* (Bonnaterre, 1788) (Chondrichthyes: Hexanchidae), stranded in Saroz Bay (NE Aegean Sea, Turkey)	2008	Hakan Kabasakal Polat İnce	Turkey	Northern Aegean Sea
57	On the capture of a large basking shark, *Cetorhinus maximus* (Chondrichthyes: Cetorhinidae) in the Bay of Edremit (northeastern Aegean Sea)	2009	Hakan Kabasakal	Turkey	Northern Aegean Sea
58	Two juvenile great white sharks, *Carcharodon carcharias* (Linnaeus, 1758) (Chondrichthyes: Lamnidae), caught in the northern Aegean Sea	2009	Hakan Kabasakal Aylin Yarmaz Sait Özgür Gedikoğlu	Turkey	Northern Aegean Sea
59	New biological data on thornback ray, *Raja clavata* (Chondrichthyes: Rajidae), off the Languedocian coast (southern France, northern Mediterranean)	2009	Christian Capapé Yvan Vergne Christian Reynaud	France	Western Mediterranean Sea
60	Post-release behavior and anthropogenic injuries of the bluntnose sixgill shark, *Hexanchus griseus* (Bonnaterre, 1788) (Chondrichthyes: Hexanchidae) in Turkish waters	2010	Hakan Kabasakal	Turkey	Eastern Mediterranean, Aegean and Marmara seas
61	A review of newspaper and internet portrayals of the sixgill shark, *Hexanchus griseus* (Bonnaterre, 1788) (Chondrichthyes: Hexanchidae), caught in Turkish waters between 1974-2009	2010	Hakan Kabasakal	Turkey	Eastern Mediterranean, Aegean, Marmara and Black seas

62	Additional records of the bull ray, *Pteromylaeus bovinus* (Chondrichthyes: Myliobatidae), in the Lagoon of Bizerte (northern Tunisia, central Mediterranean)	2010	Olfa El Kamel Néjia Mnasri Moncef Boumaiza Mohamed Mourad Ben Amor Christian Reynaud Christian Capapé	Tunisia France	Central Mediterranean Sea
63	Morphological abnormalities in two batoid species (Chondrichthyes) from northern Tunisian waters (central Mediterranean)	2010	Néjia Mnasri Olfa El Kamel Moncef Boumaiza Mohamed Mourad Ben Amor Christian Reynaud Christian Capapé	Tunisia France	Central Mediterranean Sea
64	Atypical coloration in small-spotted catshark, *Scyliorhinus canicula* (Chondrichthyes: Scyliorhinidae) caught off northern Tunisian coast (central Mediterranean)	2010	Néjia Mnasri Olfa El Kamel Moncef Boumaiza	Tunisia	Central Mediterranean Sea
65	A huge shortfin mako shark, *Isurus oxyrinchus* Rafinesque, 1810 (Chondrichthyes: Lamnidae) from the waters of Marmaris, Turkey	2011	Hakan Kabasakal Alessandro De Maddalena	Turkey Italy	Southern Aegean Sea
66	Great white tales	2011	Hakan Kabasakal Özgür Kabasakal	Turkey	Aegean and Marmara seas
67	Additional records of the bigeye thresher shark, *Alopias superciliosus* (Lowe, 1839) (Chondrichthyes: Lamniformes: Alopiidae) from Turkish waters	2011	Hakan Kabasakal Cem Dalyan Adem Yurtsever	Turkey	Eastern Mediterranean, Aegean and Marmara seas
68	Abnormalities in common torpedos, *Torpedo torpedo* (Chondrichthyes: Torpedinidae) from the Lagoon of Bizerte (northern Tunisia, central Mediterranean)	2011	Olfa El Kamel-Moutalibi Néjia Mnasri Moncef Boumaiza Christian Reynaud Christian Capapé	Tunisia France	Central Mediterranean Sea
69	First record of a shortfin mako shark, *Isurus oxyrinchus* Rafinesque, 1810 (Chondrichthyes: Lamnidae) from the Bay of Saroz (NE Aegean Sea)	2013	Hakan Kabasakal Özgür Kabasakal	Turkey	Northern Aegean Sea
70	Bluntnose sixgill shark, *Hexanchus griseus* (Chondrichthyes: Hexanchidae), caught by commercial fishing vessels in the seas of Turkey between 1967 and 2013	2013	Hakan Kabasakal	Turkey	Eastern Mediterranean, Aegean, Marmara and Black seas

71	Rare but present: Status of basking shark, *Cetorhinus maximus* (Gunnerus, 1765) in eastern Mediterranean	2013	Hakan Kabasakal	Turkey	Eastern Mediterranean and Aegean seas
72	Status of angelshark, *Squatina squatina* (Elasmobranchii: Squatiniformes: Squatinidae) in the Sea of Marmara	2014	Hakan Kabasakal Özgür Kabasakal	Turkey	Sea of Marmara
73	Not disappeared, just rare! Status of the bramble shark, *Echinorhinus brucus* (Elasmobranchii: Echinorhinidae) in the seas of Turkey	2014	Hakan Kabasakal Murat Bilecenoğlu	Turkey	Aegean and Marmara seas
74	Additional records of a rare elasmobranch species, sharpnose sevengill shark *Heptranchias perlo* (Hexanchidae) off the northern Tunisian coast (central Mediterranean)	2014	Olfa El Kamel-Moutalibi Néjia Mnasrisioudi Sihem Rafrafi-Nouira Moncef Boumaïza	Tunisia	Central Mediterranean Sea
75	Recent record of the great white shark, *Carcharodon carcharias* (Linnaeus, 1758), from central Aegean Sea off Turkey's coast	2015	Hakan Kabasakal Özgür Kabasakal	Turkey	Aegean Sea
76	Occurrence of the angular rough shark, *Oxynotus centrina* (Chondrichthyes: Oxynotidae) in the eastern Mediterranean	2015	Hakan Kabasakal	Turkey	Eastern Mediterranean, Aegean and Marmara seas
77	Photographic record of the spinner shark, *Carcharhinus brevipinna* (Müller & Henle, 1839), in Gökova Bay (south Aegean Sea, Turkey)	2015	Halit Filiz Hakan Kabasakal	Turkey	Southern Aegean Sea
78	Shark attacks against humans and boats in Turkey's waters in the twentieth century	2015	Hakan Kabasakal Sait Özgür Gedikoğlu	Turkey	Eastern Mediterranean, Aegean and Marmara seas
79	Additional records of spinetail devilray *Mobula japonica* (Chondrichthyes: Mobulidae) from the Tunisian coast (central Mediterranean)	2015	Sihem Rafrafi-Nouira Olfa El Kamel-Moutalibi Mohamed Mourad Ben Amor Christian Capapé	Tunisia France	Central Mediterranean
80	Capture of a juvenile shortfin mako shark, *Isurus oxyrinchus* Rafinesque, 1810 (Chondrichthyes: Lamnidae) in the Bay of Edremit, northern Aegean Sea (Turkey)	2016	Sezginer Tunçer Hakan Kabasakal	Turkey	Northern Aegean Sea

EDITORIAL, 131–142

POVZETEK UVODNIKA

ANNALES – SPECIALIZIRANA ZNANSTVENA REVIJA ZA RAZISKAVE O MORSKIH PSIH

Hakan KABASAKAL
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*Sredozemsko morje, v katerem živi 49 vrst morskih psov, je pomembno življenjsko okolje za ribe hrustančnice, obenem, pa tudi edinstveno razmnoževalno okolje za mnoge vrste, med drugim tudi za belega morskega volka (*Carcharodon carcharias*). V zadnjih petindvajsetih letih je znanstveni časopis Annales series historia naturalis veliko prostora odmerjal raziskavam,ki so jih opravili raziskovalci morskih psov, in na tak način obveščal strokovno javnost. Od leta 1999 pa do danes je bilo v tej izjemni znanstveni reviji objavljenih 80 znanstvenih prispevkov, ki so jih prispevali raziskovalci iz različnih sredozemskih držav in tudi mnogi, ki prihajajo iz držav izven Sredozemlja. Od 80 prispevkov jih je 36 poročalo o raziskavah iz osrednjega Sredozemlja, 31 iz vzhodnega in 13 iz zahodnega Sredozemlja. Od raziskovalcev, ki so prispevali največ del, je potrebno v prvi vrsti omeniti Christiana Capapéja, Alessandra de Maddalena in Hakana Kabasakala. Največkrat so avtorji poročali o belem morskem volku (13 prispevkov od 80), morskem psu orjaku (*Cetorhinus maximus*) (8 prispevkov), morskem psu* šesteroškrgarju *(*Hexanchus griseus*) in maku (*Isurus oxyrhincus*) (oba s po 6 prispevki). Posebej zanimivi so znanstveni prispevki o zelo redkih in ogroženih vrstah. Med njimi je omembe vreden prispevek o redkem bodičastem morskem psu (*Echinorhinus brucus*), domnevno izumrli vrsti, ki ga je posnelo daljinsko vodeno plovilo (ROV) v Marmarskem morju na globini 1214 m. Prav tako so zanimivi prispevki, ki obravnavajo pojavljanje zelo redkih vrst, kot so sklat (*Squatina squatina*) ali pa zapisi o pojavljanju novih vrst v Sredozemskem morju kot sta npr. morski tiger (*Galeocerdo cuvieri*) in javanski morski pes (*Carcharhinus amboinensis*). Znanstveno revijo Annales lahko na podlagi kakovostnih in rednih prispevkov ob priliki pomembnega jubileja upravičeno definiramo kot specializirano znanstveno revijo za morske pse in njihove sorodnike.*

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MORPHOMETRIC CHARACTERISTICS, VERTICAL DISTRIBUTION AND DENSITY OF THE LIMPET *PATELLA CAERULEA* L. IN RELATION TO DIFFERENT SUBSTRATA OF THE BAY OF KOPER (GULF OF TRIESTE, NORTHERN ADRIATIC)

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ABSTRACT

The paper presents the results of the study on the populations of Patella caerulea *of the Bay of Koper (Gulf of Trieste, northern Adriatic). The coast in the bay of Koper is composed of different types of substrata—limestone, marl and sandstone—making an ideal opportunity to study the influence of these substrata on the vertical distribution, density and morphological characteristics of this species. The observation revealed that the* Patella *population was distributed on all selected substrata in the midlittoral zone of this region. The density (individuals per 400 cm^2) was the highest on sandstone and the lowest on marl. The shells of individuals from the upper midlittoral zone were greater in size than those from the lower midlittoral, in all the investigated substrata. The surface sea temperature, salinity and chlorophyll* a*, that could explain increase of* P. caerulea *populations, have been analyzed.*

Key words: *Patella caerulea*, morphometric characteristics, vertical distribution, density, Gulf of Trieste, northern Adriatic Sea

CARATTERISTICHE MORFOMETRICHE, DISTRIBUZIONE VERTICALE E DENSITÀ DI *PATELLA CAERULEA* L. SU DIVERSI TIPI DI SUBSTRATO DELLA BAIA DI CAPODISTRIA (GOLFO DI TRIESTE, ALTO ADRIATICO)

SINTESI

L'articolo presenta i risultati di uno studio sulle popolazioni di Patella caerulea *della baia di Capodistria (Golfo di Trieste, Alto Adriatico). La costa di quest'area è composta da tre tipi diversi di substrato (calcare, marna ed arenaria), che offrono un'ottima opportunità di studio degli effetti di tali substrati su distribuzione verticale, densità e caratteristiche morfologiche di questa specie. Le osservazioni hanno rilevato che le popolazioni di* P. caerulea *sono distribuite nella zona del mediolitorale dell'area studiata. La densità delle patelle (numero di individui su 400 cm^2) è risultata la più alta sull'arenaria e la più bassa sulla marna. La grandezza della conchiglia delle patelle del mediolitorale superiore è maggiore di quella delle patelle del mediolitorale inferiore, su tutti i substrati studiati. Sono state analizzate temperatura, salinità e clorofilla* a *dell'acqua marina come fattori che potrebbero incrementare la densità delle popolazioni di* P. caerulea.

Parole chiave: *Patella caerulea*, caratteristiche morfometriche, distribuzione verticale, densità, Golfo di Trieste, Alto Adriatico

INTRODUCTION

Limpets (Patellidae) occur on different type of shores where there is substratum firm enough for their attachment. They are common on rocky shores from the most exposed to the most sheltered ones and they play a fundamental role in the ecology of rocky midlittoral habitats worldwide, so they are considered the 'keystone' species of the midlittoral zone (Branch, 1981, 1985; Hawkins & Hartnoll, 1983; Menge *et al*., 1994; Menge, 2000). They play an important role within their environment as key herbivores; grazing by limpets is a key process on rocky shores, because not only it determines macroalgal abundance, but it also modifies ecosystem stability and biodiversity and plays a key role in the structure and organization of midlittoral communities (Moreno & Jaramillo, 1983; Chapman, 1995; Coleman *et al.*, 2006; Moore *et al*., 2007; Prusina *et al*., 2015). For instance, limpets decrease algal abundance as a direct effect, but also have indirect effects on several organism groups by enhancing the abundance of e.g. barnacles (limiting algal coverage) (Menge, 2000; Arrontes *et al*., 2004). Moreover, limpets are appropriate as *in situ* monitor tools because they are abundant, sedentary or sessile, available all year long and easy to collect (Bat & Öztürk, 1998; Bresler *et al.*, 2003, Bat *et al.,* 2000).

In the Adriatic Sea, *Patella* genus is represented by three species, namely *P. caerulea* L., *P. ulyssiponensis* Gmelin (= *Patella aspera* Lam.) and *P. rustica* L. (= *P. lusitanica* Gmelin) (Grubelić, 1992; Šimunović, 1995; Zavodnik *et al*., 2005). They occupy different vertical zones of rocky shores: *P. rustica* occurs in the upper midlittoral and in the supralittoral, *P. caerulea* occurs in the mid to lower midlittoral, and *P. ulyssiponensis* in the low midlittoral and infralittoral fringe (Davies, 1969; Della Santina *et al*., 1993; Šimunović, 1995; Mauro *et al*., 2003).

At each tidal cycle, limpets are out of water, being therefore exposed to high temperature, desiccation and salinity stress (Vermeij, 1973). Limpets are adherent strongly to their permanent place. In many species of limpets, individuals return to the same resting site after feeding, which normally occurs during submersion (Della Santina & Chelazzi, 1991; Aguilera & Navarrete, 2011). Strong adhesion to the substratum reduces water loss, since there is a close fit between the shell and the substratum (Ellem *et al*., 2002). Adhesion to the substratum during inactivity is accomplished by the secretion of pedal mucus with glue-like properties (Smith, 1991, 1992; Smith *et al*., 1999).

Although a number of studies have been carried out on the biology, distribution and ecology of *Patella* species of the Mediterranean Sea (Bacci & Sella, 1970; Bannister, 1975; Guerra & Gaudencio, 1986; Della Santina *et al.*, 1993; Navarro *et al.*, 2005; Cabral, 2007; Prusina *et al*., 2014a, 2014b; 2015), very little is known about the occurrence of the *Patella* species along the Slovenian coast. Information on this genus has mostly been occasionally collected in the framework of several ecological studies, where some authors mentioned only the species *P. caerulea* for the midlittoral of Slovenian rocky shore (Matjašič & Štirn, 1975; Lipej *et al*., 2004; Pitacco *et al.*, 2013). De Min & Vio (1997) reported the presence of *P. caerulea* all along the Slovenian coast as a very common species, and the other two species as very rare: *P. ulyssiponensis* were found only in Strunjan Bay and in Rt Seča, while *P. rustica* was recorded at Rt Madona (Piran) and at Rt Seča.

In early spring 2011, an increase in density of limpets was observed in midlittoral zone all along the Slovenian rocky shore. This phenomenon coincided with the disappearance of *Fucus virsoides* J. Ag. populations, as reported by Battelli (2016).

The focus of the present study was the limpet *P. caerulea* as one of the most numerically abundant and common midlittoral grazer species distributed along the Slovenian coast. The main objectives of this study were to determine the effects of different type of substrata - limestone, marl and sandstone - on: (a) morphological characteristics (shell length, width and height); (b) vertical distribution-zonation and (c) density of the *P. caerulea* population. In addition, the effects of different position on the shore (above and below the mean water tidal level) of the *P. caerulea* individuals on their shell size (length and height) were also determined for limestone and sandstone. The surface sea temperature, salinity and chlorophyll *a*, which may act on *P. caerulea* density population, have been analyzed. The obtained results contribute to expanding current knowledge on the *P. caerulea* populations in this area.

MATERIAL AND METHODS

Study area and sites

The rocky substratum of the Slovenian coast, situated in the south-eastern part of the Gulf of Trieste, consists mainly of Eocene flysch layers with alternating solid sandstone and soft marl (Ogorelec *et al*., 1997); while in certain areas in Izola the rocky shore is formed of limestone (Pavlovec, 1985). These three types of substrata that occur in close proximity provide a useful occasion to test the influence of the substrata on the distribution and structure of *Patella caerulea* populations.

The study was conducted in the midlittoral zone of six sites located along the coast of the Bay of Koper. They were qualitatively selected on the basis of different types of rocky substrata—limestone, marl and sandstone. All sites will hereafter be indicated after the names of the substrata, as: Sand1 (45°35′12.2″ N, 13°42′34.3″ E) and Sand2 (45°32′30.7″ N, 13°40′28.6″ E) on sandstone, Marl1 (45°35′23.2″ N, 13°42′12.3″ E) and Marl2 (45°31′57.0″ N, 13°38′29.0″ E) on marl, Lim1 (45°32′02.1″ N, 13°38′47.8″ E) and Lim2 (45°32′30.9″

N, 13°39'39.4" E) on limestone. The sites Marl1 and Sand1 were located at Cape Debeli rtič, on the north-western side of the Bay of Koper, while the sites Marl2, Lim1, Lim2 and Sand2 were on the south-western side of the Bay of Koper, near Izola (Fig. 1).

The sites Sand1 and Marl1 consisted of rocky platforms with a horizontal extent of about 200 m; Sand1 was characterized by the presence of boulders of different sizes with slightly rough surface, while Marl1 was formed of large steps with a smooth surface and had a gently sloping rock platform. The sites Lim1 and Lim2 had a horizontal extent of about 250 m. The site Sand2 was located in the small bay of Viližan near Izola and was characterized by the presence of boulders of different sizes with slightly rough surface. The site Marl2 was located on the west side near the site Lim1 with a substratum composed of a gently sloping platform of large steps with a smooth surface. All the sites were exposed to wave action generated by winds blowing from north-west to northeast.

On all the sites, midlittoral zone were characterized by the presence of cyanobacteria (mainly *Scytonematopsis crustacea* (Thuret ex Bornet & Flahault) Kováli & Komárek and *Entophysalis deusta* (Meneghini) Drouet & Daily) (Giaccone *et al.*, 2003), barnacles *Chthamalus montagui* Southward and *C. stellatus* (Poli), and the limpet *Patella caerulea*. These organisms were generally present on all sites, although their relative abundance could vary. It is important to note the total absence of the macroalgal vegetation at all the investigated sites (Battelli, 2016). The mean sea level (MW) was 218 cm (Fig. 2) (baseline measurements of the sea level are Mareographic zero at the tide gauge station in Koper; data are available on the website of the Ministry of the Environment and Spatial Planning (MPO), Slovenian Environment Agency (ARSO): www.arso.gov.si/water/sea, 2016).

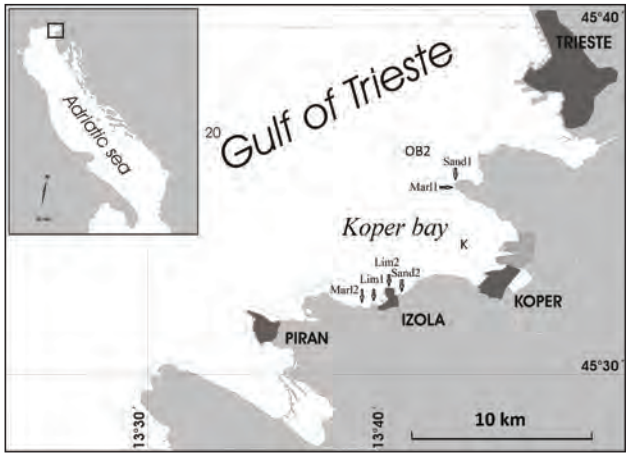

Fig. 1: Map of the study area in the Bay of Koper showing the sampling sites (Marl1, Marl2, Lim1, Lim2, Sand1, Sand2) and sampling stations for sea surface temperature, salinity and chlorophyll a (OB2 and K).
Sl. 1: Zemljevid raziskanega območja v Koprskem zalivu z prikazom vzorčevalnih mest (Marl1, Marl2, Lim1, Lim2, Sand1, Sand2) in postaj merjenja temperature, slanosti in klorofila a v površinskih vodah (OB2 in K).

Sampling methods

Samplings were carried out during April 2016 along the coast of the Bay of Koper. *Patella caerulea* individuals were analysed from three different types of substrata (limestone, marl and sandstone) in the midlittoral zone during the low water period. Two sampling sites for each type of substratum were randomly chosen (as previously described).

At each site, two transects, 1 m wide and at least 10 m apart, were randomly laid down from the mean lower low water (MLLW) to the mean higher high water tidal level (MHHW) (Fig. 2).

Three replicates 20×20 cm plots (400 cm^2) were randomly allocated to each transect: in total 36 plots were examined. *P. caerulea* individuals were counted in each plot and their abundance expressed as number of individuals per 400 cm^2.

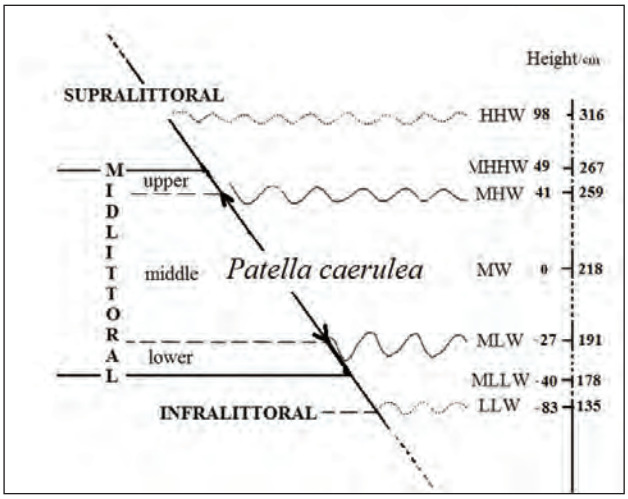

Fig. 2: Schematic representation of the vertical midlittoral zonation pattern of** Patella caerulea **in the Bay of Koper, indicating the mean sea levels for the period 2005-2015. HHW – Higher High water; MHHW – Mean Higher High Water; MHW – Mean High Water; MW – Mean Water; MLW – Mean Low Water; MLLW – Mean Lower Low Water; LLW – Lower Low Water. Source of data: MOP, ARSO, 2016.
Sl. 2: Shematski prikaz vertikalne zonacije vrste** Patella caerulea **v Koprskem zalivu. Podane so srednje vrednosti morske gladine za obdobje 2005-2015. HHW – višja visoka voda; MHHW – srednja višja visoka voda; MHW – srednja visoka voda; MW – srednja voda; MLW – srednja nizka voda; MLLW – srednja nižja nizka voda; LLW – nižja nizka voda. Vir podatkov: MOP, ARSO, 2016.

Fig. 3: *Patella caerulea* ***shell with annotated shell dimensions: shell width (SW), shell length (SL) and shell height (SH).***
Sl. 3: Lupina vrste *Patella caerulea* ***s prikazom meritev: širina (SW), dolžina (SL) in višina (SH).***

Morphometric measurements

To examine the shell size of limpets, as indicated in Figure 3, shell length (SL, greatest distance between the anterior and posterior ends), shell width (SW, greatest distance between margins) and shell height (SH, the greatest vertical distance from the apex to the base of the shell) were measured directly to the nearest 0.1 mm using a caliper. For this purpose, 2 individuals were randomly selected from each plot (72 individuals in total).

To determine differences in shell length (SL), shell height (SH) and shell height/length ratio (SH/SL) between individuals of *P. caerulea* present above and below the mean sea level, 24 individuals were measured *in situ* from 10 to 40 cm above the MW and the same number from 10 to 40 cm below the MW on limestone and sandstone.

Sea surface temperature (SST), salinity (SSS) and chlorophyll *a* (chl *a*) data

Sea surface temperature (°C), salinity and chlorophyll *a* (chl *a*) data, kindly provided by the Environment Agency of the Republic of Slovenia (ARSO) – Ministry of the Environment and Spatial Planning (MOP) were analysed. On the basis of sea temperature (which in general reaches the lowest values during February and the highest during August) monthly means of these data were processed into winter, which includes January, February and March; spring, including April, May and June; summer, including July, August and September), and autumn, including October, November and December, annual means for the period 2005–2015. This was then divided into two main periods, 2005–2010 and 2011–2015, considering abnormal increase in the abundance of limpet *Patella caerulea* observed at the end of 2010.

Data analyses

In order to establish whether there was a relationship among the values of density, morphological measurements of the *P. caerulea* individuals and different types of substrata (limestone, marl and sandstone), the raw data were subject to statistical analysis using non-parametric Kruskal-Wallis test. Comparisons of the means of the variables describing shell size (height, length and shell height/length ratio) at different heights of the shore (above and below the sea mean level) were carried out by means of 2-way Analysis of Variance (IBM SPSS 23.0). The assumption of homoscedasticity of variances was tested using Levene's test. Significance level was set at $P < 0.05$.

RESULTS

Vertical distribution (zonation) of *Patella caerulea*

The vertical midlittoral zonation pattern of the species *Patella caerulea* was determined (Fig. 2). Individuals of *P. caerulea* tend to inhabit the entire midlittoral zone. Our field notes showed that they were present in a variety of locations such as smooth (marl), rough (sandstone, limestone), regular (marl, sandstone) and irregular (limestone) rock surfaces, rocky platforms, vertical boulders, from the most wave-beaten rock surfaces to the most protected ones. They were also present in various kinds of microhabitats like crevices, cracks and rock pools.

It has been observed that the vertical distribution of the *P. caerulea* individuals was restricted within the midlittoral zone. This area ranges vertically about 49 cm below the mean sea level (MW) and about 40 cm above mean sea level with mean amplitude of 89.5 cm, as illustrated in Figure 2. This vertical area extending be-

Tab. 1: Average values of density (number of individuals/400 cm²) and morphological measurements recorded for *Patella caerulea* ***on different substrata (limestone, sandstone and marl) in the Bay of Koper. N-number of individuals, SL-Shell length, SW-Shell width and SH-Shell height.***
Tab. 1: Povprečne vrednosti gostote (število osebkov/400 cm²) in morfoloških meritev vrste *Patella caerulea* ***na različnih podlagah (apnenec, peščenjak in laporovec) v Koprskem zalivu. N-število osebkov, SL-dolžina lupine, SW--širina lupine in SH-višina lupine.***

Substratum		N / 400 cm²	SL (mm)	SW (mm)	SH (mm)
Limestone	Mean	8.11	23.33	19.54	6.37
	SD	3.34	7.20	6.59	2.30
	Min	4.00	13.50	10.50	3.50
	Max	15.00	39.00	34.20	12.00
Sandstone	Mean	9.33	31.94	26.30	8.12
	SD	3.29	10.74	8.88	3.42
	Min	3.00	16.20	13.80	4.50
	Max	13.00	56.10	46.90	17.50
Marl	Mean	2.08	27.70	23.22	7.63
	SD	0.79	4.14	4.07	1.70
	Min	1.00	18.20	16.20	4.40
	Max	3.00	34.20	29.40	11.20
Total	Mean	7.06	27.65	22.99	7.34
	SD	4.10	8.93	7.60	2.75
	Min	1.00	13.50	10.50	3.50
	Max	15.00	56.10	46.90	17.50

tween the MHHW and MLLW corresponds to the midlittoral zone and is under the direct influence of seawater because of tides and waves.

On the basis of our observations, we found that the lower limit of the presence of *P. caerulea* individuals was the MLLW, which corresponds to the lower horizon of the midlittoral zone. The upper limit was the MHHW, which represents the upper border of midlittoral zone.

Morphometric characteristics

The values of the morphological measurements, given in Table 1, varied among single substratum. The shell length (SL) values recorded at each surveyed substrata showed an average of 27.65 mm, with a minimum size of 13.50 and a maximum of 56.10 mm. The width of shells (SW) was 22.99 mm on average, and varied between 10.50 and 45.90 mm. The average shell height (SH) was 7.34 mm and it varied between 3.50 and 17.50 mm.

The comparison of the mean values of the single measurement among each type of substrata is illustrated in Figure 4. The non-parametric Kruskal-Wallis test, calculated for the shell length among each substratum, showed statistically significant differences between limestone and sandstone ($P < 0.001$) and between limestone and marl ($P < 0.05$), while between sandstone and marl the differences were statistically not significant ($P > 0.05$). The same situation was found for values of shell width.

A very different trend resulted from the comparison of shell height: the only statistically significant differ-

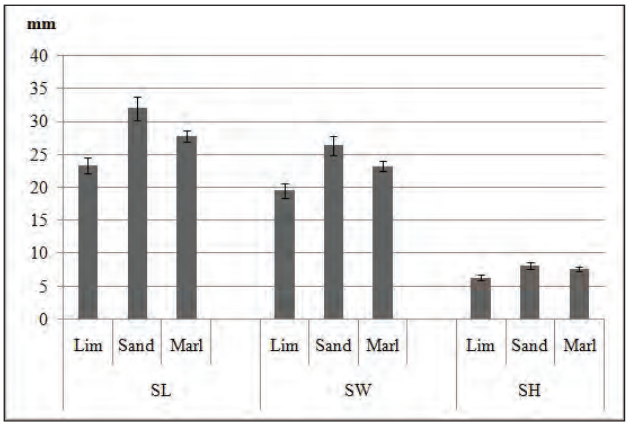

Fig. 4: Graphical representation of the average morphological measurements values recorded for populations of *Patella caerulea* ***located on different substrata (limestone-Lim, sandstone-Sand and marl- Marl) along the coast of the Bay of Koper. Legend: SL-Shell length, SW--Shell width and SH-Shell height.***
Sl. 4: Grafični prikaz povprečnih vrednosti morfoloških meritev populacij vrste *Patella caerulea* ***na različnih podlagah (apnenec-Lim, peščenjak-Sand in laporovec--Marl) vzdolž obale Koprskega zaliva. Legenda: SL-dolžina lupine, SW-širina lupine in SH-višina lupine.***

Tab. 2: Mean shell length, height and height/length ratio values recorded for** Patella caerulea **for different substrata (limestone and sandstone) and different vertical position (above and below mean sea water tidal level) of the Bay of Koper. SL-Shell length, SH-Shell height and SH/SL-Shell height/length ratio.
Tab. 2: Povprečne vrednosti dolžine, višine in razmerja višina/dolžina lupine vrste** Patella caerulea **na različnih podlagah (apnenec in peščenjak) in različnih višinah (nad in pod srednjim nivojem vode) v Koprskem zalivu. SL--dolžina lupine, SH-višina lupine in SH/SL-razmerje višina/dolžina lupine.

Substratum	Sea level	Above sea mean level			Below sea mean level		
	Variables	SL (mm)	SH (mm)	SH / SL	SL (mm)	SH (mm)	SH / SL
Limestone	Mean	25.74	5.72	0.22	20.03	4.23	0.21
	SD	6.25	2.43	0.05	4.20	1.23	0.04
	Min	17.90	3.20	0.13	13.10	2.80	0.15
	Max	43.20	13.00	0.32	30.70	8.50	0.31
Sandstone	Mean	24.77	5.90	0.24	23.53	4.39	0.19
	SD	6.31	2.22	0.05	3.80	1.10	0.05
	Min	16.40	3.20	0.17	16.30	2.40	0.12
	Max	38.70	13.40	0.35	31.20	6.80	0.30
Total	Mean	25.25	5.81	0.23	21.78	4.31	0.20
	SD	6.23	2.31	0.05	4.34	1.15	0.04
	Min	16.40	3.20	0.13	13.10	2.40	0.12
	Max	43.20	13.40	0.35	31.20	8.50	0.31

ences were found between limestone and sandstone ($P < 0.05$).

In contrast to those living in the lower part of the midlittoral zone (below the mean sea level) the results of the measurements of shell size (shell length, shell height and shell height/length ratio) of the *P. caerulea* individuals living in the upper part of the midlittoral zone (above the mean sea tidal level) showed some significant differentiation (Tab. 2). Statistical analysis supported these results indicating also where significant differences lied. In general, significant differences were found between the upper and lower extents of each single substratum.

Analysis indicated that limpets of different levels on the shore (above the MW and below MW) were of different sizes regarding shell length (SL), shell height (SH) and shell height/length ratio (SH/SL) on both the substrata at all the investigated sites (Tab. 2).

The two-way ANOVA that examined the effect of substrata (limestone and sandstone) and different levels on the shore (above and below the mean water tidal level) on limpet shell length revealed a statistically significant interaction between substrata and shore levels, $F = 4.323$, $P = 0.040$ (Tab. 3). The difference between the mean values of the shore height on sandstone was significantly higher than those on limestone (Tab. 2).

The only statistically significant effect on the shell height, detected in the ANOVA, was the effect of shore height (Tab. 3), where the values of the shells from the shore above the MW level were significantly larger than the values of those from the shore below the MW, on both the investigated substrata (Tab. 2).

The results of the ANOVA, performed for the effect of substrata and shore levels on limpet shell height/length ratio (SH/SL) revealed a statistically significant interaction between substrata and shore levels, $F = 4.941$, $P = 0.029$ (Tab. 3). This was confirmed by a greater difference of the SH/SL ratio values between limpets above the MW level and limpets below the MW level on sandstone in comparison to those on limestone (Tab. 2).

Population density

Average density values recorded for population of *P. caerulea* located on different substrata at selected sites are shown in Table 1. The results showed that the average density at surveyed area was 7.06 individuals /400 cm^2. On sandstone the average density values were 9.33 individuals/400 cm^2, markedly higher and statistically significant ($P < 0.001$) than those recorded on marl, which was 2.08 individuals/400 cm^2. It is also interesting to note that the maximum density values of individuals were found at site Sand1 (13 individuals/400 cm^2) and minimum at site Marl1 with 1 individual/400 cm^2. The highest mean density value of the entire investigated areas was recorded at site Sand1 and corresponded to 10.33 individuals/400 cm^2. Sites on limestone also showed important densities with an average of 8.11 individuals/400 cm^2, which in comparison with the density values on marl (2.08 individuals/400 cm^2) showed statistically significant difference ($P < 0.001$), while versus sandstone (9.33 individuals/400 cm^2) the difference was statistically non-significant ($P > 0.05$).

Tab. 3: ANOVA of the effect of substrata (limestone, sandstone) and different position on the shore (above and below the mean water tidal level) on** Patella caerulea **shell length, height and height/length ratio, in the Bay of Koper. Tab. 3: ANOVA vpliva podlage (apnenec, peščenjak) in navpične lege (nad in pod srednjim nivojem vode) na dolžino, višino in razmerje višina/dolžina latvice** Patella caerulea **v Koprskem zalivu.

Dependent Variable: length				
Source	df	MS	F	P
Shore height	1	289.468	10.435	0.002
Substrate	1	38.633	1.393	0.241
Shore height X Substrate	1	119.930	4.323	0.040
Error	92	27.739		
Total	95			
Dependent Variable: height				
Source	df	MS	F	P
Shore height	1	53.700	15.855	0.000
Substrate	1	0.700	0.207	0.650
Shore height X Substrate	1	0.004	0.001	0.974
Error	92	3.387		
Total	95			
Dependent Variable: height/length ratio				
Source	df	MS	F	P
Shore height	1	0.019	8.038	0.006
Substrate	1	4.972E-5	0.022	0.884
Shore height X Substrate	1	0.011	4.941	0.029
Error	92	0.002		
Total	95			

On the basis of the comparison of sea surface temperature (SST), salinity (SSS) and chlorophyll *a* (SSChl *a*) for the Bay of Koper (MOP, ARSO, 2015), shown in Figure 5, it was evident that the differences in mean values between the period before 2010 (before the increasing in abundance of *P. caerulea* populations) and after 2010 are not so remarkable. The Kruskal-Wallis test revealed that differences were no statistically significant, although slightly higher values were in general observed during the period 2011–2015, with some exceptions.

Monthly mean SST showed a consistent annual pattern with evident very similar seasonality in both periods. A slightly higher mean seasonal temperature was characteristic for the period 2011–2015 in winter, summer and autumn, while in spring it was slightly lower in this period. The highest temperature values were observed during summer and spring. The main differences were registered between winter and summer period, minimum between spring and autumn.

The SSS data also showed strong annual seasonality: a decrease in warmer seasons (spring and summer) and increase during winter and autumn were evident. The SSS values were slightly higher during the period 2011–2015 in all the seasons except in summer (Fig. 5).

The seasonal trend of the SSChl *a* revealed a slight decrease of values from winter to summer and a greater increase in autumn for both investigated periods. It is clearly evident that during the period 2005-2010 the mean values of the Chl *a* were slightly higher than those of the period 2011-2015 in all seasons (Fig. 5).

DISCUSSION

Our study provides a general perspective on the relationship between three types of substrata (limestone, marl and sandstone) and the morphological characteristics (shell size), vertical distribution and abundance of the *P. caerulea* samples. They were found on all types of substrata: on smooth (marl, sandstone) and rough surfaces (limestone), and also in crevices, cracks, gullies, overhangs, rock pools, pebbles and boulders.

Morphological characteristics

Statistical analysis clearly showed significant differences in shell size (shell length and height) between the limpets present above the mean water tidal level (MW) and those present below the MW. It was found that the

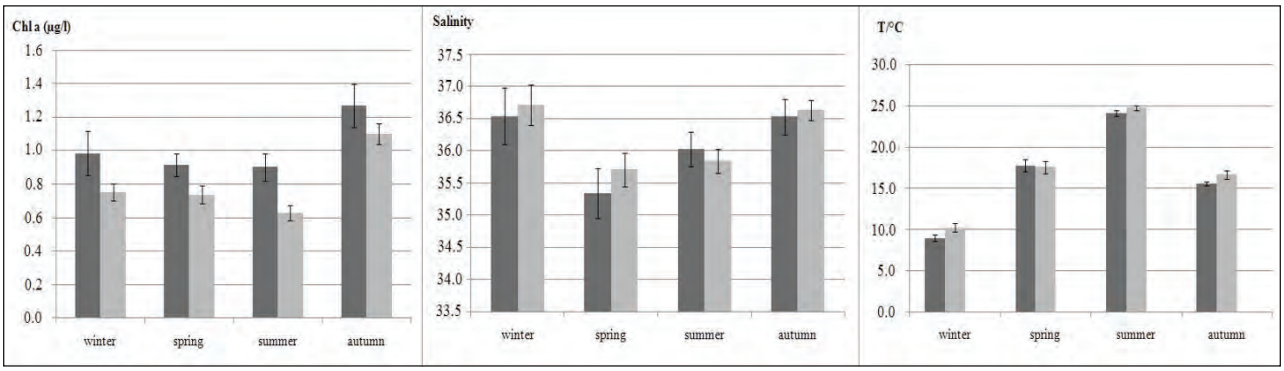

Fig. 5: Seasonal values (mean ± SE) of sea surface temperature, salinity and chlorophyll a during the period 2005–2010 (black columns) and 2011–2015 (grey columns) in the Bay of Koper (Source of data: MOP, ARSO, 2016 - http://www.arso.gov.si/en/).
Sl. 5: Sezonske vrednosti (povprečje ± SE) temperature, slanosti in klorofila a površinskih voda v obdobju 2005–2010 (črni stolpci) in 2011–2015 (sivi stolpci) v Koprskem zalivu (vir podatkov: MOP, ARSO, 2016 - http://www.arso.gov.si/en/).

values of the shell length and the shell height of *P. caerulea* individuals that live above the MW were significantly higher than those living below MW at all investigated sites. Our findings are similar to the results of the study conducted by several authors as Davies (1969), Öztürk & Ergen (1999) and Davenport & Davenport (2005). According to Öztürk & Ergen (1999) in animals living in drier zones, longer and higher shell are adaptive characteristic against dehydration. The differences in the shell size of the limpets from the upper midlittoral zone compared to those from the lower zone are most likely due to different periods of emersion. The upper part of the shore could therefore be considered as having harsher conditions leading to greater problems of desiccation (Lowell, 1984; Miller *et al*., 2009). So we can consider, in consistence with certain authors as Davies (1969, 1966), Sella (1976), Nolan (1991), that the shell size (length and height) of the *P. caerulea* individuals is heavily influenced by environmental conditions, in particular with respect to the gradients of tidal height (vertical position on the shore) and, at the same time, the type of substrata as an irrelevant factor.

Vertical (zonation) distribution

The present investigation attempts to illustrate the vertical (zonation) distribution of the species *P. caerulea,* which is widely distributed on the coast of Slovenia. *P. caerulea* individuals were found in an area with a vertical extension of about 89 cm, which corresponds to the midlittoral zone (between the Mean Lower Low Water - MLLW and Mean Higher High Water - MHHW). This is in accordance with observations of several authors from the Gulf of Trieste (Matjašič & Štirn, 1975; Vio & De Min, 1996; De Min & Vio, 1997; Lipej *et al*., 2004) and from others areas of the Adriatic (Grubelić, 1992; Zavodnik *et al*. 2005). Della Santina & Chelazzi (1991) monitored the activity of two species of limpets (*P. caerulea* and *P. rustica*) on the Tyrrhenian coast and have established that *P. caerulea* inhabits the lower and the upper midlittoral zone, while *P. rustica* inhabits the upper midlittoral and supralittoral fringe, but moves up to the supralittoral zone during foraging. Both species have a strict homing behaviour, returning to the same location after foraging. The authors pointed out also the difference of the foraging strategies of the two species: *P. caerulea* performs short, mainly regular foraging trips, while *P. rustica* carries out longer and irregularly excursions. On the basis of our field observations we noted that *P. caerulea* performs both, short regular and longer and irregular foraging excursions that reach the supralittoral zone. Our opinion is that this phenomenon could be explained with the absence of the species *P. rustica* along Slovenian coast.

Some others authors, as Evans (1947) and Davenport & Davenport (2005), for example, observed that limpets are largely restricted to the area between the tide marks and, according to this, they considered the necessity for some amount of emersion as the prime factor deciding the vertical distribution of limpets.

Density

One of the main outcomes of our investigation on the population of *P. caerulea* was high mean density found at investigated sites, especially on limestone and sandstone. Within a single substratum it has been observed that significant differences occurred between limestone and marl and between sandstone and marl. We observed that individuals of this species were generally absent from marl where fine sediment covered this substratum. Analyses have shown that the maximum number of limpets oc-

curred on limestone and the minimum on marl. This is in accordance with many authors (e.g. Airoldi & Virgilio, 1998; Airoldi, 2003; Schiel *et al*., 2006) that pointed out that herbivorous organisms, including limpets, are often scarce in areas with high sediment loading, even if the critical levels of perturbation by sediment are not known. Marl is a very friable sedimentary *rock* made of clay and limestone and at all investigated sites this substratum was covered by very fine sediment. This effect of sediment on limpets is particularly important because grazing is a key process controlling algal vegetation on rocky shores (Southward, 1964; Lubchenco & Gaines, 1981; Hawkins & Hartnoll, 1983; Benedetti-Cecchi *et al*., 2001). In the observed areas *P. caerulea* forms high-density populations on rocky midlittoral shores along the coast of the Bay of Koper and should be with the utmost attention, as highlighted by many authors, regarding the impact of climate change on Mediterranean midlittoral communities (Sarà *et al*., 2014).

We also wanted to know if there were any significant differences in the sea surface temperature (SST), salinity (SSS) and chlorophyll a (SSChl *a*) between the period before 2010 (before the increasing in abundance of *P. caerulea* populations) and after 2010, and if these differences could be related with the increase in the density of limpets. No significant differences in mean values of these parameters were obtained between the period before 2010 and after 2010. It was very interesting to note that the mean seasonal values of the chlorophyll *a* of the period before the increase in abundance of *P. caerulea* populations were higher than those of the period after the increase of *P. caerulea* populations, in all seasons. Probably the determination of the abundance of the epilithic microbial film by measuring the concentration of chlorophyll *a* on the rock surface could better explain the variations in density of the *P. caerulea* population, as observed by a number of authors (e.g. Jenkins *et al*., 2001; Espinosa *et al*., 2006). Espinosa *et al*., 2006 observed that food supply decreased significantly with increases in limpet densities, as observed in the present study, with the difference that in our study we measured the concentration of planktonic chlorophyll *a*.

CONCLUSIONS

Patella caerulea individuals are present in all examined locations and substrata (limestone, marl and sandstone), extending, vertically, from MLW to MHW.

Maximum population density of this species occurred on limestone (15 individuals per 400 cm^2) and minimum on marl where the presence of fine sediment represents an important source of stress for *P. caerulea*.

P. caerulea is an important macroalgae grazer, controlling the abundance and distribution of macroalgae of the midlittoral zone of the Bay of Koper.

The shell size of *P. caerulea* individuals is in relation with their position (above and below the MW) on the shore: significantly higher above the MW.

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MORFOMETRIČNE ZNAČILNOSTI, VERTIKALNA RAZŠIRJENOST IN GOSTOTA LATVICE *PATELLA CAERULEA* L. GLEDE NA RAZLIČNE TIPE PODLAG V KOPRSKEM ZALIVU (TRŽAŠKI ZALIV, SEVERNI JADRAN)

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POVZETEK

V prispevku avtor poroča o rezultatih raziskave populacije latvic vrste Patella caerulea *v Koprskem zalivu (Tržaški zaliv, severni Jadran). Obalo Koprskega zaliva sestavljajo različni tipi podlage kot so apnenec, laporovec in peščenjak, ki nudijo idealne možnosti za študij vpliva teh podlag na vertikalno razširjenost, gostoto in morfološke značilnosti te vrstec. Opazovanja so pokazala, da se populacija vrste* P. caerulea *pojavlja na vseh obravnavanih podlagah v mediolitoralnem pasu tega geografskega območja. Najvišje vrednosti gostote (števila osebkov na 400 cm^2) se pojavljajo na peščenjaku, najnižje pa na laporovcu. Lupine latvic zgornjega mediolitorala so na vseh raziskanih podlagah večje od tistih iz spodnjega mediolitorala. Avtor obravnava tudi temperaturo, slanost in koncentracijo klorofila* a *kot parametre, s katerimi bi lahko razložili porast populacije latvic.*

Ključne besede*: Patella caerulea*, morfometrične značilnosti, vertikalna razširjenost, gostota, Tržaški zaliv, severni Jadran

REFERENCES

Airoldi, L. (2003): The effects of sedimentation on rocky coast assemblages. Oceanogr. Mar. Biol., 41, 161–236.

Airoldi, L. & M. Virgilio (1998): Responses of turf-forming algae to spatial variations in the deposition of sediments. Mar. Ecol. Prog. Ser., 165, 271–282.

Aguilera, M.A. & S.A. Navarrete (2011): Distribution and activity patterns in an intertidal grazer assemblage: influence of temporal and spatial organization on interspecific associations. Mar. Ecol. Prog. Ser., 431, 119–136.

Arrontes, J., F. Arenas, C. Fernández, J.M. Rico, J. Oliveros, M. Martínez, R.M. Viejo & D. Alvarez (2004): Effect of grazing by limpets on mid-shore species assemblages in northern Spain. Mar. Ecol. Prog. Ser., 277, 117–133.

ARSO (2016): Ministry of the Environment and Spatial Planning (MPO), Slovenian Environment Agency (ARSO): www.arso.gov.si/water/sea. 25/08/2016.

Ayas, D. (2010): Distribution and morphometric characteristics of *Patella* species (Archaeogastropoda) in Mersin-Viranşehir region of the Northeastern Mediterranean sea. J. Fisheries Sciences, 4(2), 171–176.

Bacci, G. & G. Sella (1970): Correlations between characters and environmental conditions in *Patella* of the *coerulea* group. Pubbl. Staz. Zool. Napoli, 38, 1–24.

Bannister, V. (1975): Shell Parameters in Relation to Zonation in Mediterranean Limpets. Mar. Biol., 31(1), 63–67.

Bat, L. & M. Öztürk (1998): *Patella caerulea* as a Biomonitor of Coastal Metal Pollution. Faculty of Arts and Sciences, Dept. of Biology, Celal Bayar Univ., ISSN 1301–2428, 142–146.

Bat, L., G. Gönlügür, M. Andaç, M. Öztürk & M. Öztürk (2000): Heavy Metal Concentrations in the Sea Snail *Rapana venosa* (Valenciennes, 1846) from Sinop Coasts of the Black Sea. Turk. J. Mar. Sci., 6, 227–240.

Battelli, C. (2016): Disappearance of *Fucus virsoides* J. Agardh from Slovenian coast (Gulf of Trieste, northern Adriatic). Annales, Ser. Hist. Nat., Koper, 26(1), 1–12.

Benedetti-Cecchi, L., F. Bulleri, S. Acunto & F. Cinelli (2001): Scales of variation in the effects of limpets on rocky shores in the northwest Mediterranean. Mar. Ecol. Prog. Ser., 209, 131–141.

Branch, G.M. (1981): The biology of limpets: physical factors, energy flow and ecological interactions. Oceanogr. Mar. Biol. Ann. Rev., 19, 235–380.

Branch, G.M. (1985): Limpets: their role in littoral and sublittoral community dynamics. In P.G. Moore & R. Seed (eds). The ecology of rocky coast, New York. Columbia University Press, 97–116.

Bresler, V., Y.O. Mokad, L. Fishelson, T. Feldstein & A. Abelson (2003): Marine Molluscs in Environmental Monitoring. II. Experimental Exposure to Selected Pollutants. Helgol. Mar. Res., 57, 206.

Cabral, J. (2007): Shape and growth in European Atlantic *Patella limpets* (Gastropoda, Mollusca). Ecological implications for survival. Web. Ecol., 7, 11–21.

Coleman, R.A., A.J. Underwood, L. Benedetti-Cecchi, P. Åberg, F. Arenas, J. Arrontes, J. Castro, R.G. Hartnoll, S.R. Jenkins, J. Paula, P. Della Santina & S.J. Hawkins (2006): A continental scale evaluation of the role of limpet grazing on rocky shores. Oecologia, 147, 556–564.

Davenport, J. & J.L. Davenport (2005): Effects of shore height, wave exposure and geographical distance on thermal niche width of intertidal fauna. Mar. Ecol. Prog. Ser., 292, 41–50.

Davies, P.S. (1966): Physiological ecology of *Patella*. I. The effect of body size and temperature on metabolic rate. J. Mar. Biol. Ass. U.K., 49, 291–304.

Davies, P.S. (1969): Effect of environment on metabolic activity and morphology of Mediterranean and British species of *Patella*. Pubbl. Stn. Zool. Napoli, 37, 641– 656.

Della Santina, P. & G. Chelazzi (1991): Temporal organization of foraging in two Mediterranean limpets, *Patella rustica* (L.) and *Patella caerulea* (L.). J. Exp. Mar. Biol. Ecol., 153, 75–85.

Della Santina, P., C. Sonni, G. Sartoni & G. Chelazzi (1993): Food availability and diet composition of three coexisting Mediterranean limpets (*Patella* spp.). Mar. Biol., 116, 87–95.

De Min, R. & E. Vio (1997): Molluschi conchiferi del litorale sloveno. Ser. Hist. Nat., 11, 241–258.

Ellem, G.K., J.E. Furst & K.D. Zimmerman (2002): Shell clamping behaviour in the limpet *Cellana tramoserica*. – J. Exp. Biol., 205, 539–547.

Espinosa, F., J.M. Guerra-García, D. Fa & J.C. García-Gómez (2006): Effects of competition on an endangered limpet *Patella ferruginea* (Gastropoda: Patellidae): Implications for conservation. J. Exp. Biol., 330, 482– 492.

Evans, R.G. (1947): Studies on the Biology of British Limpets. Proc. zool. Soc. Lond., 117, 411–423.

Giaccone G., G. Alongi, C. Battelli, M. Catra, L.A. Ghirardelli, A. Pezzino & S. Stefani (2003): Guida alla determinazione delle alghe del Mediterraneo. Parte I: alghe azzurre (Cyanophyta o Cyanobacteria) (in ambiente naturale e biodeteriogeni su manumenti lapidei). Università di Catania, 92 p.

Grubelić, I. (1992): Comparative studies of littoral biocoenoses of the Kornati Islands. Acta Adriat., 33, 1/2,127–161.

Guerra, M.T. & M.J. Gaudencio (1986): Aspects of the ecology of *Patella* spp. on the Portuguese coast. Hidrobiología, 142, 57–69.

Hawkins, S.J. & R.G. Hartnoll (1983): Grazing of intertidal algae by marine invertebrates. Oceanogr. Mar. Biol., 21, 195–282.

Jenkins, S.R., F. Arenas, J. Arrontes, J. Bussell, J. Castro, R.A. Coleman, S.J. Hawkins, S. Kay, B. Martínez, J. Oliveros, M.F. Roberts, S. Sousa, R.C. Thompson & R.G. Hartnoll (2001): European-scale analysis of seasonal variability in limpet grazing activity and microalgal abundance. Mar. Ecol. Prog. Ser., 211, 193–203.

Jenkins, S.R., R.A. Coleman, P. Della Santina, S.J. Hawkins, M.T. Burrows & R.G. Hartnoll (2005): Regional scale differences in the determinism of grazing effects in the rocky intertidal. Mar. Ecol. Prog. Ser., 287, 77–86.

Lipej, L., M. Orlando-Bonaca & T. Makovec (2004): Raziskovanje biodiverzitete v slovenskem morju. Morska biološka postaja, Nacionalni inštitut za biologijo. Piran, 136 p.

Lowell, R.B. (1984): Desiccation of intertidal limpets: effects of shell size, fit to substratum and shape. J. Exp. Mar. Biol. Ecol., 77, 197–207.

Lubchenco, J. & S.D. Gaines (1981): A unified approach to marine plant–herbivore interactions. I. Populations and communities. Annu. Rev. Ecol. Syst., 12, 405–437.

Mauro, A., M. Arculeo & N. Parrinello (2003): Morphological and molecular tools in identifying the Mediterranean limpets *Patella caerulea*, *Patella aspera* and *Patella rustica*. J. Exp. Mar. Biol. Ecol., 295, 131–143.

Matjašič, J. & J. Štirn (1975): Flora in favna severnega Jadrana. Ljubljana, Prisp. 1., Slovenska Akademija Znanosti in Umetnosti, Razprave, 4, 19–23.

Menge, B.A., E.L. Berlow, C.A. Blanchette, S.A. Navarrete & S.B. Yamada (1994): The keystone species concept: variation in interaction strength in a rocky intertidal habitat. Ecol. Monogr., 64, 249–286.

Menge, B.A. (2000): Top-down and bottom-up community regulation in marine rocky intertidal habitats. J. Exp. Mar. Biol. Ecol., 250, 257–289.

Miller, L.P., C.D.G. Harley & M.W. Denny (2009): The role of temperature and desiccation stress in limiting the local-scale distribution of the owl limpet, *Lottia gigantea*. Funct. Ecol., 23, 756–767.

Moore, P., R.C. Thompson & S.J. Hawkins (2007): Effects of grazer identity on the probability of escapes by a canopy-forming macroalga. J. Exp. Mar. Biol. Ecol., 344, 170–180.

Navarro, P.G., R. Ramirez, F. Tuya1, C. Fernandez-Gil, P. Sanchez-Jerez & R.J. Haroun (2005): Hierarchi-

cal analysis of spatial distribution patterns of patellid limpets in the Canary Islands. J. Moll. Stud., 71, 67–73.

Nolan, C.P. (1991): Size, shape, and shell morphology in the antarctic limpet *Nacella concinna* at Signy Island, south Orkney Islands. J. Moll. Stud., 57, 225–238.

Ogorelec, B., J. Faganeli, M. Mišič & B. Čermelj (1997): Reconstruction of paleoenvironment in the bay of Koper (Gulf of Trieste, Northern Adriatic). Annales, Ser. Hist. Nat., 11, 187–200.

Öztürk, B. & Z. Ergen (1999): *Patella* species (Archaeogastropoda) distributed in Saros Bay (northeast Aegean Sea). Tr. J. Zool., 23, 513–520.

Pavlovec, R. (1985): Numulitine iz apnencev pri Izoli (SW Slovenija). Razprave 4. razred Slovenska Akademija Znanosti in Umetnosti, 26, 219–230.

Pitacco, V., B. Mavrič, M. Orlando-Bonaca & L. Lipej (2013): Rocky macrozoobenthos mediolittoral community in the Gulf of Trieste (North Adriatic) along a gradient of hydromorphological modifications. Acta Adriat., 54(1), 67–86.

Prusina, I., D. Ezgeta-Balić, S. Ljubimir, T. Dobroslavić & B. Glamuzina (2014a): On the reproduction of the Mediterranean keystone limpet *Patella rustica*: histological overview. J.M.B.A. U.K., 1–10.

Prusina, I., G. Sarà, M. De Pirro, J.W. Dong, G.D. Han, B. Glamuzina & G.A. Williams (2014b): Variations in physiological responses to thermal stress in congeneric limpets in the Mediterranean Sea. J. Exp. Mar. Biol. Ecol., 456, 34–40.

Prusina, I., M. Peharda, D. Ezgeta-Balić, S. Puljas, B. Glamuzina & S. Golubić (2015): Life-history trait of the Mediterranean keystone species *Patella rustica*: growth and microbial bioerosion. *Medit. Mar. Sci., 16/2, 393–401.*

Sarà, G., M. Milanese, I. Prusina, I. Sarà, A. Angel, D.L. Glamuzina, B. Tali, B. Nitzan, S. Freeman, A. Rinaldi, V. Palmeri, V. Montalto, M. Lo Martire, P. Gianguzza, V. Arizza, S. Lo Brutto, M. De Pirro, B. Helmuth, J. Murray, S. De Cantis & G.A. Williams (2014): The impact of climate change on Mediterranean intertidal communities: losses in coastal ecosystem integrity and services. Regional Environmental Change, 14(14), 5–17.

Schiel, D.R., S.A. Wood, R.A. Dunmore & D.I. Taylor (2006): Sediment on rocky intertidal reefs: effects on early post-settlement stages of habitat-forming seaweeds. J. Exp. Mar. Biol. Ecol., 331, 158–172.

Sella, G. (1976): Biometrical relationships between mesolittoral and infralittoral *Patella* populations in the Mediterranean. Publ. Staz. 2001. Napoli, 40, 123–132.

Smith, A. M. (1991): The role of suction in the adhesion of limpets. J. Exp. Biol., 161,151–169.

Smith, A. M. (1992): Alternation between attachment mechanisms by limpets in the field. J. Exp. Mar. Biol. Ecol., 160, 205–220.

Smith, A.M., T.J. Quick & R.L. St. Peter (1999): Differences in the composition of adhesive and non-adhesive mucus from the limpet *Lottia limatula*. Biol. Bull., 196, 34–44.

Southward, A.J. (1964): Limpet grazing and the control of vegetation on rocky shores. In: Crisp DJ (ed) Grazing in terrestrial and marine environments. Blackwell Scientific Publications, Oxford, p. 265–273.

Šimunović, A. (1995): Ecological study of Prosobranchiata (Gastropoda) in the eastern part of the Adriatic Sea and their relationship to benthic biocenoses. Acta Adriat., 36, 3–162.

Vermeij, G.J. (1973): Morphological patterns in high-intertidal gastropods: adaptive strategies and their limitations. Mar. Biol., 20, 319–346.

Vio, E. & R. De Min (1996): Contributo alla conoscenza dei molluschi marini del Golfo di Trieste. Atti Mus. Civ. Nat. Trieste, 47, 173–233.

Zavodnik, D., A Pallaoro, A. Jaklin, M. Kovačić & M. Arko Pijevac (2005): A benthos survey of the Senj Archipelago (North Adriatic Sea, Croatia). Acta Adriat., 46(2), 3–68.

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LE ORCHIDACEAE D'ABRUZZO: AGGIORNAMENTO SISTEMATICO E NUOVA CHECK-LIST

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SINTESI

L'Abruzzo è una regione dell'Italia centrale con la superfice di 10794 km2 in cui al termine del 2010 erano segnalate 3409 entità di piante vascolari. Le ricerche floristiche successive hanno portato ad altri ritrovamenti che hanno ulteriormente arricchito la flora regionale. Nella famiglia delle Orchidaceae le recenti revisioni tassonomiche e le nuove entità segnalate e descritte portano a riconsiderare i numeri della loro presenza nel territorio abruzzese. Nel presente lavoro si riporta un nuovo elenco floristico di tutte le Orchidacee comprendente le specie, le sottospecie e gli ibridi e in alcuni casi si discute il loro rango tassonomico. Inoltre è stata fatta l'analisi corologica che evidenzia la prevalenza degli elementi mediterranei.

Parole chiave: Abruzzo, Orchidaceae, check-list regionale, elementi floristici

THE ORCHID FLORA OF ABRUZZO: NEW SYSTEMATIC UPDATE AND CHECKLIST

ABSTRACT

Abruzzo is a region of the central Italy with 10,794 km^2 of surface, and in which at the end of 2010 were reported 3409 entities of vascular plants. Subsequent floristic researches led to other discoveries that have enriched the regional flora. In the family Orchidaceae recent taxonomic revisions and new marked and described entities lead to reconsider the numbers of their presence in the Abruzzo region. This paper reports a new floristic list of all the Orchids including species, subspecies and hybrids, and in some cases their taxonomic rank was discussed. The chorological analysis that highlights the prevalence of Mediterranean elements was also performed.

Key words: Abruzzo, Orchidaceae, regional check-list, floristic contingents

INTRODUZIONE

L'Abruzzo è una regione disposta al centro della penisola con la superfice di 10794 km^2. Il suo territorio molto articolato, a grandi linee è costituito da:

– una fascia litoraneo-costiera lunga circa 131 Km, con ampiezza media di circa un km, più o meno rettilinea, bassa e generalmente sabbiosa che verso sud (Provincia di Chieti) è interrotta dai promontori di Ortona, Punta Cavalluccio (Fossacesia) e Punta Penna (Vasto).
– una fascia collinare prevalentemente argillosa e larga circa 30 km che è disposta tra il Mare Adriatico e l'Appennino Centrale;
– una fascia montana di natura generalmente calcarea che si dispiega lungo tre direttrici principali separate tra loro da bacini interni e raggiunge la quota massima di m 2.914 sul Gran Sasso.

Il clima regionale, molto variabile, può essere suddiviso nelle seguenti principali tipologie:

– una zona con clima tipicamente mediterraneo limitato alla fascia costiera;
– una zona di transizione che caratterizza la fascia subappenninica e alcune valli interne favorevolmente esposte;
– una zona a clima temperato fresco, tipico della fascia montana.

All'interno di tali tipologie sono individuabili altre la cui analisi esula dal presente lavoro.

Le varietà geomorfologiche, climatiche e altimetriche evidenziate influenzano la vita vegetale e contribuiscono ad accrescere la ricchezza floristica poiché favoriscono lo sviluppo di entità con diverse esigenze ecologiche. Infatti, la flora regionale, secondo Peruzzi, al termine del 2010 annoverava 3409 diversi taxa di piante vascolari, un valore superiore a quello di vari stati europei con superfice molto più vasta. All' Abruzzo è stato assegnato il titolo di "*Regione Verde d'Europa*", a causa della sua importanza naturalistica animale e vegetale che ha portato all'istituzione di tre parchi nazionali (il Parco Nazionale d'Abruzzo, Lazio e Molise, il Parco Nazionale della Majella e il Parco Nazionale del Gran Sasso e Monti della Laga), il Parco Naturale Regionale Sirente-Velino, l'Area Marina Protetta Torre del Cerrano e trentotto aree protette tra oasi, riserve regionali e riserve statali che rappresentano il 36,3% della sua superficie. Ad arricchire il corteggio floristico regionale e l'importanza delle varie aree protette concorrono anche le Orchidaceae che nel presente lavoro saranno analizzate e discusse.

Le ricerche floristiche sulle Orchidaceae d'Abruzzo

Le ricerche floristiche di una certa importanza in Abruzzo iniziarono nel XIX secolo con Gravina (1812), Brocchi (1822), Gussone (1826), Mauri et al. (1830), Tenore (1831, 1832, 1835, 1842), Tenore & Gussone (1842), Cesati (1872, 1873), Terracciano (1872, 1873, 1874, 1878, 1890), Rigo (1877), Groves (1880), Nardelli (1883), Crugnola (1894), Falqui (1899) e altri che in alcuni loro scritti citano il ritrovamento di varie Orchidaceae.

Nel secolo successivo le ricerche e pubblicazioni aumentarono e tenendo conto di esse, Pignatti (1982) nella sua flora d'Italia riportò per la Regione quarantanove diverse entità subgeneriche. In seguito altri studi sono stati pubblicati di cui alcuni monografici che hanno contribuito a incrementare il patrimonio orchidologico regionale. Essi sono iniziati con Lastoria (1988) che nel suo testo sosteneva che nella regione erano presenti oltre cinquanta specie: ne riporta le schede di quarantadue e segnala la presenza anche di due ibridi. In seguito le ricerche floristiche nel territorio regionale abruzzese hanno registrato una nuova crescita. Vengono in seguito riportati alcuni cenni riassuntivi sulle principali ricerche riguardanti la famiglia delle Orchidaceae.

Conti & Pellegrini (1990) nel loro volume riportavano le schede di sessantasei taxa e ne indicavano altre all'epoca segnalate da vari ricercatori per un totale di circa settanta. Inoltre nel loro lavoro citano la presenza di due ibridi uno dei quali segnalato in precedenza anche da Lastoria (1988).

Daiss & Daiss (1996) a loro volta segnalano per l'Abruzzo settantanove taxa incrementandoli di alcune unità rispetto al lavoro precedente. Conti (1998) riporta settantacinque taxa distinti tra specie e sottospecie. Griebl (2010) contribuisce ad accrescere il patrimonio orchidologico regionale segnalando oltre novanta entità mentre considera dubbie altre segnalate in precedenza. Colella et al. (2011) segnalano per la Regione settantatré diversi taxa distinti tra specie e sottospecie. Pezzetta (2013), a sua volta ne riporta novantasette ed infine nel recente volume del GIROS (2016) si riportano per l'Abruzzo novantadue taxa.

Le pubblicazioni riportate forniscono dati discordanti tra loro. Alla luce di tali fatti si rende opportuno compilare un nuovo elenco delle entità presenti facendo notare quali possono essere considerate discutibili e/o dubbie.

Materiali e metodi

L'elenco floristico che segue è stato realizzato tenendo conto delle ricerche sul campo dell'autore, dei nuovi arrangiamenti tassonomici, delle segnalazioni inedite di vari studiosi e dei dati ricavati dalle consultazioni bibliografiche successive alla monografia di Pezzetta (2013). Esso comprende le specie, le sottospecie e gli ibridi mentre non sono state prese in considerazione le varietà cromatiche e morfologiche.

L'elenco floristico non comprende vari taxa segnalati in precedenza che alla luce delle conoscenze attuali e dei nuovi arrangiamenti tassonomici sono considerati non presenti. Accanto ad ogni taxon sono riportati: il

tipo corologico, gli autori che l'hanno segnalato e le eventuali osservazioni sul rango tassonomico. Non sono riportati nell'elenco gli autori d'indicazioni generiche inserite in pubblicazioni scientifiche che sconfinano anche in altre regioni e non indicano nessuna località abruzzese di presenza.

Considerata la vastità delle pubblicazioni esistenti, in tale sede sono state prese in considerazione le fonti successive al 1986, includendo segnalazioni antecedenti solo nel caso in cui queste riportassero per la prima volta il ritrovamento di un taxon, lo riconfermassero o ne approfondissero il rango tassonomico.

Per la nomenclatura delle varie entità si sono seguite le indicazioni del recente volume a cura del GIROS (2016) con varie precisazioni che sono riportate nelle osservazioni ai vari taxa dell'elenco floristico.

Per l'assegnazione dei tipi corologici si è tenuto conto di Pignatti (1982) e Pezzetta (2011). Inoltre per varie entità, tenendo conto dell'attuale distribuzione geografica, si è operata una ridefinizione del corotipo di appartenenza.

RISULTATI E DISCUSSIONE

Elenco florisitico

Nell'elenco sotto riportato le lettere maiuscole sono sigle che si riferiscono agli autori delle segnalazioni e hanno il seguente significato:

AA: Tammaro 1986; AX: Kalteisen & Reinhard 1987; AY: Baumann e Baumann 1988;

AZ: De Angelis & Scacchi 1988; BB: Lastoria 1988; BX: Conti & Pellegrini 1990;

BY: Daiss & Daiss 1996; CC: Conti 1998; CX: Centurione 1999; CY: Hennecke & Hennecke 1999; DD: Di Pede 2001; DX: Tinti & Conti 2002; DY: Conti et al. 2006; DZ: Hertel & Presser 2006; EE: Bongiorni et al. 2007; EX: Galetti 2008; EY: Soca 2008; FF: Souche 2008a;

FH: Souche 2008b; FX: Hertel & Presser 2009; FY: Griebl 2010; GG: Colella et al. 2011;

GH: Ferrari 2011; GX: Paris & Scivola 2011; GY: Romolini & Soca 2011a; HH: Romolini & Soca 2011b; HX: Conti & Manzi 2012; HY: Conti & Tinti 2012; IA: Romolini & Souche 2012;

IX: Pezzetta 2013; IY: Romolini & Soca 2014; LL: Soca 2014; LX: Brunamonte et al. 2015;

LY: Conti & Bartolucci 2015; MM: Lorenz et al. 2015; MX: Pezzetta 2015; MY: Soca 2015;

NN: Conti & Bartolucci 2016; NX: Giros 2016; NY: Pezzetta 2016; OO: Souche informazione personale.

1. *Anacamptis coriophora (*subsp. *fragrans* (Pollini) R.M. Bateman, Pridgeon & M.W. Chase – Eurimediterraneo (AA, BX, BY, CC, FY, GG, HX, IX, LY, MX, MY, NN, NX, NY).
2. *Anacamptis laxiflora (*Lam.) R.M. Bateman, Pridgeon & M.W. Chase – Eurimediterraneo (BX, BY, CC, CY, DD, EX, FY, GG, IX, LX, NX, NY).
3. *Anacamptis morio* (L.) R.M. Bateman, Pridgeon & M.W. Chase - Europeo-Caucasico (AA, BB, BX, BY, CC, CY, DD, DX, EX, EY, FY, GG, GH, GX, HH, HY, IX, LX, MX, MY, NX, NY).
4. *Anacamptis papilionacea* (L.) R.M. Bateman, Pridgeon & M.W. Chase - Eurimediterraneo (BB, BX, CC, EX, FY, IX, MX, MY, NX, NY).
5. *Anacamptis palustris* (Jacq.) R.M. Bateman, Pridgeon & M.W. Chase – Eurimediterraneo (CC, DX, FY, GG, IX, NX).
6. *Anacamptis pyramidalis* subsp. *pyramidalis* (L.) Rich. – Eurimediterraneo (AA, BB, BX, BY, CC, CX, CY, DX, EX, FY, HH, IX, MX, MY, NX, NY).
7. *Anacamptis pyramidalis* subsp. *serotina* Presser – Eurimediterraneo (FY, IX, NX).
8. *Barlia robertiana* (Loisel.) Greuter – Stenomediterraneo (BY, EX, FY, GG, IX, NX).
9. *Cephalanthera damasonium* (Mill.) Druce – Eurimediterraneo (AA, BB, BX, BY, CC, CY, DD, DX, EX, FY, GG, HX, HY, IX, MX, MY, NX, NY).
10. *Cephalanthera longifolia* (L.) Fritsch – Eurasiatico (AA, BB, BX, BY, CC, CY, DD, DX, EE, EX, FY, IX, MX, NX, NY).
11. *Cephalanthera rubra* (L.) Rich. – Eurasiatico (AA, BB, BX, BY, CC, EX, FY, GG, HX, HY, IX, MX, NX, NY).
12. *Coeloglossum viride* (L.) Hartm. – Circumboreale (AA, BB, BX, BY, CC, DX, EX, FY, GG, IX, MX, NX).
13. *Corallorhiza trifida* Chatel. – Circumboreale (AA, BB, BX, BY, CC, CY, EX, FY, GG, IX, MX, NX, NY).
14. *Cypripedium calceolus* L. – Eurosiberiano (BB, BX, BY, CC, EX, FY, GG, IX, LY, NX, NY).
15. *Dactylorhiza incarnata* (L.) Soó – Eurosiberiano (AA, BB, BX, BY, CC, DX, EX, FY, IX, MX, NX, NY).
16. *Dactylorhiza maculata* (L.) Soó subsp. *fuchsii* (Druce) Hyl. – Eurasiatico (BY, DX, DX, EX, FY, IX, MX, NX, NY.
17. *Dactylorhiza maculata* subsp. *saccifera* (Brongn.) Diklić (sin. *D. gervasiana* [Tod.] H. Baumann & Künkele) – Paleotemperato (AA, BY, CY, EE, EX, HY, IX, MX, NX, NY). Lastoria (1988) segnala per l'Abruzzo *D. maculata* subsp. *maculata*. Secondo vari autori la sua presenza in Italia è dubbia e pertanto essa deve essere ricondotta a una delle altre due sottospecie elencate.
18. *Dactylorhiza romana* (Sebast.) Soó – Stenomediterraneo (CY, IX, NX).
19. *Dactylorhiza sambucina* (L.) Soó – Europeo (AA, BB, BX, BY, CC, CY, DX, EX, FY, GG, GH, HY, IX, MX, MY, NX, NY).
20. *Epipactis atrorubens* (Hoffm.) Besser – Europeo (AY, BB, BX, BY, CC, CY, EE, EX, FY, IX, MX, NX, NY).
21. *Epipactis distans* Arvet-Touvet (sin. *E. helleborine* subsp. *orbicularis* (K. Richt.) E. Klein) – Centro-Europeo (EE, HY, IX, LY, NN, NX, NY).
22. *Epipactis exilis* P. Delforge (sin. *E. persica* subsp. *gracilis* (B. Baumann & H. Baumann) W. Rossi) –

Sud-Est-Europeo (AY, BX, CC, CY, FY, GG, IX, MX, NX).

23. *Epipactis helleborine* subsp. *helleborine* (L.) Crantz – Paleotemperato (BB, CC, DX, EE, EX, FY, HX, IX, MX, NX, NY).
24. *Epipactis leptochila* subsp. *leptochila* (Godfery) Godfery – Centro-Europeo (CC, FY, GG, IX, LY, NX, NY).
25. *Epipactis lucana* H. Presser, S. Hertel & V. A. Romano – Endemico (Hertel & Presser 2015, NY).
26. *Epipactis meridionalis* H. Baumann & R. Lorenz – Endemico (FY, GG, IX, NX).
27. *Epipactis microphylla* (Ehrh.) Sw. – Europeo-Caucasico (AA, BX, BY, CC, CX, DD, DX, EX, FY, GG, HX, IX, MX, NX, NY).
28. *Epipactis muelleri* Godfery – Centro-Europeo (AY, BX, BY, CC, EX, FY, GG, IX, MX, NN, NX, NY).
29. *Epipactis neglecta* (Kümpel) Kümpel – Centro-Europeo (EE, FY, IX, NX).
30. *Epipactis palustris* (L.) Crantz – Circumboreale (AY, BX, BY, CC, DX, EX, FY, GG, IX, MX, NX, NY).
31. *Epipactis purpurata* Sm. – Subatlantico (BY, BY, CC, FY, GG, IX, LY, MX, NN, NX, NY).
32. *Epipogium aphyllum* Sw. – Eurosiberiano (BB, BY, CC, FY, GG, IX, NN, NX, NY).
33. *Gymnadenia conopsea* (L.) R. Br. in W. T. Aiton – Eurasiatico (AA, BB, BX, BY, CC, CY, DD, DX, EE, EX, FY, GG, HH, IX, LX, MX, MY, NX, NY).
34. *Himantoglossum adriaticum* H. Baumann – Eurimediterraneo (BB, BX, BY, CC, CY, DD, DX, FY, HH, IX, MX, MY, NX, NY).
35. *Limodorum abortivum* (L.) Sw. – Eurimediterraneo (AA, BB, BX, BY, CC, CX, CY, DD, EE, EX, FY, GG, HX, IX, MX, MY, NX, NY).
36. *Listera ovata* (L.) R. Br. – Eurasiatico (AA, BB, BX, BY, CC, CY, DX, EX, FY, GG, IX, MX, NX, NY).
37. *Neotinea lactea* (Poir.) R.M. Bateman, Pridgeon & M.W. Chase – Stenomediterraneo (FY, IX, NX).
38. *Neotinea maculata* (Desf.) Stearn - Mediterraneo-Atlantico (BX, BY, CC, CY, EX, FY, GG, IX, MX, MY, NX, NY).
39. *Neotinea tridentata* (Scop.) R.M. Bateman, Pridgeon & M.W. Chase – Eurimediterraneo (AA, BB, BX, BY, CC, CY, DD, DX, EX, EY, FY, GG, GH, HY, IX, MX, MY, NX, NY).
40. *Neotinea ustulata* (L.) R.M. Bateman, Pridgeon & M. W. Chase - Europeo-Caucasico (BB, BX, BY, CC, CY, EX, FY, GG, IX, MX, NX).
41. *Neottia nidus-avis* (L.) Rich. – Eurasiatico (AA, BB, BX, BY, CC, CY, EE, EX, EY, FY, GG, IX, MX, NX, NY).
42. *Nigritella rubra* Teppner & E. Klein subsp. *widderi* H. Baumann & R. Lorenz – Subendemico (BB, BX, BY, CC, EX, FY, GG, IX, LY, MX, NY).
43. *Ophrys apifera* Huds. – Eurimediterraneo (BB, BX, BY, CC, CX, DD, EX, FY, GG, HH, HX, IA, IX, MX, MY, NX, NY).
44. *Ophrys argolica* subsp. *crabronifera* (Sebast. & Mauri) Faurh. – Endemico (BB, BY, CC, EX, EY, FY, GG, GX, IA, IX, LX, MX, MY, NN, NX, NY).
45. *Ophrys bertolonii* subsp. *bertolonii* Moretti - Appennino-Balcanico (AA, AX, BB, BX, BY, CC, CX, CY, DD, EX, EY, FY GG, GH, HH, HX, IX, MX, MY, NX, NY). Sono state ricondotte al taxon tutte le segnalazioni di *O. romolinii* Soca.
46. *Ophry bertolonii* subsp. *bertoloniformis* (O. Danesch & E. Danesch) H. Sund. - Endemico (BX, BY, CY, F, IX). Secondo Conti & Bartolucci (2015) tutte le segnalazioni del taxon per il Parco Nazionale d'Abruzzo, Lazio e Molise devono riferirsi *Ophrys bertolonii* subsp. *bertolonii*). Non indicata per l'Abruzzo in GIROS (2016).
47. *Ophrys bombyliflora* Link – Stenomediterraneo (BX, BY, CC, EX, FY, GG, IA, IX, NX).
48. *Ophrys exaltata* subsp. *archipelagi* (Gölz & H.R. Reinhard) Del Prete – Appennino-Balcanico (CX, FY, GG, HX, IX, LY, MY, NN, NX, NY). Sono state riportate al taxon tutte le segnalazioni di *Ophrys exaltata* subsp. *exaltata* Ten.
49. *Ophrys fusca* subsp. *funerea* (Viv.) Arcang. (sin. *O. sulcata* Devillers. Tersch. & Devillers) – Stenomediterraneo (FY, IA, IX, MY, NN, NX, NY).
50. *Ophrys fusca* subsp. *lucana* (P. Delforge, Devillers-Tersch. & Devillers) Kreutz – Endemico (EY, FY, HH, IA, IX, LX, MX, MY, NX, NY).
51. *Ophrys holosericea* (Burm. f.) Greuter subsp. *appennina (*Romolini & Soca) Kreutz – Endemico (GY, IA, IX, MX, MY, NX, NY).
52. *Ophrys holosericea* (Burm. f.) Greuter subsp. *dinarica* (Kranjcev & P. Delforge) Kreutz – Appennino-Balcanico (FX, HH, IA, IX, LX, MX, MY, NX, NY). Secondo Conti & Bartolucci (2015) probabilmente devono essere ricondotte al taxon tutte le segnalazioni per il Parco Nazionale d'Abrzzo, Lazio e Molise riguardanti *Ophrys apulica*, *Ophrys scolopax* e *Ophrys bremifera* susbp. *oestrifera*.
53. *Ophrys holosericea* subsp. *gracilis* (Büel, O. Danesch & E. Danesch) Büel, O. Danesch & E. Danesch – Endemico (BY, FY, HH, IA, IX, LY, MX, NN, NX, NY).
54. *Ophrys holosericea* subsp. *parvimaculata* (O. Danesch & E. Danesch) O. Danesch & E. Danesch – Endemico (BB, IX, NX).
55. *Ophrys holosericea* (Burm. f.) Greuter subsp. *pinguis* (Romolini & Soca) Kreutz– Endemico (GY, IA, IX, MX, MY, NN, NX, NY).
56. *Ophrys holosericea* (Burm. f.) Greuter subsp. *serotina* (Rolli ex H. F. Paulus) Kreutz. – Subendemico (FY, IX, MX, NY). Segnalata in Istria, Friuli Venezia Giulia e varie località dell'Italia centrale.
57. *Ophrys holosericea* subsp. *tetraloniae* (W.P. Teschner) Kreutz - Appennino-Balcanico (BY, CC, EX, FY, HH, IA, IX, LY, MX, MY, NY). Sono state ricondotte al taxon tutte le segnalazioni nel territorio

abruzzese riguardanti *O. holosericea* subsp. *elatior* (Gumprecht) Gumprecht e *O. holosericea* subsp. *posidonia* (P. Delforge) Kreutz.

58. *Ophrys illyrica* S. Hertel & K. Hertel – Appennino-Balcanico (FY, HH, IX, MX, IA, LY, MY; NX come *O. ausonia*, NY). In accordo con Hertel & Presser (2006) *O. ausonia* e *O. illyrica* sono considerati sinonimi. In alcuni lavori precedenti lo scrivente aveva ricondotto a *Ophrys illyrica* le segnalazioni per l'Abruzzo di *O. riojana*.
59. *Ophrys incubacea* Bianca subsp. *brutia* (P. Delforge) Kreutz– Endemico (IA, MX, MY, NX).
60. *Ophrys incubacea* Bianca subsp. *incubacea* – Stenomediterraneo. (BB, BY, CC, CY, DX, EY, EX, FY, GG, IA, IX, MX, MY, NX NY).
61. *Ophrys insectifera* L. – Europeo (BX, BY, CC, CY, DX, EX, FY, GG, IA, IX, LX, NX NY).
62. *Ophrys lacaitae* Lojac. – Appennino-Balcanico (FY, HH, IA, IX, LY, MX, NX NY).
63. *Ophrys lutea* Cav. subsp. *corsica* (Soleirol ex G. Foelsche & W. Foelsche) Kreutz – Mediterraneo-Orientale (NN, NX). Secondo Conti & Bartolucci (2016) dovrebbero essere ricondotte al taxon tutte le segnalazioni per l'Abruzzo di *Ophrys lutea* subsp. *minor* (Tod.) O. Danesch & E. Danesch (sin. *O. sicula* Tin.).
64. *Ophrys lutea* subsp. *lutea* Cav. – Stenomediterraneo (BX, BY, CC, EX, GG, HX, IA, NX).
65. *Ophrys molisana* Delforge – Endemico. (Deforge 2016). Lo scrivente ha osservato la specie nei pressi di Campo di Giove (41. 965989, 14.07163) e Santo Stefano di Sessanio.
66. *Ophrys passionis* subsp. *majellensis* (Helga & Herm. Daiss) Romolini & Soca. – Endemico (BY, DD, EX, FY, IA, IX, NX NY).
67. *Ophrys passionis* subsp. *passionis* Sennen ex Devillers-Tersch. & Devillers (sin. *O. garganica* O. Danesch & E. Danesch) – Mediterraneo-Occidentale (BY, CC, CY, EX, FY, IA, IX, NX NY).
68. *Ophrys promontorii* O. Danesch & E. Danesch – Endemico (AX, BB, BX, BY, CC, EX, EY, FY, GG, GH, HY, IA, IX, LX, MX, MY, NX NY).
69. *Ophrys speculum* Link – Stenomediterraneo (BB, BX, BY, CC, DD, GG, DY, GX, IA, IX, LY, MX, MY, NX NY).
70. *Ophrys sphegodes* subsp. *minipassionis* (Romolini & Soca) Biagioli & Grünanger – Endemico (IA, MX, NN, NX NY).
71. *Ophrys sphegodes* subsp. *sphegodes* Mill. – Eurimediterraneo (AA, BB, BX, BY, CC, CY, EX, FY, GX, GG, GH, IX, LX, MX NY). Sono state ricondotte al taxon tutte le segnalzioni di *Ophrys aranifera* s.l. fatte da Soca (2015). Souche (2008b), Romolini & Soca (2011b), Romolini & Souche (2012), Conti & Bartolucci (2015 e 2016) e GIROS (2016) segnalano per l'Abruzzo *O. classica*, un'entità controversa che Greuter (in Euro+Med 2006) e Hertel & Presser (2006) pongono in sinonimia con *O. sphegodes*, e che è da approfondire ulteriormente (De Simoni & Biagioli 2016).
72. *Ophrys sphegodes* subsp. *tarquinia* (P. Delforge) Kreutz. – Endemico (EY, FH, IX, MX, NN NY).
73. *Ophrys sphegodes* subsp. *tommasinii* (Vis.) Soó. – Appennino-Balcanico (CY come *O. araneola*, DZ, FY, IX, MX NY). Sono state ricondotte alla specie tutte le segnalazioni per l'Abruzzo relative a *O. litigiosa* E.G. Camus, *O. araneola* subsp. *araneola* Rchb. e *O. riojana* (C. E. Hermos.) Biagioli & Grünanger. Come più volte scritto le varie piante osservate e pubblicate con tale denominazione, secondo lo scrivente presentano caratteri riconducibili *a Ophrys tommasinii* e talvolta a *O. illyrica*. In questa sede, si è optato per la denominazione di *O. tommasinii* tenendo anche conto che Delforge (2016) ritiene che le popolazioni abruzzesi di *O. riojana* vadano assegnate a *O. incantata*, un'entità che da vari studiosi è da porre in sinonimia con *O. tommasinii* stessa. Secondo Hertel & Presser (2006) le piante a piccoli fiori presenti lungo il massiccio della Majella che appartengono al gruppo di *Ophrys sphegodes* non mostrano differenze reali rispetto al taxon in oggetto e quindi confermano la sua presenza in Abruzzo.
74. *Ophrys tenthredinifera* subsp. *neglecta* (Parl.) E.G. Camus – Stenomediterraneo (BY, CC, EX, FY, GG, IX, NN, NX).
75. *Orchis anthropophora* (L.) All. - Mediterraneo-Atlantico (AA, BB, BX, BY, CC, CX, CY, DD, EX, EY, FY, GG, GX, HX, HY, IX, LX, MX, MY, NX NY).
76. *Orchis italica* Poir. – Stenomediterraneo (BB, BX, BY, CC, CX, DD, EX, EY, FY, GG, GH, GX, HH, HX, IX, MX, MY, NX NY).
77. *Orchis mascula* subsp. *mascula* (L.) L. – Europeo-Caucasico (CC, DX, DX, DX, EX, FY, GH, IX, MX, NX NY).
78. *Orchis mascula* subsp. *speciosa* (Mutel) Hegi. (sin. *O. mascula* [L.] L. subsp. *signifera* [Vest.] Soó) – Centro-Europeo (AA, CY, FY, IX, MX, NX NY).
79. *Orchis militaris* L. – Eurasiatico (AA, BX, BY, CC, CY, EX, FY, GG, GH, IX, MX, NN, NX NY).
80. *Orchis pallens* L. – Europeo-Caucasico (BX, BY, CC, CY, DX, EX, FY, GG, GH, IX, MX, NX NY).
81. *Orchis pauciflora* Ten. – Stenomediterraneo (BB, BX, BY, CC, CY, DD, EX, FY, GG, GH, GX, HY, IX, LX, MX, MY, NX NY).
82. *Orchis provincialis* Balb. Ex Lam. – Stenomediterraneo (BX, BY, CC, CY, DD, EX, FY, GG, IX, LY, MY, NN, NX NY).
83. *Orchis purpurea* Huds. – Eurasiatico (AA, BB, BX, BY, CC, CX, CY, DD, DX, EX, EY, FY, GG, GH, HH, HX, IX, LX, MX, MY, NX NY).
84. *Orchis quadripunctata* Cirillo ex Ten. – Mediterraneo-Orientale (BY, CC, EX, FY, GG, IX, NX).

85. *Orchis simia* Lam. – Eurimediterraneo (AA, BB, BX, BY, CC, CY, DD, EX, FY, GG, HX, IX, MY, NX) NY.
86. *Orchis spitzelii* Saut. – Europeo-Caucasico (BB, BX, BY, CC, EX, FY, GG, IX, NN, NX NY).
87. *Platanthera algeriensis* Batt. & Trab. – Mediterraneo-Occidentale (FY, IX, LY, MX, NN NY). In GIROS (2016) non è riportata per l'Abruzzo.
88. *Platanthera bifolia* (L.) Rchb. subsp. *bifolia* – Paleotemperato (AA, BX, BY, CC, EX, IX, MX, MY NY).
89. *Platanthera bifolia* (L.) Rchb subsp. *osca* R. Lorenz, Romolini, V.A. Romano & Soca – Endemico (MM, NX NY).
90. *Platanthera chlorantha* (Custer) Rchb. – Eurosiberiano (AA, BB, BY, CC, DD, EX, FY, GG, IX, MX, MY, NX NY)
91. *Pseudorchis albida* (L.) A. Löve & D. Löve - Artico-Alpino (AA, BY, CC, EX, FY, GG, IX, LY, MX, NX NY).
92. *Serapias cordigera* L. – Stenomediterraneo (BX, BY, CC, EX, IX, MX, NN, NX).
93. *Serapias lingua* L. – Stenomediterraneo (BX, BY, CC, EX, IX, MX, NX).
94. *Serapias parviflora* Parl. – Stenomediterraneo (BX, BY, CC, CY, FY, GG, HH, IX, MY, NN, NX NY).
95. *Serapias vomeracea* subsp. *longipetala* (Ten.) H. Baumann & & Künkele – Mediterraneo-Orientale (MX, MY, NX).
96. *Serapias vomeracea* (Burm.f.) Briq.subsp. *vomeracea* – Eurimediterraneo (AA, BB, BX, BY, CC, DD, FY, GG, HH, IX, MX, MY NY).
97. *Spiranthes spiralis* (L.) Chevall. – Europeo-Caucasico (BY, CC, DD, EX, FY, GG, IX, NN, NX NY).
98. *Traunsteinera globosa* (L.) Rchb. – Orof. Sud-Europeo (AA, BY, CC, FY, GG, IX, NN, NX NY).

Ibridi

1. *Anacamptis xalata* (Fleury) H. Kretzschmar, Eccarius & H. Dietr. (A. *laxiflora x A. morio*) (DD, FY, IX, MY NY).
2. *Anacamptis xgennarii* (Rchb. f.) Nazzaro & La Valva (*A. morio x A. papilionacea*) (FY, GX, IX, MX NY).
3. *Cephalanthera ×schulzei* EG Camus (*C. damasonium x C. longifolia*) (Allard informaz. person.).
4. *Coeloglossum viride* x *Dactylorhiza saccifera* (OO).
5. *Dactylorhiza* x*altobracensis* Coste (Soò). (*D. maculata* s. l. *x D. sambucina)* (AZ).
6. *Dactylorhiza* x*guillaumeae* C.Bernard (*D. incarnata* x *D. sambucina*) (NY, OO).
7. *Dactylorhiza* x*influenza* Sennholz (*D. fuchsii* x *D. sambucina*) (FY, IX, MX, NN).
8. *Dactylorhiza* x*serbica* Fleischm (*D. incarnata* x *D. saccifera*) (FY, IX, NN, NY).
9. *Dactylorhiza maculata* subsp. *saccifera* × *Gymnadenia conopsea* (MX, NN, OO).
10. *Epipactis* x*barreana* B.Baumann & H.Baumann. (*Epipactis helleborine* subsp. *latina* x *E. muelleri*) (AY, NY).
11. *Epipactis* x*capellonensis* B.Baumann & H.Baumann (*Epipactis atrorubens* x *E. helleborine* subsp. *latina*) (AY, IX, NY).
12. *Epipactis* x*vermionensis* B. Baumann & H. Baumann (*E. helleborine* subsp. *helleborine* x *E. persica* subsp. *gracilis*) (IX).
13. *Neotinea* x*dietrichiana* (Bogenh.) H. Kretzschmar, Eccarius & H. Dietr. (*N. tridentata* x*ustulata*) (FY, IX, MY, NY).
14. *Ophrys apifera* x *O. dinarica* (IX, MY, NN, NY).
15. *Ophrys apifera x O. majellensis (*FY*, IX*).
16. *Ophrys apifera* x *Ophrys pinguis* (MY, NY, OO).
17. *Ophrys apifera* x *Ophrys tetraloniae* (NY, OO).
18. *Ophrys appennina* x *Ophrys bertolonii* (MX, NY, OO come *Ophrys appennina* x *O. romolinii*).
19. *Ophrys appennina* x *O. dinarica* (IA, IX, MX, NY).
20. *Ophrys appennina* x *O. incubacea* (NY, OO).
21. *Ophrys appennina* x *O. tetraloniae* (IX, NY, OO).
22. *Ophrys bertolonii* x *O. gracilis* (SERAFINI 2015).
23. *Ophrys bertolonii* x *O. tetraloniae* (FY, IX, NY).
24. *Ophrys bertolonii* x *Ophrys tommasinii* (MY come O. *romolinii* x *O. riojana,* NY).
25. *Ophrys bertolonii* x *O. serotina*.(FY, IX).
26. *Ophrys brutia* x *O. incubacea* (NY, OO).
27. *Ophrys dinarica* x *O. gracilis* (IA, IX, NY).
28. *Ophrys dinarica* x *O. promontorii* (E NY).
29. *Ophrys dinarica* x *O. sphegodes* subsp. *sphegodes* (FY, IX, MY come *O. aranifera* "Popoli" x *O. dinarica,* MX, NY).
30. *Ophrys dinarica* x *O. tommasinii* (MY come *O. dinarica* x *O. riojana,* NY).
31. *Ophrys exaltata* susbp. *archipelagi* x *O. promontorii* Capestrano (NY, OO).
32. *Ophrys gracilis* x *O. pinguis* (SERAFINI 2015, NY).
33. *Ophrys gracilis* × *O. sphegodes* (NY, OO).
34. *Ophrys illyrica* x *O. majellensis* (FF come *O. ausonia* x *O. majellensis*, IX).
35. *Ophrys incubacea* x *O. majellensis* (OO).
36. *Ophrys lacaitae* x *O. serotina* (FY, IX, NY).
37. *Ophrys majellensis* x *O. promontorii* (FY, IX).
38. *Ophrys passionis* subsp. *passionis* x *Ophrys promontorii* (E, NY).
39. *Ophrys promontorii* x *O. serotina* (FY, IX, NY).
40. *Ophrys promontori* x *O. tarquinia* (FF, IX, LY, MX, NY).
41. *Ophrys serotina* x *O. sphegodes* (FY, NY).
42. *Ophrys* x*angelensis* H.Baumann & Künkele (*O. incubacea* x *O. promontorii*) (EY, FY, IX, MX, MY, NN, NY).
43. *Ophrys* x*aquilana* H.Baumann & Künkele (*O. fuciflora* s. l. x *O. promontorii*) (AX, CY, FY).
44. *Ophrys* x*bilineata* Barla (*O. bertolonii* x *O. sphegodes* subsp. *sphegodes*) (FY, GH, IX, MX, NN come *O. bertolonii* x *O. classica*, NY).
45. *Ophrys* x*brunamontei* Soca (*O. dinarica* x *O. majellensis*) (IA, LL, NY).
46. *Ophrys xcamusii* Cortesi *(O. crabronifera x O. sphegodes* subsp. *sphegodes*) (LX, NY).

47. *Ophrys* ×*capistrelloi* Soca (*O. dinarica* x *O. tetraloniae*) (LL, NY).
48. *Ophrys* x*capracottae* Soca (*O. brutia* x *O. dinarica*) (IA, IY, NY).
49. *Ophrys* x*catinii* Soca (O. *bertolonii* x *O. pinguis*) (IA come *O. pinguis* x *O. romolinii*, IX).
50. *Ophrys* x*couloniana* P. Delforge (*O. bertolonii* x *O. promontorii*.) (AX, FY, IX, MX, MY come *O. promontorii* x *O. romolinii*, GH, NN, NY).
51. *Ophrys* x*dekegheliana* P. Delforge (*O. bertolonii* x *O. majellensis*) (FF come *O. majellensis* x *O. romolinii*, FY, IX).
52. *Ophrys* x*flahaultii* Ladouze (*O. apifera* x *O. sphegodes* (OO come *O. apifera* x *O. classica*).
53. *Ophrys* ×*hybrida* Pokorny ex Rchb. f. (*O. insectifera* × *Ophrys sphegodes*) (LX, NY).
54. *Ophrys* ×*impresciae* Soca (*O. dinarica* x *O. pinguis*) (IA, IX, NY).
55. *Ophrys* x*lociceroi* Soca. (*O. lucana* x *O. majellensis*) (IA, IX, LL).
56. *Ophrys* x*lyrata* H. Fleischm. (*O. bertolonii* x *O. incubacea*) (EY, FF come O. *romolinii* x *O. incubacea*; FY, IX, MX, NY).
57. *Ophrys* x*palenae* Soca (*O. brutia* x *O. majellensis*) (SOCA 2014).
58. *Ophrys* x*pauli* Fuchs (*O. sphegodes* x *O. tommasinii*) (E).
59. *Ophrys* x*pescocanalei* Soca (*O. pinguis* x *O. tetraloniae*) (IA, LL, NY).
60. *Ophrys* x*petruccii* Romolini & Soca (*O. apifera* x *O. appennina*) (IY, MX, NY).
61. *Ophrys* x*piconei* Soca (*O. bertolonii* x *O. dinarica*) (FF, IA e LL come *O. dinarica* x *O. romolinii*; IX, MX, NY).
62. *Ophrys* ×*recchiae* Soca (*O. dinarica* x *O. incubacea*) (EY, FF, IA, IX, LL, MX, MY, NY).
63. *Ophrys* x*terrae-laboris* W. Rossi & F.Minutillo (*O. promontorii* x *O. sphegodes*) (IX, MX, MY come *O. aranifera* "Popoli" x *O. promontorii*, NN, NY).
64. *Ophrys todaroana* Macchiati (*O. incubacea* x *O. sphegodes*) (FY, MY come *O. aranifera* "Popoli" x *O. incubacea*).
65. *Ophrys* x*trombettensis* Soca (*O. exaltata* susbp. *archipelagi* x *O. sphegodes* subsp. *sphegodes*) (OO come *O. exaltata* susbp. *archipelagi* x *O. aranifera* , NY).
66. *Ophrys* ×*vernacchiae* Soca (*O. bertoloni* × *O. brutia*) (SOCA 2014 come *O. brutia* × *O. romolinii*, MX, NY).
67. *Ophrys* x*vespertilio* W. Rossi & M. Contorni (*O. apifera* x *O. bertolonii*) (OO come *O. apifera* x *O. romolinii*, NY).
68. *Orchis* x*bivonae* Tod. (*O. antropophora* x *O. italica*) (IX, MX).
69. *Orchis* x*amsittenii* Hautz (*Orchis mascula* x *O. spitzelii*) (NY, OO).
70. *Orchis* x*angusticruris* Franch. ex Rouy (*O. purpurea* x *O. simia*) (DD, FY, IX, NY).
71. *Orchis* x*bergoni* Nanteuil (*O. antropophora* x *O. simia*) (FY, IX, NY).
72. *Orchis* x*colemanii* Cortesi (*O. mascula* s. l. x *O. pauciflora*) (BB, BY, CY, FY, GH, IX, MX, MY, NN, NY).
73. *Orchis* x*hybrida* (Lindl.) Boenn. ex Rchb. (*O. militaris* x *O. purpurea)* (BB, DX, FY, GH, IX, MX, NY).
74. *Orchis* x*klopfensteiniae* P. Delforge (*O. pallens* x *O. spitzelii*) (FY, IX, NY).
75. *Orchis* ×*lorenziana* Brügger (Orchis *mascula* x *O. pallens*) (NY, OO).
76. *Orchis* x*penzigiana* A. Camus *(O. mascula* x *O. provincialis*) (NY, OO).
77. *Orchis O.* x*spuria* Rchb. f.) (*O. antropophora* x *O. militaris*) (FY, IX, NY).

L'elenco floristico sopra riportato è costituito da novantotto diverse entità distinte in specie e sottospecie. Tale numero, facendo riferimento a GIROS (2016), costituisce il 41,9 delle Orchidaceae presenti in Italia. All'insieme di tali entità si aggiungono settantasette ibridi per cui l'ammontare complessivo dei taxa è di 175. Rispetto a quanto riportato in Pezzetta (2013) si registra un incremento di una specie e quaranta ibridi.

Le varie entità sono ripartite in ventuno generi. Il più rappresentato è il genere *Ophrys* con trentatré taxa. Seguono i generi *Orchis* ed *Epipactis* con dodici specie, *Anacamptis* con sette, *Serapias* e *Dactylorhiza* con cinque, *Neotinea* e *Platanther*a con quattro, *Cephalanthera* con tre e tutti gli altri con valori inferiori.

Nel territorio abruzzese i seguenti generi raggiungono la maggior diversità rispetto a tutte le altre regioni italiane: *Anacamptis, Neotinea*, *Orchis* e *Platanther*a. Inoltre sono presenti tutte le specie del genere *Cephalanthera* appartenenti alla flora italiana.

I recenti rimaneggiamenti tassonomici e le nuove ricerche portano a escludere dalla flora abruzzese le seguenti entità riportate in studi precedenti e non inserite nel presente elenco:

- *Ophrys fusca* subsp. *fusca* Link. (BX, BY, IX). Secondo Romolini & Souche (2012), Delforge (2016) e GIROS (2016) in Italia il taxon è assente, mentre con tale denominazione ora s'indicano solo individui presenti nella penisola iberica. Le popolazioni presenti nel territorio italiano, a loro volta, tenendo conto di piccole differenze morfologiche e fenologiche sono state ripartite in varie sottospecie nella maggioranza dei casi endemiche e presenti in ambiti molto ristretti.
- *Epipactis helleborine* subsp. *latina* W. Rossi & E. Klein. (AY, BY, CC, EX, FY, IX, LY, MX). Bongiorni et al. (2014) considerano il taxon, un ecotipo da ricondurre a *E. helleborine* subsp *helleborine* con caratteri morfologici mutati a causa di una maggiore esposizione alla luce solare. Delforge (2016) a sua volta fa rientrare il taxon nella variabilità di *Epipactis tremolsii* C. Pau.
- *Epipactis savelliana* Bongiorni, De Vivo & Fori – Endemico. (EE, IX, NX). Ad avviso di Hertel & Presser

(2014) e Delforge (2015) deve considerarsi una varietà di *Epipactis leptochila*.

- *Ophrys holosericea* subsp. *apulica*. Danesch & E. Danesch) Buttler – (BX, BY, CC, CY, EX, IX, NX). Romolini & Souche (2012) non riportano il taxon per l'Abruzzo mentre Conti & Bartolucci (2015), come visto, sostengono che probabilmente tutte le sue segnalazioni per il Parco Nazionale d'Abrzzo, Lazio e Molise devono essere ricondotte a *O. dinarica*.
- *Ophrys holosericea* subsp. *holosericea* (Burm. f.) Greuter. – Eurimediterraneo. IN GIROS (2016) la specie è segnalata in tutta Italia. Secondo Delforge (2016) è un'entità a distribuzione centro-europeo-occidentale i cui limiti meridionali sono poco conosciuti a causa della confusione con taxa simili. Ad avviso dello scrivente le recenti descrizioni di *O. apennina* e *O. pinguis*, due nuove entità con cui è da porre in sinonimia, portano alla sua esclusione dalla flora abruzzese. Tuttavia la presenza in natura di piante con caratteristiche intermedie di difficile classificazione e il fatto che le differenze morfologiche tra le due nuove specie sono minime dovrebbero condurre a una revisione tassonomica e altri studi e ricerche.
- *Ophrys lutea* subsp. *minor* (Tod.) O. Danesch & E. Danesch (sin. *O. sicula* Tin.) (BY, FY, MX). Romolini & Souche (2012) e GIROS (2016) non la riportano per l'Abruzzo.
- *Ophrys oxyrrinchos* Todaro subsp. *oxyrrinchos*. –Ad avviso di Conti (1998) deve essere confermato per l'Abruzzo mentre Colella et al. (2011) ritengono certa la sua presenza. Non riportato per l'Abruzzo in GIROS (2016).
- *Ophrys scolopax* Cav. (Reinhard 1989, BX, BY, CC, EX, FY, F). Romolini & Souche (2012) lo escludono dalla flora italiana. Per Delforge (2016) il taxon in Italia è presente solo in Liguria. Ad avviso di Gulli & Tosi (in GIROS 2016) il taxon si può considerare assente o molto dubbio in Italia e le sue segnalazioni vanno riferite ad alcune sottospecie che in Abruzzo non sono mai state osservate o a forme scolopaxoide di *O. holosericea* s. l. Souche nel corso del 2016 ha trovato nell'isola di Pantelleria, diverse piante appartenenti alla specie.
- *Ophrys sphegodes* subsp. *riojana*. (EY, IA, LY, MY, NX). Delforge (2016) pone il taxon in sinonimia con *O. quadriloba* (Reichenbach fil.) E.G. Camus e ritiene che tutte le sue segnalazioni per l'Italia siano assegnate a *O. incantata* Devillers-Tersch. & Devillers, un'entità endemica istro-dalmata che da vari autori è posta in sinonimia con *O. tommasinii*. Ad avviso dello scrivente sono inspiegabili i processi migratori che avrebbe seguito *O. riojana* per portarsi dal centro d'origine all'altra parte del suo areale disgiunto e l'assenza nei territori intermedi rispetto al locus classicus.
- *Serapias bergonii* E.G. Camus. (CC, IX). In GIROS (2016) non è riportato per l'Abruzzo. Secondo Delforge (2016) Il taxon in Italia è presente solo in Calabria e Sicilia ove raggiunge il limite occidentale di distribuzione geografica.

Nell'elenco sono riportate le seguenti entità che presentano diverse criticità:

- *Dactylorhiza maculata* subsp. *fuchsii* e subsp. *saccifera*. Secondo Conti & Pellegrini (1990) in Abruzzo s'incontrano popolamenti con caratteri intermedi che talvolta rendono difficoltosa l'attribuzione a una delle due sottospecie. Pacifico & Biagioli in (GIROS 2016) sostengono che i caratteri distintivi tra le due entità sono deboli mentre in GIROS (2008), evidenziavano che l'Italia centrale è una zona di contatto tra gli areali di *Dactylorhiza maculata* subsp. *fuchsii* e *D. maculata* subsp. *saccifera* ove s'incontrano popolazioni in cui possono prevalere i caratteri dell'uno o dell'altro e quindi anche quelli intermedi.
- *Ophrys holosericea* subsp. *dinarica*. Faurholdt (2009) sostiene che l'entità deve considerarsi una varietà di *O. fuciflora (holosericea)*. Recentemente Delforge (2015) ha descritto per l'Abruzzo *Ophrys personata* che a suo avviso sostituirebbe il taxon in considerazione. Ciononostante, poiché nella Regione *O. dinarica* forma numerosi ibridi che andrebbero rinominati, in attesa di nuovi studi e ricerche, in tale sede si continua a utilizzare la vecchia denominazione.
- *Ophrys holosericea* subsp. *serotina* (Rolli ex H. F. Paulus) Kreutz. Romolini & Souche (2012) pongono in sinonimia il taxon con *O. tetraloniae*. Secondo Delforge (2016), invece, le due entità differiscono per il colore e grandezza della cavità stigmatica e, la lunghezza e larghezza dei petali. Biagioli (in GIROS 2016) s sua volta sostiene che *O. serotina* è un'entità dubbia con caratteri a volte vagamente più vicini a *O. tetraloniae* e tutte le sue segnalazioni per l'Italia centrale dovrebbero essere ascrivibili a *Ophrys holosericea* subsp. *posidonia*.
- *Ophrys holosericea* subsp. *tetraloniae*. Ad avviso di Delforge (2016) la specie è presente in Istria, Dalmazia Centrale e Veneto e le sue citazioni per altre località italiane probabilmente riguardano specie diverse.
- *Ophrys sphegodes* subsp. *sphegodes*. Tale specie è caratterizzata da una grande varibilità morfologica. De Simoni & Biagioli (in GIROS 2016) evidenziano che la nomenclatura del taxon è molto controversa. L'entità con tale denominazione a loro avviso è presente solo nell'Italia settentrionale mentre le popolazioni dell'Italia centro-meridionale andrebbero assegnate a *O. sphegodes* subsp. *classica*. Romolini & Souche (2012) a loro volta, assegnano le popolazioni abruzzesi a *O. classica* e a *O. aranifera s. l.*
- *Orchis mascula* subsp. *speciosa*. Secondo Gulli & Tosi (in GIROS 2016) il taxon è di dubbio valore tassonomico mentre secondo Perazza & Lorenz (2013) sarebbe esclusivo della catena alpina centro-orientale.
- *Platanthera bifolia* susp. *bifolia*. Non riportato per l'Abruzzo in GIROS (2016). La recente descrizione di

Platanthera bifolia subsp. *osca* porterebbe a escludere la specie nominale. Nella Regione il nuovo taxon raggiunge il limite settentrionale di distribuzione geografica e spesso in natura accade che al limite dei loro areali s'incontrino sottospecie appartenenti allo stesso gruppo. Alla luce di tale fatto la presenza della specie nominale non è da escludere, com'è confermato da recenti segnalazioni e da verifiche dello scrivente. Saranno le ricerche successive a portare chiarezza e a confermare o smentire quanto scritto.

- *Serapias vomeracea* subsp. *longipetala* e *S. vomeracea* subsp. *vomeracea* che non è riportata per l'Abruzzo in GIROS (2016). Secondo Delforge (2016), all'interno dell'areale di diffusione non s'incontrano mai popolazioni pure comprendenti un'unica sottospecie tra le due riportate. Lorenz (in GIROS 2016), a sua volta sostiene che all'interno dell'areale, singole piante possono essere attribuite sia a una sia all'altra tra le due sottospecie e di conseguenza alcuni studiosi considerano la subsp. *longipetala*, una varietà abbassando il suo rango tassonomico.

Altre specie tra cui *Neotinea lactea, Ophrys parvimaculata* e *O. tarquinia* sono segnalate solo in pochi contributi scientifici, non sono confermate in varie ricerche regionali e di conseguenza la loro presenza in Abruzzo potrebbe essere dubbia.

La criticità e quindi anche la presenza o meno di alcuni taxa si estende se si considera che vari studiosi non sempre concordano sul numero delle entità che costituiscono qualche genere appartenente alla famiglia. In particolare il genere *Ophrys* è molto discusso e le interpretazioni sul numero delle entità che lo costituiscono vanno da un minimo comprendente diciannove specie e quarantasei sottospecie proposto da Pedersen & Faurholdt (2007) a un massimo di oltre 350 (Delforge 2016).

Passando dall'insieme del genere *Ophrys* ad alcuni sottoinsiemi dei vari gruppi che lo costituiscono e che nella regione abruzzese sono rappresentati da diversi taxa, emergono altre criticità. In tal senso si può supporre che diverse segnalazioni emerse dalle consultazioni bibliografiche possano riferirsi allo stesso taxon. A tal proposito, dall'elenco floristico si nota che sono segnalate tre taxa del gruppo di *Ophrys holosericea* molto simili tra loro: *O. holosericea* subsp. *gracilis*, *O. holosericea* subsp. *serotina* e *O. holosericea* subsp. *tetraloniae*. E' possibile che tali segnalazioni possano essere espressione dei diversi punti di vista degli autori e indicativi di una stessa specie e della sua variabilità. Il gruppo cui appartengono comprende complessivamente 8 taxa e a quelle citate vanno aggiunte *O. appennina*, *O. dinarica*, O. *lacaitae, O. parvimaculata* e *O. pinguis*. In più occasioni lo scrivente tenendo conto di quanto sostenuto da Del Prete (1982) e Devey et al. (2009) ha evidenziato che i seguenti fattori, sono indicativi di ranghi tassonomici alquanto dubbi:

- Il forte sembramento in cui il taxon è stato sottoposto tenendo conto di piccole differenze morfologiche che sono state intrepretate come caratteri distintivi per indicare nuove specie.
- Molte di esse condividono habitat e periodo di fioritura. Ciò potrebbe dimostrare che non c'è la speciazione ecologica in cui la selezione divergente dall'ambiente (biotica o abiotica) spinge alla divergenza e alla formazione di nuovi taxa.
- Non sono chiari i meccanismi d'isolamento riproduttivo e speciazione che hanno portato alla loro genesi.
- Tra le popolazioni dello stesso gruppo che condividono lo stesso habitat avviene un flusso genico.
- Diverse piante del gruppo classificate ibride possono essere interpretate come forme intermedie di transizione tra le specie che le costituiscono e quindi ripropongono il problema della corretta definizione di ogni singolo taxon e dell'intervallo di variabilità dei suoi caratteri.

Considerazioni quasi analoghe possono essere applicate anche al gruppo *Ophrys exaltata* / *incubacea* / *sphegodes* che in ambito regionale è rappresentato da 11 taxa: *O. exaltata* subsp. *archipelagi*, *O. illyrica*, *O. incubacea* subsp. *brutia*, *O. incubacea* subsp. *incubacea*, *O. molisana*, *O. passionis* subsp. *majellensis*, *O. passionis* subsp. *passionis*, *O. sphegodes* subsp. *minipassionis* *O. sphegodes* subsp. *sphegodes*, *O. sphegodes* subsp. *tarquinia* e *O. sphegodes* subsp. *tommasinii*. Del Prete (1982) rilevava che l'identificazione e la definizione delle varie entità della Sect. *Araniferae* cui il gruppo in esame appartiene, incontrano notevoli difficoltà. Rossi (2001), a sua volta sostiene che il gruppo è costituito da popolamenti molto variabili che senza soluzioni di continuità sfumano nelle varie specie. Soliva & Widmer (2003), analizzando individui del gruppo di *O. sphegodes* raccolti in Italia e nel Sud della Francia hanno dimostrato che la differenziazione genetica tra i vari taxa è la più bassa tra tutte le orchidee e che a causa del flusso genico si ha una scarsa diversità tra le varie specie. Romolini & Souche (2012), esperti conoscitori del genere *Ophrys*, confermano l'alta variabilità che caratterizza il gruppo e alcuni popolamenti abruzzesi preferiscono indicarli con *Ophrys aranifera* seguito dalla località di ritrovamento (Bominaco, Capestrano, Navelli, Palena, etc.). Le ricerche di Sedeek et al. (2014) hanno evidenziato che dal punto di vista genetico *O. sphegodes* e *O. exaltata* sono indistinguibili. In alcuni casi le differenze morfologiche non sono corrisposte da isolamento riproduttivo oppure esemplari simili sono parzialmente isolati dal punto di vista riproduttivo. Questi dati sono spiegabili ammettendo che il periodo di formazione delle varie specie è abbastanza recente ed esse condividono alcuni aspetti del polimorfismo ancestrale (Peakall & Whitehead 2014). Altri studi tuttora in corso sottolineano che il genere *Ophrys* è di recente formazione, sta attraversando una fase di grande evoluzione, i caratteri genetici non variano insieme a quelli morfologici ed il numero dei taxa è caratterizzato da un continuo divenire.

Tab. 1: Corotipi delle Orchidaceae abruzzesi.
Tab. 1: Horotip kukavičevk v deželi Abruci.

Elementi geografici	Numero taxa	%
Endemico e Subendemico	**17**	**17,35**
Endemico	15	
Subendemico	2	
Mediterraneo	**34**	**34,69**
Eurimediterraneo	14	
Stenomediterraneo	15	
Est-Mediterraneo	3	
Ovest-Mediterraneo	2	
Eurasiatico	**22**	**22,45**
Eurasiatico s.s.	8	
Europeo-Caucasico	7	
Eurosiberiano	4	
Paleotemperato	3	
Nordico	**4**	**4,08**
Artico-Alpino	1	
Circumboreale	3	
Europeo	**18**	**18,37**
Europeo s.s.	3	
Centro-Europeo	6	
Orofita Sud-Est-Europeo	1	
Appennino-Balcanico	7	
Sud-Est-Europeo	1	
Mediterraneo-Atlantico	**3**	**3,06**
Mediterraneo-Atlantico	2	
Subatlantico	1	
Totale	**98**	**100**

Da un punto di vista generale, a favore dell'esistenza contemporanea di specie diverse appartenenti allo stesso gruppo che condividono identici ambiti geografici, giocano quattro ipotesi. Nella prima si tiene conto che può avvenire una speciazione localizzata provocata da una deriva genica cui segue un differenziamento casuale che produce specie simili dette anche "sister species" che occupano nicchie ecologiche analoghe. Nella seconda si ammette che l'isolamento riproduttivo potrebbe essere pregresso, una conseguenza di un processo di speciazione allopatrica causato dall'isolamento geografico. In seguito con le trasformazioni ambientali favorite dall'uomo, le varie entità colonizzano nuovi territori e vengono in contatto generando individui con caratteri intermedi. Nella terza ipotesi, la spiegazione dell'esistenza di un gran numero di taxa dello stesso gruppo si può avere ammettendo che una specie è definita se include tutti gli individui morfologicamente simili che hanno solo e sempre lo stesso e unico impollinatore. Nella quarta si ammette che le barriere riproduttive che favoriscono la speciazione tra popolazioni simpatriche possono essere costituite dai diversi impollinatori (isolamento floreale) e dalle variazioni del periodo di fioritura (isolamento temporale).

Da ciò segue che è possibile la speciazione simpatrica, l'isolamento riproduttivo nello stesso habitat e che popolazioni morfologicamente simili che non condividono l'insetto impollinatore appartengono a specie diverse. A tale ipotesi si può obbiettare facendo presente che individui considerati appartenenti alla stessa specie presenti in aree geografiche diverse non hanno sempre lo stesso pronubo, sono considerate specie diverse anche popolazioni costituite da individui molto dissimili che condividono lo stesso impollinatore e che non è ancora stato dimostrato che tutte le specie e sottospecie appartenenti a medesimi gruppi (nel nostro caso quelli di *Ophrys sphegodes* e *O. holosericea*) sono sempre impollinate da insetti diversi. Solo futuri studi e ricerche potranno chiarire tutti i dubbi e problemi che sono stati posti.

Essendo alcune entità del genere *Ophrys* discutibili, ne segue che la segnalazione di alcuni ibridi possa essere dubbia, e che esista la probabilità che segnalazioni di entità differenti, in realtà possano corrispondere allo stesso soggetto. In particolare, tra i vari ibridi riportati, sono dubbi quelli formati da specie parentali appartenenti allo stesso gruppo quali: *Ophrys appennina* × *O. dinarica*, *O. appennina* × *O. tetraloniae*, *O. dinarica* × *O. gracilis*, *O. gracilis* × *O. pinguis*, *O. dinarica* × *O. pinguis*, *O. brutia* × *O. incubacea*.

Nella Tabella 1 sono riportati i risultati dell'analisi corologica e da essa si può osservare che domina l'elemento mediterraneo con trentaquattro taxa. Esso è seguito dagli elementi: eurasiatico con ventidue, europeo con diciotto, endemico con diciassette, dall'elemento nordico con quattro e infine da quello mediterraneo-atlantico con tre.

La presenza di entità appartenenti a diciannove diversi corotipi è un dato di conferma che anche per le Orchidaceae l'ambito in esame rappresenta un crocevia di correnti migratorie di diversa origine e distribuzione geografica. Le entità endemiche registrate sono presenti anche in altre regioni peninsulari. E' esclusiva dell'Abruzzo solo *Epipactis savelliana*, che, come visto, non è riportata nell'elenco poiché considerata una varietà.

In Abruzzo sono segnalate anche sette specie appennino-balcaniche e tre mediterraneo-orientali che potrebbero rappresentare forme relittiche, attuali testimonianze di processi migratori avvenuti in ere geologiche passate tra le penisole italiana e balcanica.

In una pubblicazione sulle orchidacee della Croazia, Kranjčev (2005) segnala la presenza nella Dalmazia continentale e/o nelle sue isole le seguenti specie: *Ophrys sphegodes* subsp. *brutia, Ophrys bertolonii*

subsp. *bertoloniformis* e *Ophrys holosericea* subsp. *gracilis*. Se le ricerche successive le confermeranno, il loro areale si estenderebbe e anziché essere considerate endemiche italiane rientrerebbero a pieno titolo nel corotipo Appennino-Balcanico che quindi crescerebbe di numero.

Si è anche osservato che per vari taxa l'Abruzzo è il territorio posto al limite del loro areale di distribuzione geografica settentrionale, meridionale o orientale, Ciò avviene anche per altre specie sia vegetali che animali ivi presenti. Quest'altro fatto contribuisce ad accrescere l'importanza della Regione dal punto di vista biogeografico. In particolare:

- Raggiunge il limite nord-orientale di distribuzione geografica: *Platanthera algeriensis*.
- Raggiungono il limite settentrionale di distribuzione geografica: *Epipactis lucana, Ophrys bertolonii* subsp. *bertoloniiformis*, *Ophrys exaltata* subsp. *archipelagi*, *Ophrys fusca* subsp. *lucana*, *Ophrys holosericea* subsp. *parvimaculata*, *Ophrys lacaitae*, *Orchis quadripunctata* e *Platanthera bifolia* subsp. *osca*.
- Raggiungono il limite meridionale di distribuzione geografica: *Cypripedium calceolus* e *Traunsteinera globosa*.
- Raggiungono il limite orientale di distribuzione geografica: *Ophrys argolica* subsp. *crabronifera* e *Ophrys holosericea* subsp. *pinguis*.

CONCLUSIONI

L'elevato numero di Orchidaceae presenti conferma l'importanza naturalistica dell'Abruzzo e contribuisce a collocarlo insieme a Lazio, Puglia e Toscana tra le regioni italiane più ricche per il patrimonio orchidologico. Il fatto che diverse entità sono considerate dubbie dimostra che i criteri di classificazione adottati dai ricercatori sono molto diversi e si adotta un concetto di specie non ampiamente condiviso.

KUKAVIČEVKE DEŽELE ABRUCI: SISTEMATSKA DOPOLNITEV IN NOV SEZNAM VRST

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POVZETEK

Abruci je dežela v osrednji Italiji s površino 10794 km², na kateri so do konca leta 2010 popisali 3409 višjih rastlin. Nadaljnje floristične raziskave z novimi odkritji so dodatno dopolnile popis regionalne flore. V družini kukavičevk so recentne taksonomske revizije, najdbe in opisi novih vrst spremenile število vrst v deželi Abruci. V pričujočem delu avtor podaja nov floristični popis kukavičevk na nivoju vrst, podvrst in križancev, poleg tega pa razpravlja o njihovemu taksonomskemu rangu. Podaja tudi horološko analizo, ki izkazuje prevladovanje sredozemskih elementov.

Ključne besede: Abruci, Orchidaceae, regionalni popis vrst, floristični elementi

BIBLIOGRAFIA

Baumann, B. & H. Baumann (1988): Ein Beitrag zur Kenntnis der Gattung *Epipactis* Zinn im Mittelmeergebiet. J. Eur .Orch., 20 (1), 1- 68.

Baumann, B. & R. Lorenz (1988): Beitrag zur Kenntnis der Gattung *Epipactis* Zinn im Mittel- und Verbreitung einiger in diesen Gebiet spät blühenden Orchideen. Mitt. Bl. Arbeitkrskr. Heim. Baden Württ., 20, 652-694.

Biagioli, M. (2016): *Ophrys holosericea* subsp. *posidonia*. In: GIROS 2016, Orchidee d'Italia. Guida alle orchidee spontanee: 268. 2° ed., Il Castello, Cornaredo (MI).

Bongiorni, L., R. De Vivo & S. Fori (2007): *Epipactis savelliana* Bongiorni, De Vivo & Fori spec. nov. (Orchidaceae) nel gruppo della Majella (Abruzzo, Italia Centrale). J. Eur. Orch., 39 (1), 501-516.

Bongiorni, L., R. De Vivo & S. Fori (2014): *Epipactis tremolsii* C. Pau ed *Epipactis helleborine* subsp. *latina* W. Rossi & E. Klein: considerazioni sul valore di questi taxa. GIROS Notizie, 55, 85-88.

Brocchi S., 1822: Osservazioni naturali fatte in alcune parti degli Appennini degli Abruzzi. Bibliot. Itale quattordici: 363.

Brunamonte, F. R., G. Picone, M. Rempicci, E. Gransinigh, M. Antonj, S. Magrini & S. Buono (2015): *Ophrys ×camusii* e *Ophrys ×hybrida*, due ibridi del genere *Ophrys* nuovi per l'Abruzzo (Italia centrale). - J. Eur. Orch., 47 (1), 65-70.

Centurione, N., (1999): Orchidee rare in Abruzzo. GIROS Notizie, 11, 27.

Cesati, V. (1872): Piante della Majella, del Morrone e delle loro adiacenze nell'Abruzzo Citeriore. Stamperia Univ. Napoli.

Cesati, V. (1873): Relazione botanica. Elenco delle piante raccolte da diversi botanici che presero parte all'escursione sul gruppo della Majella e del Morrone. Boll. CAI, 7, 157-187.

Colella, A., E. De Santis, G. Frizzi & R. Soldati (2011): Orchidee spontanee d'Abruzzo e chiavi analitiche digitali per il loro riconoscimento. Lucoli (AQ).

Conti, F. (1998): Flora d'Abruzzo. Bocconea 10, Palermo.

Conti, F. & F. Bartolucci (2015): The Vascular Flora of the National Park of Abruzzo, Lazio and Molise (Central Italy). An Annotated Checklist. Geobotany Studies (eBook) DOI 10.1007/978-3-319-09701-5.

Conti, F. & F. Bartolucci (2016): The vascular flora of Gran Sasso and Monti della Laga National Park (Central Italy. Phytotaxa 256. Magnolia Press, Auckland.

Conti, F. & A. Manzi (2012): Flora vascolare della Riserva naturale regionale "Lecceta di Torino di Sangro". Talea Ed., Atessa (CH).

Conti, F. & D. Tinti (2012): Flora vascolare della Riserva Naturale "Gole del Sagittario" (Abruzzo). Bollettino del Museo Civico di Storia Naturale di Verona, 36, Botanica Zoologia, 03-30.

Conti, F. & M. Pellegrini (1990): Orchidee spontanee d'Abruzzo. Cogecstre, Penne (PE).

Crugnola, G. (1894): La vegetazione al Gran Sasso d'Italia. G. Fabbri ed., Teramo.

Daiss H. & H. Daiss (1996): Orchideen um die Majella (Abruzzen, Italien). J. Eur. Orch., 28, 603-640.

De Angelis, G. & R. Scacchi (1988): Segnalazioni floristiche italiane 537- 539. Inform. Bot. Ital., 20 (2/3), 658-660.

Delforge, P. (2015): Nouvelles contributions taxonomiques et nomencaturales aux Orchidées d'Europe. Les Naturalistes belges, 96 (hors-série), 14-21.

Delforge, P. (2016): Guide des orchidées d'Europe, d'Afrique du Nord et du Proche Orient. Delachaux et Niestlé, Paris.

De Simoni, M.G. & M. Biagioli (2016): *Ophrys sphegodes* subsp. *classica*. In: GIROS 2016, Orchidee d'Italia. Guida alle orchidee spontanee: 224. 2° ed., Il Castello, Cornaredo (MI).

Devey, D.S., R. M. Bateman, M. F. Fay & J. A. Hawkins (2009): Genetic structure and systematic relationships within the *Ophrys fuciflora* aggregate (Orchidaceae: Orchidinae): high diversity in Kent and a wind-induced discontinuity bisecting the Adriatic. Annals of Botany, 104 (3), 483-495.

Del Prete, C. (1982): Sintesi dei problemi tassonomici e corologici delle orchidacee dell'Italia peninsulare. Atti Soc. Tosc. Sci. Nat., Mem., Ser. B, 89, 251-268.

Di Pede, A. (2001): *Ophrys sphegodes* Mill. subsp. *majellensis* H. & H. Daiss ed altre Orchidaceae della bassa Val Roveto. GIROS Notizie, 18, 14-20.

Euro+med (2006): Euro+Med Plantbase - the information resource for Euro-Mediterranean plant diversity. - http://ww2.bgbm.org/EuroPlusMed.

Faurholdt, N. (2009): Notes on *Ophrys fuciflora s.l.* in Croatia and Central Italy. J. Eur. Orch., 41 (3/4), 635-642.

Ferrari, G. (2011): A visit to Abruzzo. 66-69. Journal of the Hardy Orchid Society, 8 (2), 66-69.

Galetti, G. (2008): Abruzzo in fiore. D'Abruzzo Libri, Ed. Menabò, Ortona (CH).

GIROS (a cura) (2016): Orchidee d'Italia: guida alle orchidee spontanee. Ed. Il Castello, Cornaredo (MI).

Gravina, P. (1812): Giornale della peregrinazione Botanica eseguita nelle Montagne del Circondario di Scanno, dal Sig. Pasquale Gravina. Giornale Enciclopedico di Napoli, 6, 3–49.

Griebl, N. (2010): Die Orchideen der Abruzzen. Ber. A.H.O, 27(2), 123-170.

Groves, H. (1880): Flora del Sirente. Nuovo Giorn. Bot. Ital. 12: 51-68.

Gulli V. & G. Tosi (2016): *Orchis mascula* subsp. *speciosa*. In: GIROS 2016, Orchidee d'Italia. Guida alle orchidee spontanee: 134. 2° ed., Il Castello, Cornaredo (MI).

Gussone, G. (1826): Plantae rariores quas in Itinere per Oras Ionii as Adriatici maris et per regiones Samnii et Aprutii collegit J. Gussone, Regia Tip., Napoli.

Hennecke, G. & M. Hennecke (1999): Neue Orchideen-Funde in den Abruzzen (Italien). J. Eur. Orch., 31 (4), 936-948.

Hertel, S. & H. Presser (2006): Zur Kenntnis der Italienischen Orchideen. J. Eur. Orch., 28 (3), 485-532.

Hertel, S. & H. Presser (2009): Zur Kenntnis der Italienischen Orchideen –Nachtrag. J. Eur. Orch., 41(1), 195-209.

Hertel, S. & H. Presser (2015): Weitere Erkenntnisse zu *Epipactis*-Arten in Italien. Ber. Arbeitskrs. Heim. Orchid., 32(2), 79- 109.

Kalteisen, M. & H. R. Reinhard (1987): Das Areal von *Ophrys promontorii* E. & 0. Danesch. Mitt. B1. Arbeitskr. Heim. Baden - Württ., 19, 801-821.

Kranjčev, R. (2005): Hrvatske Orhideje. AKD, Zagreb.

Lastoria, M. (1988): Orchidee in Abruzzo. Edizioni Deltagrafica, Teramo.

Lorenz, R., M. Akhalkatsi, P.L. Cortis, R. Galesi, G. Giotta, J. Madl, E. Obrist, M. Piccitto, V. A. Romano, R. Romolini & R. Soca (2015): Morphometrische Untersuchungen zur Variabilität und Gliederung der Gattung *Platanthera* in Italien. J. Eur. Orch., 47(1), 123- 238.

Mauri, E., A. Orsini & M. Tenore (1830): Enumeratio plantarum quas in itinere per Aprutium vel per Pontificiae ditionis finitimas provincias, aestati anni 1829 colligerunt. Atti Accad. Pontam., 1, 185, 326, Napoli.

Nardelli, R. (1883): Climatologia, vegetazione, agronomia della Marsica prima e dopo il prosciugamento del Lago del Fucino. Tip. Marsicana, Avezzano (Aq).

Paris, P. & S. Scivola (2011): *Ophrys speculum* Link: un'altra segnalazione per l'Abruzzo. GIROS Notizie, 48, 62-63.

Peakall, R. & M.R. Whitehead (2014): Floral odour chemistry defines species boundaries and underpins strong reproductive isolation in sexually deceptive orchids. *Annals of Botany*, 113, 341-355.

Pedersen, H. & N. Faurholdt (2007): *Ophrys*, the Bee Orchids of Europe. Royal Botanic Gardens, Kew.

Perazza, G. & R. Lorenz (2013): Le orchidee dell'Italia nord-orientale. Atlante corologico e guida al riconoscimento. Ed. Osiride, Rovereto (Tn).

Peruzzi, L. (2010): Segnalazioni floristiche per le regioni italiana 2005-2010: una prima analisi dei dati a 5 anni della pubblicazione della Checklist della flora vascolare italiana. Società botanica italiana. La biodiversità vegetale in Italia: aggiornamenti sui gruppi critici della flora vascolare. Comunicazioni. Dipartimento di Biologia Vegetale, La Sapienza, Università di Roma, 23 ottobre 2010.

Pezzetta, A. (2011): Fitogeografia delle orchidee italiane. GIROS Notizie, 47, 36-53.

Pezzetta, A. (2013): Le Orchidaceae d'Abruzzo. GIROS Notizie, 52, 65-76.

Pezzetta, A. (2015): Le Orchidaceae del Gran Sasso d'Italia (Abruzzo). GIROS Orch. Spont. Eur., 58 (2), 197-213.

Pezzetta, A. (2016): Le Orchidaceae della Provincia dell'Aquila. Annales, Ser. hist. nat., 26(1), 85-104.

Pignatti, S. (1982): Flora d'Italia, voll. I-III. Edagricole, Bologna.

Reinhard, H. R. (1989): *Ophrys scolopax* Cav. (Orchidaceae) in den Abruzzen (Italien).- J. Eur. Orch., 21(1), 143-161.

Rigo, G. (1877): Relazione botanica del viaggio eseguito da Porta e Rigo nelle province meridionali d'Italia dalla fine di marzo a tutto il 10 agosto 1875. Nuovo Giorn. Bot. Ital., 9, 282-317.

Romolini, R. & R. Soca (2011a): New species in *Ophrys* (Orchidaceae) to the Italian and French Florae. J. Eur. Orch., 43(4), 750-784.

Romolini, & R. Soca (2011b): Una stazione abruzzese di *Ophrys lacaitae* Lojac., nuovo limite Nord per la specie in Italia. GIROS Notizie, 46, 48-49.

Romolini, R. & R. Soca (2014): Descrizione di dieci nuovi ibridi di *Ophrys* italiane. GIROS Notizie, 55, 48-68.

Romolini, R. & R. Souche (2012): Ophrys d'Italia. Editions Sococor, Saint Martin de Londres.

Sedeek, K. E. M., G. Scopece, A.M., Staedler, J. Schönenberger, S. Cozzolino, F. P. Schiestl & P. M. Schlüter (2014): Genic rather than genome-wide between sexually deceptive *Ophrys* orchids with different pollinators. Mol. Ecol., 23, 6192-6205.

Serafini, I. (2015): Ibrido di orchidea nuovo per la scienza scoperto sul Trigno. http://www.altovastese.it/flora-2/ibrido-di-orchidea-nuovo-per-la-scienza-scoperto-sul-trigno/

Soca, R. (2008): Presenza di *Ophrys riojana* Hermosilla in Italia. GIROS Notizie, 38, 41-43.

Soca, R. (2014): Description of ten new *Ophrys*-hybrids (Orchidaceae) of the Abruzzo (Italy). J. Eur. Orch., 46 (3/4), 661-678.

Soca, R. (2015): Aggiornamento della presenza di *Ophrys riojana* in Italia. GIROS Orch. Spont. Eur., 58 (1), 88-97.

Soliva, M. & A. Widmer (2003): Gene ow across species boundaries sympatric, sexually deceptive *Ophrys* (Orchidaceae) species. Evolution, 57(10), 2252-2261. Doi: http://dx.doi.org/10.1554/02-442.

Souche, R. (2008a): Hybrides d'*Ophrys* du bassin méditerranèen occidental. Editions sococor, Saint Martin de Londres.

Souche, R. (2008b): Presenza di *Ophrys riojana* Hermosilla in Italia. GIROS Notizie, 38, 41-43.

Tammaro, F. (1986): Documenti per la conoscenza naturalistica della Majella: repertorio sistematico della flora. Centro Servizi Culturali, Chieti.

Tenore, M. (1830): Succinta relazione del viaggio fatto in Abruzzo ed in alcune parti dello Stato Pontificio dal Cavalier Tenore nell'Està del 1829. Stamperia della Società Filomatica, 1, 90-91.

Tenore , M . (1831) : Sylloge plantarum vascularium Florae Neapolitanae hucusque detectarum. Ex Typ. Fibreni, Napoli.

Tenore, M. (1832): Relazione del viaggio fatto in alcuni luoghi di Abruzzo Citeriore nella state del 1832. Ristampa anastatica. Ed. Polla, Avezzano (Aq).

Tenore, M. (1835): Ad Florae Neapolitanae Syllogem, Appendix quarta.Tipografia del Fibre. Napoli.

Tenore, M. (1835–1838): Flora Napolitana 5. Stamperia e Cartiera del Fibreno, Napoli.

Tenore, M. (1842): Ad Florae Neapolitanae Syllogem, Appendix quinta. Typis p. Tizzano, Napoli.

Tenore, M. & G. Gussone (1842): Memorie sulle peregrinazioni eseguite dai soci ordinari Signori M. Tenore e G. Gussone. Stamperia Reale, Napoli.

Terracciano, N. (1872): Relazione intorno alle peregrinazioni botaniche fatte nella provincia di Terra di Lavoro. Nobili & Cie, Caserta.

Terracciano, N. (1873): Seconda relazione intorno alle peregrinazioni botaniche fatte nella provincia di Terra di Lavoro. Nobile e Cie, Caserta.

Terracciano, N. (1874): Terza relazione intorno alle peregrinazioni botaniche fatte nella provincia di Terra di Lavoro. Nobile e Cie, Caserta.

Terracciano, N. (1878): Quarta relazione intorno alle peregrinazioni botaniche fatte nella Provincia di Terra di Lavoro. Nobile e Cie, Caserta.

Terracciano , N . (1890) : Intorno ad alcune piante - della flora di Terra di Lavoro. Napoli.

Tinti, D. & F. Conti (2002): Orchidaceae rinvenute presso il lago di Campotosto (L'Aquila, Abruzzo). GIROS Notizie, 19, 21-25.

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FUNCTIONAL COMPOSITION OF MID-STREAM GRAVEL BAR VEGETATION (MIDDLE DRAVA RIVER, NE SLOVENIA)

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ABSTRACT

In the present study we sampled vegetation, plant functional traits and environmental properties to investigate the functional composition of gravel bar vegetation along the middle Drava River in Slovenia in relation to various abiotic controls. Our analysis of the species-traits data resulted in six plant functional types (FTs) which may coexist within gravel bar plant communities. Conditions of intermediate fertility and disturbance (areas with coarse gravel sediments, from low to higher micro-elevations) promote coexistence of a greater diversity of species and FTs. More fertile and moist conditions on areas with fine silt and sand sediments increased the dominance by tall plants with more competitive strategies, thereby leading to lower species richness and lower number of FTs. This study shows that gravel bars form a highly significant landscape element in terms of maintaining higher functional diversity of river ecosystem.

Key words: Plant functional traits, functional diversity, river ecosystems, plant diversity, flood disturbance, Natura 2000.

COMPOSIZIONE FUNZIONALE DELLA VEGETAZIONE DELLE BARRE GHIAIOSE NEL FLUSSO INTERMEDIO (FIUME DRAVA CENTRALE, SLOVENIA NORD-ORIENTALE)

SINTESI

Nel presente studio gli autori hanno campionato la vegetazione, le caratteristiche funzionali delle piante e le variabili ambientali al fine di indagare la composizione funzionale della vegetazione delle barre ghiaiose nella parte centrale del fiume Drava in Slovenia. L'analisi dei dati specie-tratti ha portato al risultato di sei tipi funzionali di piante (FTs), che possono coesistere all'interno delle comunità vegetali delle barre ghiaiose. Le condizioni di fertilità intermedia e di disturbo (aree con sedimenti ghiaiosi grossolani) possono promuovere la coesistenza di una maggiore diversità di specie e FTs. Condizioni più fertili e umide in zone con sedimenti fini di limo e sabbia aumentato il predominio di piante alte con strategie più competitive, e portano ad una diminuzione della ricchezza di specie e del numero di FTs. Lo studio dimostra che le barre ghiaiose costituiscono un elemento paesaggistico molto significativo in termini di mantenimento di una diversità funzionale elevata dell'ecosistema fluviale.

Parole chiave: caratteri funzionali della pianta, diversità funzionale, ecosistemi fluviali, diversità vegetale, disturbi da inondazioni, Natura 2000.

INTRODUCTION

The maintenance of Life on Earth depends on an efficient ecosystem functioning (Laureto *et al*., 2015). Ecosystem functions represent processes that regulate the flux of energy and matter through the environment (e.g. nutrient cycling, storage and recycling of organic matter, erosion control, and decomposition) and several aspects of human well-being depend on benefits provided by ecosystems (the so-called ecosystem services, Millenium Ecosystem Assessment, 2005). Extensive declines in biodiversity at both global and local level have motivated many scientific studies demonstrating how loss and changes in biodiversity may affect ecosystem functioning and ecosystem services (ES) (Tilman *et al*., 1997; Díaz *et al.,* 2006; Villeger *et al*., 2008).

Plant diversity is an important driver of ecosystem functioning (Villeger *et al.,* 2008) which contributes significantly to the delivery of ES (Lavorel & Grigulis, 2012). Particularly, functional components of diversity strongly determine different ecosystems properties and there is a growing consensus, that functional diversity, rather than species diversity (species number), is the component of biodiversity most relevant to ES (Hooper *et al.,* 2002; Bellwood *et al.,* 2004; Díaz *et al*., 2006; Wright *et al*., 2006; de Bello *et al*., 2010).

Functional diversity can have different definitions (Díaz & Cabido, 2001; Ricotta & Moretti, 2011) and can be quantified using a variety of indices (Villeger *et al*., 2008). Widely adopted definition for functional diversity is "the value and range of functional traits of the organisms present in a given ecosystem" (Díaz & Cabido, 2001). With functional diversity indices we can identify patterns of community structure reflecting complementarity of resource use or trait redundancy (Lavorel *et al*., 2011). One commonly used technique for measuring functional diversity consist of clustering species with shared taxonomic, physiological and morphological traits into functional groups (Wright et al., 2006). These alternative classes are referred to as plant functional types (PFTs) (Gitay & Noble, 1997; Pipenbaher *et al*., 2008), assuming that groups with similar traits differ in their response to and effect on resources (Lavorel & Garnier, 2002). Functional diversity has been seen as the key to predicting the stability, invisibility, and resource capture, nutrient cycling and productivity of communities. It had been suggested that ecosystems with a greater diversity of functional traits, i.e. higher functional diversity, will operate more efficiently (Tilman *et al*., 1997). The number of functional groups can be used as an approximation of functional diversity in an ecosystem (Wright *et al*., 2006).

Gravel bars are a typical feature of the braided gravel-bed rivers that were once widespread in temperate piedmont and mountain-valley areas (Tockner *et al.,* 2006). Because of their aquatic-terrestrial ecotone environment, are highly dynamic, with the potential to support high biodiversity and a range of environmental processes (Sadler *et al.,* 2004; Zeng *et al.,* 2015). The vegetation dynamics on river gravel bars is an indicator of the health of the river-floodplain ecosystem. Today, however, owing to anthropogenic modification - flood control engineering, canalization and gravel extraction - most gravel-bed rivers bear little resemblance to their highly dynamic natural state (Trockner *at al.,* 2006; Schnauder & Moggridge, 2009). Consequently, braided rivers are among the most endangered ecosystems (Sadler *et al*., 2004), and gravel bars are recognized as one of the most endangered landscape elements worldwide (Trockner *et al.,* 2006; Zeng *et al.,* 2015).

Patterns of plant species distribution and diversity on gravel bars are shaped according to a multitude of environmental gradients, including elevation above the water line, frequency, depth and duration of flooding, and various soil properties, in particular, the particle size and moisture content of sediment (Ellenberg, 1988; Prach, 1994; Prach *et al.,* 2014). Floods act as the main disturbing factor (Gilvear & Willby, 2006; Prach *et al*., 2014) and are fundamental in creating and maintaining environments that comprise habitats in various successional stages of different age, each with its own distinct vegetation community (Gray & Harding, 2007). An understanding of the relative roles of the various environmental controls on gravel bar vegetation forms the prerequisite for developing sustainable management schemes (Ward *et al.,* 2001) and for successful restoration (Tockner *et al.,* 2006; O´Donnell *et al.,* 2015).

There is a little published information on the complex relationship between environmental conditions and biodiversity of gravel bars (Gilvear & Willby, 2006; Zeng *et al.,* 2015) and the knowledge about the correlations of the environmental factors with the gravel bars vegetation pattern was expressed only in terms of floristic composition (Gilvear & Willby, 2006; Eremiášová & Skokanová, 2014). However, the investigations of functional trait diversity of gravel bar vegetation, considered as the overall difference among species in a plant community in terms of their traits, remains to be carried out. There is no knowledge about how functional diversity of gravel bar plant communities changes in response to combined environmental gradients such as micro-elevation above the water line and texture of the substrate, making it difficult to project the future structure and function of this ecosystem.

With a length of 750 km and an average discharge of 550 m³/s at its mouth, the Drava River is one of the most important tributaries of the Danube River (Takács & Kern, 2015). It originates in the Alpine Mountains and joins the Danube at the edge of the Pannonian lowland. In the middle Drava River system in Slovenia, where this study was conducted, natural disturbances are still allowed to occur. It forms part of the network of NATURA 2000 sites. Therefore, it can serve as model system for study the complex relationship between environmental

conditions and biodiversity of rivers and their landscape elements (Tockner *et al.*, 2006). Such studies are needed for river restoration and management purposes (Zeng *et al.,* 2015).

In this study, we sampled vegetation, plant functional traits and environmental properties to investigate the functional composition of gravel bar vegetation along the middle Drava River in Slovenia in relation to various abiotic controls. Specifically, we focused on the following questions: (1) How many different plant functional types could be defined on the studied gravel bars?; (2) How is the plant functional composition of river gravel bar vegetation related to morphological and sedimentological properties?

MATERIALS AND METHODS

Study site

We studied vegetation on gravel bars alongside the middle Drava River (northeastern Slovenia, southern central Europe). Our study area was located in its middle stream between Ptuj and the Croatian border near Ormož: a belt about 15 km long between 46°25′ N and 15°52′ E, 16°09′ E, at ca. 200 m above sea level (Fig. 1). According to Köppen's classification (Köppen, 1923), the climate of the study area belongs to the climatic type Cfb (moderately warm, rainy climate without a dry period). The long-term mean maximum temperature in the warmest month (July) is 19.6 °C and the mean minimum temperature in the coldest month (January) is -1.5 °C. The average annual precipitation is between 900 mm and 1000 mm. The precipitation is spread rather evenly through the year, with a maximum in summer (July and August) and a minimum in winter (January, February) (Žiberna, 2000).

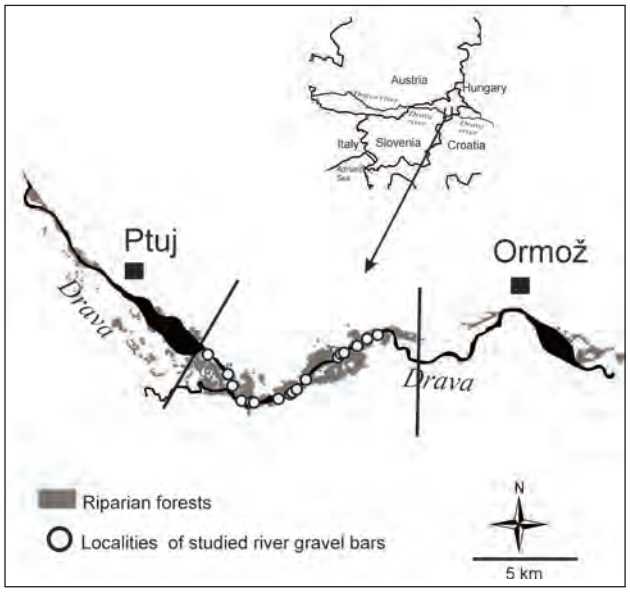


Fig. 1: Map of Slovenia and neighbouring regions. The more detailed map shows the position of studied gravel bars (N=17) along the middle Drava River in Slovenia.
Sl. 1: Prikaz območja Slovenije in sosednjih držav. Karta v večjem merilu prikazuje lokacije prodišč (N=17) vzdolž srednjega toka reke Drave v Sloveniji.

Data sampling

In April 2011 the total study area along this stretch of river was scanned using field observation with aerial photos. For data sampling, we selected only those gravel bars obviously undisturbed by human activities. Within these bars, we distinguished particular vegetation stages that were uniform in vegetation cover and located at the same height above the water line in the river at the time. We sampled differently aged stages of succession from bare deposits with sparse herb vegetation, to well-developed stands of *Salix* species. In our study, we examined seventeen (17) mid-channel river bars (Fig. 1). *We randomly sample*d multiple sites (min. 4 and max. 13 plots per bar) across each of 17 *gravel bar* systems; in total, 143 sampling plots were surveyed.

The species composition data of the gravel bar vegetation were collected between May and September 2011. Species composition was recorded in 143 plot relevés, each measuring 5 x 5 m. In each 25m^2 plot, vascular plants were sampled using, a seven-point cover-abundance scale according to Braun-Blanquet (1964). All plant species occurring in only one relevé were removed, to exclude casual occurrences from the analyses. In each plot, species richness was noted as the number of species recorded, and vegetation cover was estimated visually as the percentage of ground *covered* by *vegetation*. The rough grouping to species occurring in grassland communities, woodland and shrubland communities and disturbed habitats were summarized from Ellenberg *et al.* (1992). Taxonomic nomenclature followed Martinčič *et al.* (2007).

For each plot, we estimated in the field the following environmental variables: (1) micro-elevation (in cm) of the study plot above the present water line of the river (we roughly measured the elevation of the surface above the water line of the river using a tape measure); (2) relative presence of particular substrate categories: gravel, sand and silt (we visually estimated the approximate percentage of the substrate that corresponded to the texture size categories) and (3) bar age (1 = < 5 years, 2 = 5 to 10 years and 3 = > 10 years). The data for the approximate year of bar creation were obtained from aerial photographs and from personal communications.

Plant functional traits

In choosing key plant traits, we followed different literature sources (Hodgson *et al.,* 1999; Kahmen *et al.,*

2002; Cornelissen *et al*., 2003). Information on plant species traits were chosen from our own database, from the literature (Martinčič *et al.,* 2007) and also from existing trait databases: BiolFlor (Klotz *et al.,* 2002, Kühn *et al.,* 2004), LEDA (Kleyer *et al.,* 2008), CLO-PLA (Klimešova & Klimeš, 2006; Klimešova & de Bello, 2009). We selected 10 traits for each species : "life form", "life cycle", "growth form", "plant height", "specific leaf area (SLA)", leaf dry matter content (LDMC)", "flowering start", "flowering end", "flowering period", "CSR strategy". The list of traits with the description of classes in the matrix and the sources of information are presented in Tab. 1. Categorical traits were all transformed into binary variables, with one for each possible level of the factor (dummy variables). In this way the number of traits in the matrix increased from 14 to 34 (Tab. 1).

Data Analysis

To analyse the gravel bar vegetation according to functional types composition, two data-matrix were composed: (a) species-relevé matrix (211 plant species x 143 relevés) and (b) a species-traits matrix (211 species x 34 plant traits). Braun-Blanquet cover-abundance data for the species were converted to a 2 to 9 scale (van der Maarel, 1979).

To determine the plant functional types, a species-traits matrix was subjected to divisive clustering, using WinTWINS version 2.3 (Hill & Šmilauer, 2005). Differences between plant functional types (Twinspan groups) were tested with Kruskal-Wallis test since the data were not normally distributed. Differences between groups were assessed using the Dunn-Bonferroni post hoc method.

In order to provide a visual representation of functional composition of mid-stream gravel bar vegetation, species names in the species-relevés matrix were replaced by plant functional types.

Plant functional types-environmental relationships were analysed using multivariate ordination techniques (Canoco for Windows, ter Braak & Šmilauer, 2002). Each vegetation record (relevé) was characterized according to the following features: i) environmental variables: substrate texture (gravel, sand and silt cover), height above water line (elevation), bar age (1 = < 5 years, 2 = 5 to 10 years and 3 = > 10 years), and ii)

Tab. 1: Plant traits, recorded on 211 vascular plant species from the river gravel bar vegetation along the Drava River in Slovenia. Scales of measurement were originally categorical or continuous.
Tab. 1: Morfološko-funkcionalne poteze za 211 rastlinskih vrst prodiščne vegetacije vzdolž srednjega toka reke Drave v Sloveniji. Podatki so bili v osnovi kategorični ali zvezni.

Traits	Abbreviation and description	Details	Data source
Life form	LF_Ha=chamaephytes; LF_Ge=geophytes; LF_He=hemicryptophytes; LF_Th=therophytes; LF_Ph=phanerophytes; LF_Hy=hydrophytes;	Categorical variable	Martinčič *et al.*, 2007
Life cycle	LC_Annu=annual; LC_Bien=biennial; LC_ Pere=perennial	Categorical variable	Martinčič *et al.*, 2007
Growth form	GF_Tuss= tussocks; GF_Rose = rosette; GF_le_st = leafy stem; GF_ro_le = rosette and leafy stem; GF_clem = climbers	Categorical variable	Rothmaler, 1995; Martinčič *et al.*, 2007
Plant height	P_height (cm)	Continuous variable	Own measurements
Specific leaf area	SLA (mm2/mg)	Continuous variable	Own measurements; LEDA database (Kleyer *et al.*, 2008)
Leaf dry matter content	LDMC (mg/g)	Continuous variable	Own measurements; LEDA database (Kleyer *et al.*, 2008)
Flowering start	F_start (month)	Continuous variable	Martinčič *et al.*, 2007
Flowering end	F_end (month)	Continuous variable	Martinčič *et al.*, 2007
Flowering period	F_lenght (months)	Continuous variable	Martinčič *et al.*, 2007
CSR strategy	C = competitors; S = stress-tolerators; R = ruderals	Categorical variable	Own measurements; Hodgson *et al.*, 1999

vegetation characteristics: number of plant species, vegetation cover and vegetation height. To relate functional composition to estimated environmental variables, Canonical Correspondence Analysis (CCA, ter Braak, 1986; Jongman *et al*., 1995) was used. In CCA, vegetation characteristics were considered as supplementary environmental variables (in Canoco terminology). The values for herb layer cover (in %) and substrate texture (in %) were square-root transformed, whereas the elevation and vegetation height data were log(X + 1) - transformed prior to analysis. The effect of rare species was reduced by downweighting. The data were first subjected to Detrended Correspondence Analysis (DCA, Hill & Gauch, 1980). Gradient length for the first DCA axis was 3.385 SD (standard deviation) units, indicating that both types of ordination methods, linear and unimodal, were suitable for the analysis.

In the CCA, we applied manual forward selection (FS), mainly to see the sequence of contribution by individual variables to an explanation of species composition (Lepš & Šmilauer, 2003). The significance of each variable was evaluated using the Monte Carlo permutation test (499 permutations). Correlations between relevé scores of CCA axis 1 and environmental variables were analyzed using the Spearman rank-order correlation coefficient. All tests were performed with the statistical package SPSS Base ®for Windows 21.0 (Released in 2012, IBM, New York).

RESULTS AND DISCUSSION

In 143 plots (relevés) we identified 211 vascular plant species (mean = 17 ± 8 s.d. per relevé). The assemblage was strongly marked by species typical of disturbed habitats (56%), followed by species of riparian woodland/shrubland (14%), grassland species (11%), species of aquatic and wetland habitats and species with indifferent habitat preference (11% and 9%, respectively). Our results confirmed the relatively high floristic diversity that is typical of this landscape element, as has been described by other authors (Prach *et al.*, 1996; Gilvear & Willby, 2006). The position of passively projected environmental variables (number of plant species, vegetation cover and vegetation height) in the CCA indicated that the number of species in gravel bar vegetation increased with increasing gravel content, whereas vegetation cover and height increased with an increasing proportion of silt and sand (Fig. 2). It is likely that various soil properties, in particular substrate texture, are over-riding controls on gravel-bar plant species diversity.

Differences in functional composition were analyzed with TWINSPAN classification of the 211 species x 34 plant traits matrix (dendrogram not shown). Six clusters (groups FT1-FT6) emerged; the groups were defined as six main plant functional types (FT) of gravel bar vegetation (Tab. 2): (1) FT1 (33 plant species) includes mainly therophytes, pioneer ruderal species, characteristic for segetal plant communities from the class *Stellarietea mediae* such as *Amaranthus retroflexus, Capsella bursa-pastoris, Convolvulus arvensis, Conyza canadensis, Galinsoga parviflora* and *Sonchus oleraceus*. Species of FT1 are relatively small plants, with high SLA and low LDMC values (Tab. 2). They start to flower early in the season and have a long flowering period till the autumn; (2) FT2 (27 plant species) represents ruderal perennials, such as *Leersya orizoides, Lolium perenne, Myosoton aquaticum, Poa annua, Silene vulgaris* and *Tussilago farfara*; this plants are medium height and have high SLA values (Tab. 2); (3) FT3 (57 plant species) are hemicryptophytes with a substantial share of species from *Artemisietea vulgaris* class, such as *Artemisia vulgaris, Melilotus albus, Oenothera biennis,* and *Saponaria officinalis*; in comparison to FT2 (Tab. 2) these plant species are higher but with lower SLA values. Similar to FT1 they start with flowering earlier in the season; (4) FT4 (44 plant species) are late flowering annuals and biennials and when compared to annuals in FT1, species in FT4 are higher in growth and with higher LDMC values. Many of them are characteristic for hygrophilous ruderal vegetation of the class *Bidentetea tripartiti*, for example *Bidens tripartitus, Rorippa palustris, Xanthium italicum, Brassica nigra, Chenopodium ficifolium* and *Chenopodium album*; FT5 (30 plant species) are tall perennial herbs, with tussock growth form, such as *Barbarea stricta, Dactylis glomerata, Iris pseudacorus, Koeleria pyramidata, Molinia caerulea, M. arundinacea, Solidago gigantea* and *Urtica galeopsifolia;* FT6 (20 plant species) are phanerophytes, woody plant species with low SLA and high LDMC values (Tab. 2): their characteristic is also early and short flowering period. Species in FT6 are for instance *Acer campestre, Acer negundo, Populus alba, Populus nigra, Robinia pseudacacia, Salix alba, Salix caprea, Salix eleagnos, Salix fragilis, Salix purpurea, Salix triandra, Salix viminalis* and *Frangula alnus*. All defined FT are presented with 20 or more plant species (Tab.2). The highest number of plants is classified to FT3 (xerophilous ruderal perennials, N=57) and the lowest to FT6 (woody species, N=20). Functional groups represented by a larger number of plant species are typical for stable ecological systems. If one species goes extinct, another from the same FT can take place and the loss of one species will have less effect if others from the FT are preserved (Lawton & Brown, 1994).

In the CCA of all 143 vegetation relevés made on the gravel bars, species scores of axis 1 (eigenvalue=0.18) were positively correlated with silt cover ($R=0.52$, $p < 0.01$), vegetation cover and vegetation height ($R=0.6$, $p < 0.01$; $R=0.47$, $p < 0.01$, respectively), and negatively correlated with gravel cover ($R=-0.52$, $p < 0.01$), plot position above the water line ($R=-0.47$, $p < 0.01$),) and species number ($R=-0.24$, $p < 0.01$), as illustrated in Fig. 3.

In CCA analysis species names in the matrix species relevés were replaced by plant functional types in order

Tab. 2: Characteristics of six functional types (FT1-FT6) of plant species (N=211) of gravel bar vegetation (Middle Drava River, NE Slovenia). Legend: Numbers with different letters are significantly different at the 0.05 level.
Tab. 2: Značilnosti šestih funkcionalnih tipov (FT1-FT6) rastlinskih vrst (N=211) vegetacije prodišč srednjega toka reke Drave (SV Slovenija). Legenda: Vrednosti z različnimi črkami se statistično značilno razlikujejo pri p <0,05.

	FT1	FT2	FT3	FT4	FT5	FT6
Number of plant species	33	27	57	44	30	20
SLA (mm^2/mg)	22.7 ± 11^{ac}	37.8 ± 18^{b}	23 ± 7^{c}	20.2 ± 7.3^{ac}	17.3 ± 8.6^{a}	18.2 ± 7.8^{ac}
LDMC (mg/g)	195.4 ± 67.3^{a}	169.6 ± 61.7^{a}	203.3 ± 54^{a}	215.8 ± 72.6^{a}	277.2 ± 84^{b}	313.3 ± 97.6^{b}
Plant height (mm): mean ±s.d.	341.5 ± 259^{a}	374.2 ± 241^{a}	463.2 ± 225^{a}	481.6 ± 268^{a}	526.5 ± 359^{a}	7786.5 ± 6967^{b}
Flowering start (month)	5.9 ± 1.2^{b}	5.1 ± 1.2^{ab}	5.9 ± 1^{b}	6.5 ± 0.9^{bc}	6.1 ± 1.2^{b}	3.6 ± 1.3^{a}
Flowering end (month)	9.4 ± 1.2^{a}	8.3 ± 1.4^{ed}	8.2 ± 1.0^{bd}	8.9 ± 0.8^{ae}	7.8 ± 1.2^{bd}	5.1 ± 1.5^{c}
Flowering period (Number of months)	4.6 ± 1.6^{a}	4.1 ± 1.2^{a}	3.3 ± 0.8^{ad}	3.5 ± 0.9^{d}	2.8 ± 0.4^{bc}	2.5 ± 0.8^{b}

to relate functional composition of vegetation to environmental variables. The CCA analysis with 143 relevés made on the gravel bars and 211 plant species classified in six functional types (FT1-FT6) is shown in Fig. 2 for all FT-s together and in Fig. 3 a-c for separate pairs of FT-s. The arrangement of species in ordination indicated that plant functional diversity was highest on areas with higher proportion of gravel in soil, where all six FT could be found (Fig. 2) and where, from low to higher microelevations, FT1, FT2, FT3 and FT 4 were represented by larger number of species. Common to all four FT-s is functional traits characteristic for ruderal strategists (Grime, 2001): e.g. the tendency for the life-cycle to be that of the annual or short-lived perennial (FT1, FT4), high SLA (FT2) and low LDMC values (FT1-FT4) (Tab. 2). Plant functional types and traits are useful concepts to the understanding of the ecological processes of succession and competition (Duckworth *et al.,* 2000). Floods are the main disturbing factor on gravel bars and are fundamental in creating and maintaining gaps in vegetation. The bare ground conditions favor *pioneer* plant *species,* and periodic floods prevent total competitive displace-

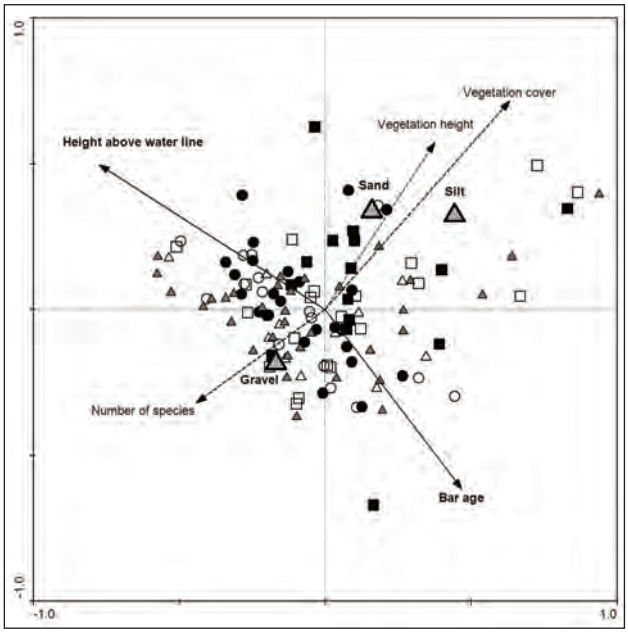
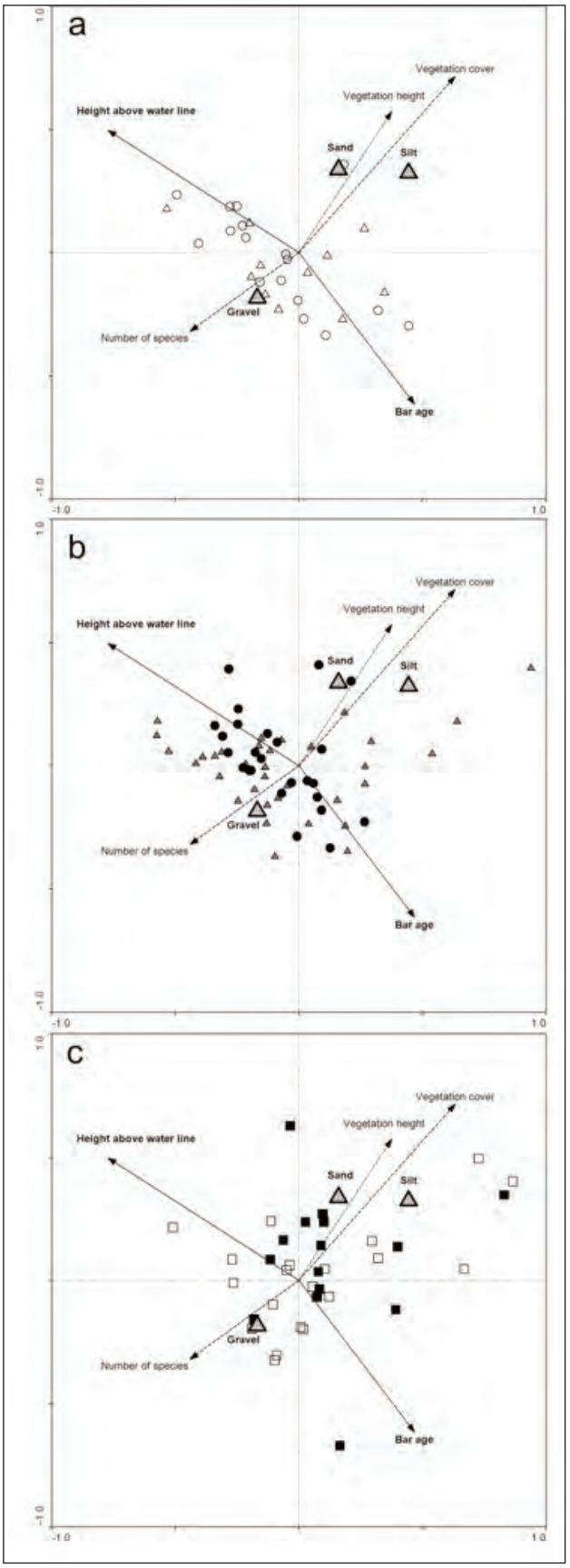


Fig. 2: CCA ordination diagram with environmental variables of river gravel bar vegetation (143 relevés) along the Drava River in Slovenia and plant species (N = 211) classified in six plant functional types (FT): FT1 = empty circle, FT2 = empty up-triangle; FT3 = gray up-triangle; FT4 = black circle; FT5 = empty square and FT6 = black square. Number of species, vegetation cover and vegetation height were added as supplementary variables (dashed line) without any affect on the analysis. Eigenvalues: 0.15 (axis 1), 0.14 (axis 2); 7.4 % of variance in species composition is explained by both axes.
Sl. 2: CCA ordinacijski diagram z okoljskimi spremenljivkami vegetacije prodišč (143 popisov) in rastlinskimi vrstami (N = 211), klasificiranimi v šest (6) funkcionalnih tipov (FT): FT1 = prazen krog), FT2 = prazen trikotnik), FT3 = siv trikotnik, FT4 = črn krog, FT5 = prazen kvadrat in FT6 = črn kvadrat. Število vrst, pokrovnost in višina vegetacije so v diagramu prikazane kot dodane spremenljivke (črtkana linija) brez vpliva na analizo. Lastne vrednosti osi: 0,15 (os 1), 0,14 (os 2). Prvi dve osi razložita 7,4 % variance v vrstni sestavi.



ment of pioneer species. Thus the functional types that usually are important (dominant) only in the early stages of succession will be present permanently in the mosaic vegetation of gravel bars. This pattern is consistent also with the intermediate-disturbance hypothesis (Gillison, 2016) as well as cyclic pattern of natural disturbance on gravel bar mosaics (e.g. gaps after periodic floods). Plant species form the FT2 and FT4 may be classified as competitive-ruderals, which occur in habitats of higher productivity in which dominance by competitors is prevented by disturbance. However, the sites colonised by competitive-ruderals experience a smaller effect of disturbance in comparison with areas populated exclusively by ruderals (Grime, 1977, 2001). Flowering in these plants is induced by increasing daylenght (summer annuals) preceded by a relatively long vegetative phase and at maturity, the shoots may be rather tall (e.g. *Impatiens glandulifera*). For the FT3 (thermophilous perennial) species centre of occurrence were areas on higher micro-elevations on gravel. They occupy habitats in which stress conditions, due to desiccation, could be experienced during the period of growth.

On the other hand, areas with silt/sand and on middle to high micro-elevation, were covered by dense vegetation and are characterized by lower number of plant species and lower functional diversity (Fig. 2). These substrates are usually moist and rich in available mineral nutrients and often support extremely rapid plant growth (van Dobben, 1967). In such conditions, the gravel bar vegetation was composed almost exclusively of FT5 (tall perennial herbs) and FT6 (woody plants) (Fig. 3a-3c).

Fig. 3: CCA ordination diagram with environmental variables of river gravel bar vegetation (143 relevés) along the Drava River in Slovenia and plant species (N=211) classified in: a) FT1 (empty circle) and FT2 (empty up-triangle); b) FT3 (gray triangle) and FT4 (black circle) and c) FT5 (empty square) and FT6 (black square). Number of species, vegetation cover and vegetation height were added as supplementary variables (dashed line) without any affect on the analysis. Eigenvalues: 0.15 (axis 1), 0.14 (axis 2); 7.4 % of variance in species composition is explained by both axes. Shown species have the highest weight.

Sl. 3: CCA ordinacijski diagram z okoljskimi spremenljivkami vegetacije prodišč (143 popisov) vzdolž srednjega toka reke Drave in rastlinskimi vrstami (N=211), klasificiranimi v: a) FT1 (prazen krog) in FT2 (prazen trikotnik); b) FT3 (siv trikotnik) in FT4 (črn krog) in c) FT5 (prazen kvadrat) in FT6 (črn kvadrat). Število vrst, pokrovnost in višina vegetacije so v diagramu prikazane kot dodane spremenljivke (črtkana linija) brez vpliva na analizo. Lastne vrednosti osi: 0,15 (os 1), 0,14 (os 2). Prvi dve osi razložita 7,4 % variance v vrstni sestavi. Prikazane so samo vrste (kot funkcionalni tipi), ki imajo največjo obtežbo v analizi.

Combination of characteristic plant functional attributes in FT5 and FT6 (e.g. tall stature) suggested that competition is the key factor process which affects the structure of trait values within these habitats. Gravel bars are usually poor in nutrients and their vegetation full of gaps, where there is no competition between plants. Nutrient availability increases in gravel bars that are impacted by reduced hydrodynamics (Müller & Okuda, 1998).

CONCLUSIONS

We investigated the functional composition of gravel bar vegetation using plant functional traits and environmental properties. Our analysis of the species-traits data resulted in six plant functional types which may coexist within gravel bar plant communities. Conditions of intermediate fertility and disturbance (areas with coarse gravel sediments, from low to higher micro-elevations) promote coexistence of a greater diversity of species and functional types (strategies) (Grime, 2001). More fertile and moist conditions on areas with fine silt and sand sediments increased the dominance by tall plants with more competitive strategies, thereby leading to lower species richness and lower number of plant functional types. Complementarity between functional groups may have important consequences for conservation planning at landscape scale. Where clear evidence indicates that the number of different functional groups increases with number of species, as we observed in our study, conserving a large proportion of the plant functional traits will also require conserving a large proportion of all species (Petchey & Gaston, 2002). Unfortunately, the natural floodplain dynamics and diverse riparian landscape of most gravel-bed rivers in Europe are under enormous anthropogenic pressure, in the form of canalization, gravel exploitation and flood control measures. This study also shows that gravel bars form a highly significant landscape element (component) in terms of maintaining higher species and *functional diversity* of the middle Drava river ecosystem.

FUNKCIONALNA SESTAVA VEGETACIJE PRODIŠČ SREDNJEGA TOKA REKE DRAVE (SV SLOVENIJA)

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POVZETEK

Z raziskavo na prodiščih srednjega toka reke Drave v Sloveniji smo z vzorčenjem vegetacije, ob upoštevanju morfološko-funkcionalnih potez rastlin in okoljskih dejavnikov, ugotavljali funkcionalno sestavo prodiščne vegetacije. Prodišča predstavljajo prehodno območje med vodnim in kopenskim ekosistemom, kar omogoča razvoj različnih habitatov in je zaradi številnih okoljskih dejavnikov in procesov značilna vegetacijska dinamika. Biodiverziteta prodišč je zato lahko zelo visoka. Funkcionalna sestava kot komponenta biodiverzitete ima bistveno vlogo pri številnih ekosistemskih funkcijah, zato so raziskave funkcionalne pestrosti nujne za celostno poznavanje in razumevanje delovanja ekosistemov. Na območju srednjega toka reke Drave med Ptujem in Ormožem smo vzorčili vegetacijo po standardni srednjeevropski fitocenološki metodi na 143 popisnih ploskvah. Na vsaki ploskvici smo zbrali podatke o naslednjih okoljskih dejavnikih: višini popisne ploskvice nad gladino vode (v cm), deležih proda, peska in mulja (v %) ter starosti prodišča. Popisali smo 211 vrst oz. taksonov rastlin, za katere smo zbrali tudi podatke o 10 morfološko-funkcionalnih potezah (MFP). Podatke smo analizirali s klasifikacijskimi in ordinacijskimi metodami. S Twinspan analizo smo razvrstili vrste na osnovi MFP v šest funkcionalnih tipov (FT). Na osnovi ordinacijskih analiz smo ugotavljali povezavo med merjenimi okoljskimi dejavniki in pestrostjo FT. Ugotovili smo, da je najvišja pestrost vrst, in tudi FT, na tistih delih prodišč, kjer je največji delež prodnate podlage, saj so se tam pojavljale vrste vseh šestih FT. Takšna tla so zmerno hranljiva in podvržena zmerni motnji (poplavam), kar omogoča sobivanje večjega števila vrst in funkcionalnih tipov. Na območjih prodišč, kjer so tla bogatejša s hranili in vlažna (mesta, kjer v tleh prevladujeta mulj in pesek), se uveljavijo in prevladujejo rastlinske vrste z bolj kompetitivnimi strategijami, kar vodi v manjšo pestrost vrst in manjše število funkcionalnih tipov. Na predelih prodišč z zmernimi okoljskimi razmerami smo ugotovili komplementarnost funkcionalnih tipov v vegetaciji, kar ima zelo pomembno uporabno vrednost pri načrtovanju ustreznega upravljanja s temi habitati za njihovo ohranjanje. Kadar z naraščanjem števila vrst narašča funkcionalna pestrost, kot smo ugotovili v raziskavi, je pogoj za ohranitev obstoječih funkcij ekosistema ohranitev velikega števila prisotnih vrst. Z raziskavo smo še potrdili, da so prodišča pomemben element rečne krajine, saj značilno prispevajo k raznolikosti vrst in ekoloških funkcij v rečnem ekosistemu.

Ključne besede: Funkcionalne poteze rastlin, funkcionalna pestrost, rečni ekosistemi, rastlinska pestrost, poplavna motnja, Natura 2000.

REFERENCES

Bellwood, D. R., T. P. Hughes, C. Folke & M. Nyström (2004): Confronting the coral reef crisis. Nature, 429, 827-833.

Braun-Blanquet, J. (1964): Pflanzensoziologie. Grundzuge der Vegetationskunde. Springer, 865 pp.

Cornelissen, J. H. C., S. Lavorel, E. Garnier, S. Díaz, N. Buchmann, D. E. Gurvich, P. B. Reich, H. ter Steege, H. D. Morgan, M. G. A. van der Heijden, J. G. Pausas & H. Poorter (2003): A handbook of protocols for standardised and easy measurement of plant functional traits worldwide. Aust. J. Bot., 51, 335-380.

de Bello, F., S. Lavorel, S. Díaz, R. *et al.* (2010): Towards an assessment of multiple ecosystem processes and services via functional traits. Biodivers. Conserv., 19, 2873-2893.

Díaz, S. & M. Cabido (2001): Vive la difference: plant functional diversity matters to ecosystem processes. Trends in Ecol. Evol., 16, 646-655.

Díaz, S., J. Fargione, F. S. Chapin III & D. Tilman (2006): Biodiversity loss threatens human well-being. PLoS Biol., 4(8): e277. doi:10.1371/journal.pbio.0040277

Duckworth, J. C., M. Kent & P. M. Ramsay (2000): Plant functional types: an alternative to taxonomic plant community description in biogeography? Prog. Phys. Geog., 24, 515-542.

Ellenberg H. (1988): Vegetation Ecology of Central Europe. Cambridge University Press, Cambridge, 731 p.

Ellenberg, H., H. E. Weber, R. Dull, V. Wirth, W. Werner & D. Paulißen (1992): Zeigerwerte von Pflanzen in Mitteleuropa. Datenbank. Scripta Geobot., 18, 1-258.

Eremiášová, R. & H. Skokanová (2014): Response of vegetation on gravel bars to management measures and floods: case study from the Czech Republic. Ekol. Bratislava, 33, 274-285.

Gillison, A. N. (2016): Vegetation Functional Types and Traits at Multiple Scales. In: Box, E. O. (ed.): Vegetation Structure and Function at Multiple Spatial, Temporal and Conceptual Scales. Springer International Publishing, pp. 53-97.

Gilvear, D. & N. Willby (2006): Channel dynamics and geomorphic variability as controls on gravel bar vegetation; River Tummel, Scotland. River Res. Appl., 22, 457–474.

Gray, D. P. & J. S. Harding (2007): Braided river Ecology: a literature review of physical habitats and aquatic invertebrate communities. Prepared for the Department of Conservation. New Zealand, 50 pp.

Grime, J. P. (1977): Evidence for the existence of three primary strategies in plants and its relevance to ecological and evolutionary theory. Am. Nat., 1169-1194.

Grime, J. P. (2001): Plant strategies. Vegetation Processes and ecosystem Properties (second edition). John Wiley and Sons, Chichester, 417 pp.

Gitay, H. & I. R. Noble (1997): What are functional types and how should we seek them. In: Smith, T. M., H.H. Shugart & F. I. Woodward (eds.): Plant functional types: their relevance to ecosystem properties and global change. Cambridge University Press, Cambridge, pp. 3-19.

Hill, M. O. & H. G. Gauch Jr. (1980): Detrended correspondence analysis: an improved ordination technique. Vegetatio, 42, 47-58.

Hill, M. O. & P. Šmilauer (2005): TWINSPAN for Windows version 2.3. Centre for Ecology & Hydrology and University of South Bohemia, České Budějovice.

Hodgson, J. G., P. J. Wilson, R. Hunt, J. P. Grime & K. Thompson (1999): Allocating CSR plant functional types: a soft approach to a hard problem. Oikos, 282-294.

Hooper, D. U., M. Solan, A. Symstad, S. Diaz, M. O. Gessner, N. Buchmann, V. Degrange, P. Grime, F. Hulot, F. Mermillod-Blondin, J. Roy, E. Spehn & L. van Peer (2002): Species diversity, functional diversity and ecosystem functioning. In: Inchausti, P., M. Loreau & S. Naeem (eds.): Biodiversity and ecosystem functioning: synthesis and perspectives, Oxford University Press, pp. 195-208.

Jongman, R. H. G, C. J. F. ter Braak, & O. F. R. van Tongeren (1995): Data analysis in community and landscape ecology. Cambridge University Press, Cambridge, 299 pp.

Kahmen, S., P. Poschlod & K. F. Schreiber (2002): Conservation management of calcareous grasslands. Changes in plant species composition and response of functional traits during 25 years. Biol. Conserv., 104, 319-328.

Kühn, I., W. Durka & S. Klotz (2004): BiolFlor: a new plant-trait database as a tool for plant invasion ecology. Divers. Distrib., 10, 363-365.

Kleyer, M.,R. M. Bekker, I. C. Knevel, J. P. Bakker, K. Thompson, M. Sonnenschein, P. Poschlod, J. M. van Groenendael, L. Klimeš, J. Klimešová, S. Klotz, G. M. Rusch, M. Hermy, D. Adriaens, G. Boedeltje, B. Bossuyt, A. Dannemann, P. Endels, L Götzenberger, J. G. Hodgson, A-K. Jackel, I. Kühn, D. Kunzmann, W. A. Ozinga, C. Römermann, M. Stadler, J. Schlegelmich, H. J. Steendam, O. Tackenberg, B. Wilmann, J. H. C. Cornelissen, O. Eriksson, E. Garnier & B. Peco (2008): The LEDA Traitbase: A database of plant life-history traits of North West Europe. Journal of Ecology 96: 1266-1274.

Klimešová, J. & L. Klimeš (2006): CLO-PLA3: a database of clonal growth architecture of Central-European plants. URL:[http://clopla. butbn. cas. cz].

Klimešová, J. & F. De Bello (2009): CLO-PLA: the database of clonal and bud bank traits of Central European flora. J. Veg. Sci., 20, 511-516.

Klotz, S., I. Kühn & W. Durka (2002): BIOLFLOR – Eine Datenbank mit biologisch-okologischen Merkmalen zur Flora von Deutschland. Schriftenr. Vegetationsk., 38, 1-334.

Köppen, W. (1923): Die Klimate der Erde. De Gruyter, Berlin, Leipzig, 388 pp.

Laureto, L. M. O., M. V. Cianciaruso & D. S. M. Samia (2015): Functional diversity: an overview of its history and applicability. Natureza & Conservação, 13, 112-116.

Lavorel, S. & E. Garnier (2002): Predicting changes in community composition and ecosystem functioning from plant traits: revisiting the Holy Grail. Funct. Ecol., 16, 545-556.

Lavorel, S., K. Grigulis, P. Lamarque, M. P. Colace, D. Garden, J. Girel, G. Pellet & R. Douzet (2011): Using plant functional traits to understand the landscape distribution of multiple ecosystem services. J. Ecol., 99, 135-147.

Lavorel, S. & K. Grigulis (2012): How fundamental plant functional trait relationships scale-up to trade-offs and synergies in ecosystem services. J. Ecol., 100, 128-140.

Lawton, J. H., & V. K. Brown (1994): Redundancy in ecosystems. In: Schulze & H. A. Mooney (eds.): Biodiversity and ecosystem function. Springer-Verlag, Berlin, Heidelberg, pp. 255-270.

Lepš, J. & P. Šmilauer (2003): Multivariate analysis of ecological data using CANOCO. Cambridge University Press, 269 p.

Martinčič, A., T. Wraber, N. Jogan, A. Podobnik, B. Turk, B. Vreš, V, Ravnik, B. Frajman, S. Strgulc Krajšek, B. Trčak, T. Bačič, M. A. Fischer, K. Eler & B. Surina (2007): Mala flora Slovenije. Ključ za določanje praprotnic in semenk. (Flora of Slovenia in brief. Identification key for the ferns and flowering plants). Tehniška založba Slovenije, Ljubljana, 967 p.

Millennium Ecosystem Assessment (2005): Ecosystems and Human Well-being: Synthesis. Island Press, Washington, DC.

Müller, N. & S. Okuda (1998): Invasion of alien plants in floodplains – a comparison of Europe and Japan. In: Starfinger, U., K, Edwards, I. Kowarik & M. Williamson (eds): Plant invasions: Ecological Mechanisms and human responses. Backhuys Publishers, Leiden, pp. 321-332.

O´Donnell, J., K. Fryirs & M. R. Leishman (2015): Can the regeneration of vegetation from riparian seed banks support biogeomorphic succession and the geomorphic recovery of degraded river channels? River Res. Appl., 31, 834-846.

Pipenbaher, N., M. Kaligarič & S. Škornik (2008): Functional comparison of the sub-Mediterranean Illyrian meadows from two distinctive geological substrates. Annales, 18, 247-258.

Petchey, O. L. & K. J. Gaston (2002): Functional diversity (FD), species richness and community composition. Ecol. Lett., 5, 402-411.

Prach, K. (1994): Vegetation succession on river gravel bars across the northwestern Himalayas, India. Arctic Alpine Res., 26,117-125.

Prach, K., P. Petřík, Z. Brož & J. S. Song (2014): Vegetation succession on river sediments along the Nakdong river, South Korea. Folia Geobot., 49, 507-519.

Ricotta, C. & M. Morett. (2011): CWM and Rao's quadratic diversity: a unified framework for functional ecology. Oecologia, 167, 181-188.

Sadler, J. P., D. Bell & A. Fowles (2004): The hydrological controls and conservation value of beetles on exposed riverine sediments in England and Wales. Biol. Conserv., 118, 41-65.

Schnauder, I. & H. L. Moggridge (2009): Vegetation and hydraulic-morphological interactions at the individual plant, patch and channel scale. *Aquat. Sci.,* 71, 318–330.

Takács, K. & Z. Kern (2015): Multidecadal changes in the river ice regime of the lower course of the River Drava since AD 1875. J. Hydrol., 529, 1890-1900.

ter Braak, C. J. F. (1986): Canonical correspondence analysis: a new eigenvalue technique for multivariate direct gradient analysis. Ecology, 67, 1167-1179.

ter Braak, C. J. F. & P. Smilauer (2002): CANOCO reference manual and CanoDraw for Windows user's guide: software for canonical community ordination (version 4.5).

Tilman, D., J. Knops, D. Wedin, P. Reich, M. Ritchie & E. Siemann (1997): The influence of functional diversity and composition on ecosystem processes. Science, 277, 1300-1302.

Tockner, K., A. Paetzold, U. Karaus, C. Claret & J. Zettel (2006): Ecology of Braided Rivers. In: Sambrook Smith, G. H., J. L. Best, C. S. Bristow & G. E. Petts (eds.): Braided rivers: process, deposits, ecology and management. Blackwell Publishing Ltd., Oxford, UK, pp. 339.

van der Maarel, E. (1979): Multivariate methods in phytosociology, with reference to the Netherlands. The study of vegetation, 161, 225.

van Dobben, W. H. (1967): Physiology of growth in two *Senecio* species in relation to their ecological position. Jaarb IBS 346, 75–83.

Villéger, S., N. W. Mason & D. Mouillot (2008): New multidimensional functional diversity indices for a multifaceted framework in functional ecology. Ecology, 89, 2290-2301.

Ward, J. V., K. Tockner, U. Uehlinger & F. Malard (2001): Understanding natural patterns and processes in river corridors as the basis for effective restoration. Regul. River, 17, 311–323.

Wright, J. P., S. Naeem, A. Hector, C. Lehman, P. B. Reich, B. Schmid & D. Tilman (2006): Conventional functional classification schemes underestimate the relationship with ecosystem functioning. Ecol. Lett., 9, 111-120.

Zeng, Q., L. Shi, L. Wen, J. Chen, H. Duo & G. Lei (2015): Gravel bars can be critical for biodiversity conservation: A case study on Scaly-Sided Merganser in South China. Plos One 10(5): e0127387. doi:10.1371/journal.pone.0127387.

Žiberna, I. (2000): Geografski oris slovenskega Podravja (Geographical outline of the Slovenian region of Podravje). In: Mauch, P. (ed.): Drava nekoč in danes: zemljepisne, zgodovinske in etnološke značilnosti sveta ob Dravi; splavarstvo in energetika (Drava River in the past and present: geographical, historical and ethnological characteristics of the Drava River area; timber rafting and energetics). Založba Obzorja, Maribor, pp 19-65.

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NERETVA RUDD, *SCARDINIUS PLOTIZZA* HECKEL & KNER, 1858 (CYPRINIDAE), ENDEMIC FISH SPECIES OF THE ADRIATIC WATERSHED; BIOLOGICAL-ECOLOGICAL AND CONSERVATION TRAITS

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ABSTRACT

The Neretva rudd, Scardinius plotizza, *is an endemic cyprinid species restricted to the Adriatic drainage system (Neretva River basin) of Croatia and Bosnia and Herzegovina, which biological and ecological characteristics, occurrence and distribution, are yet largely unknown and is cataloged as being data deficient (DD) in the Croatian Red Book. Due to its exceptionally small distribution range, it can be considered a stenoendemic. Therefore, more information about its life cycle is essential to develop appropriate management strategies. Major threats are a very narrow distribution area, sparse information about its biology, sensitivity to organic pollution, regulation of rivers and draining of wetlands. This paper is a brief summary of taxonomy, biological-ecological status, present population trends and conservation traits. It represents an overview of the current state of knowledge of the species, with particular emphasis on the conservation challenges.*

Key words: *Scardinius plotizza,* endemic species, Neretva River basin, conservation

SCARDOLA DELLA NERETVA, *SCARDINIUS PLOTIZZA* HECKEL & KNER, 1858 (CYPRINIDAE), SPECIE ITTICA ENDEMICA DELLO SPARTIACQUE ADRIATICO; TRATTI BIOLOGICI-ECOLOGICI E DI CONSERVAZIONE

SINTESI

La scardola della Neretva, Scardinius plotizza, *è una specie endemica di ciprinidi, limitata al sistema di drenaggio dell'Adriatico (bacino del fiume Neretva) della Croazia e della Bosnia ed Erzegovina. Le caratteristiche biologiche ed ecologiche, presenza e distribuzione, sono in gran parte sconosciute e pertanto la specie è catalogata come "carenza di dati" (DD) nel Libro rosso della Croazia. Visto il suo areale eccezionalmente piccolo, può essere considerata specie steno-endemica. Nuove informazioni sul suo ciclo di vita sono pertanto essenziali al fine di sviluppare strategie di gestione adeguate. Le principali minacce sono: zona di distribuzione molto stretta, informazioni scarse sulla sua biologia, sensibilità all'inquinamento organico, regolazione dei corsi d'acqua e drenaggio delle zone umide. L'articolo è un breve riassunto di: tassonomia, stato biologico-ecologico, attuali tendenze demografiche e caratteristiche di conservazione. Esso rappresenta una panoramica dello stato attuale delle conoscenze sulla specie, con particolare enfasi sulle sfide di conservazione.*

Parole chiave: *Scardinius plotizza,* specie endemica, bacino del fiume Neretva, conservazione

INTRODUCTION

Freshwater ichthyofauna of the Adriatic watershed is characterized by a significant number of endemic species with a narrow range of distribution (Mrakovčić *et al*., 2006; Kottelat & Freyhof, 2007). These species are critical components of community structure in a sense that their endangerment can serve as an excellent indicator for monitoring the environmental perturbation on natural biodiversity of the particular area. However, one of major disadvantages is a paucity of published data relating to their essential biological and ecological characteristics, as well as distribution, vulnerability and protection (Economidis, 2002). One such valuable endemic species is cyprinid Neretva rudd *Scardinius plotizza* Heckel & Kner, 1858, locally called „peškelj" or „keljavac" (for specimens lesser than 20 cm). Attempts to develop an effective population management strategy have been obstructed by a deficiency of basic biological information (Tutman *et al*., 2012).

All information on the biology and ecology of this species are sparse and mostly scattered in the older literature. The papers available are mainly related to general biology (Vuković & Ivanišević, 1962; Vuković & Ivanović, 1971; Vuković, 1977) and distribution (Kosorić, 1978; Kosorić *et al*., 1983) issues. In recent years, the research presented the length-weight relationship (Dulčić *et al*., 2009), morphological and meristic characteristics (Prusina *et al*., 2009), morphometric analysis of pharyngeal teeth (Marčić *et al*., 2012) and some biological and ecological characteristics and conservation status of the population in the Hutovo blato wetland from Bosnia and Herzegovina (Tutman *et al*., 2012). Despite the fact that surveys of taxonomy and phylogeny of endemic and rare cyprinid lately attracted considerable interest (Ketmaier *et al*., 2003; Bianco *et al*., 2004; Freyhof *et al*., 2005), data on Neretva rudd are rather scarce (Perea *et al*., 2010). In this paper, all the data from the former literature were analyzed together with some recent data gathered by the author and his colleagues from 2012 till 2015. Finally, we propose some management guidelines that could improve the conservation of *S. plotizza*.

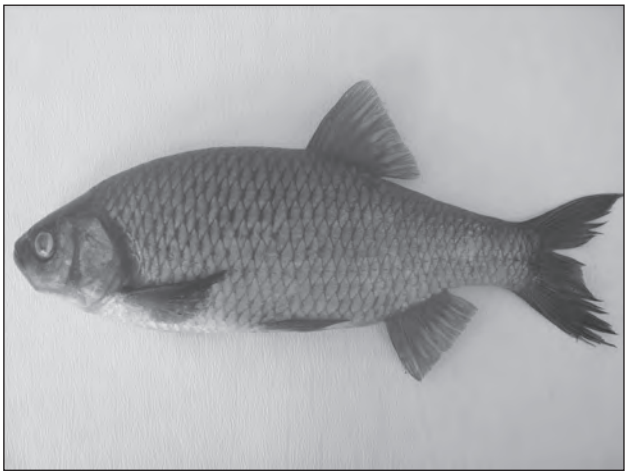

Fig. 1: The Neretva rudd, *Scardinius plotizza****, 23 cm TL (photo by P. Tutman, October 2008).***
Sl.. 1: Krapovec vrste *Scardinius plotizza* ***iz reke Neretve, dolžina 23 cm. (Foto: P. Tutman, oktobra 2008).***

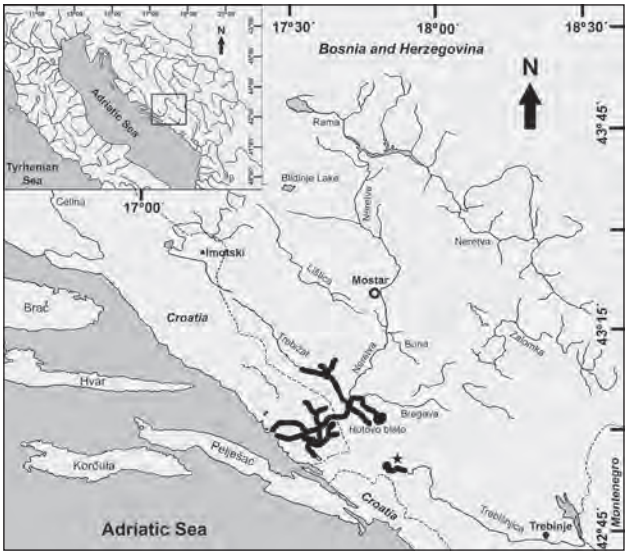

Fig. 2: The distribution map of the Neretva rudd, *Scardinius plotizza* ***(bold black lines). The star indicates a new record in the Trebišnjica channel above the Svitavsko accumulation of the Hutovo blato wetland (Bosnia and Herzegovina).***
Sl.. 2: Zemljevid območja razširjenosti krapovca vrste *Scardinius plotizza* ***(krepke črne črte). Zvezdica označuje nov podatek o pojavljanju vrste iz kanala Trebišnjice nad akumulacijo Svitavsko v mokrišču Hutovo blato (Bosna in Hercegovina).***

REVIEW OF AVAILABLE LITERATURE

Distribution

The Neretva rudd (Fig. 1), in the older literature mentioned as *Scardinius erythrophthalmus scardafa* (Bonaparte, 1837), is an endemic species of limited distribution, geographically restricted to the rivers and lakes of the Adriatic watershed area (lower Neretva River drainage) in Croatia and Bosnia and Herzegovina. In Croatia it is restricted to the rivers Neretva, Norin and Matica drainage near Vrgorac, and lakes Baćina, Kuti, and Desne, while in Bosnia and Herzegovina in the river Neretva and their tributaries Tihaljina, Krupa and Hutovo blato wetland (Mrakovčić *et al*. 2006; Kottelat & Freyhof, 2007) (Fig. 2). It is also recorded on the Trebišnjica channel above the Svitavsko accumulation

of the Hutovo blato wetland (eastern Herzegovina, Bosnia and Herzegovina; 42°55'37.68" N, 17°50'36.83" E; 224 m a.s.l (Hamzić, A., *pers. comm.*). The total range (EOO) of the species is estimated to be less than 2000 km^2, with the estimated area of occupancy (AOO) less than 500 km^2.

Taxonomical status

This species was firstly described as *Scardinius plotizza* from type localities Jessero Grande (Matica River in Jezero valley) near Vrgorac and near Imotski, Dalmatia (Croatia) and Livno (Bosnia and Herzegovina) (Heckel & Kner, 1858). A recent study on the phylogenetic relationships and biogeographical patterns of the Circum-Mediterranean subfamily Leuciscinae inferred from both mitochondrial and nuclear data (Perea *et al*., 2010) confirms the generic status as an independent and highly supported clade.

Description

Scardinius plotizza is a moderately large fish (up to 40 cm TL), with a quite high body, slightly laterally flattened, mouth terminal, facing up; in adult specimens all the fins are dark grey with a yellow-white base, the back dark greyish flanks can be silvery-yellow to grey, silvery-white on the abdomen (Vuković, 1977; Mrakovčić *et al*., 2006; Ćaleta *et al*., 2015). From other known European *Scardinius* it is distinguished by the following diagnostic characteristics: dorsal head profile straight, snout pointing forward, tip above level of middle eye; back not humped behind nape; eye not close to dorsal head profile when viewed laterally; articulation of lower jaw below or in front of anterior margin of eye; ventral head profile with a conspicuous angle at articulation of lower jaw; all fins dark grey in adults (Kottelat & Freyhof, 2007). In addition to these characteristics, *S. plotizza* is also characterized by a specific combination of meristic and certain morphometric characters: dorsal fin (D) encountered III unbranched and 8-9 branched rays; anal fin (A) III unbranched and 9-11 branched rays; pectoral fin (P) I unbranched and 13 branched rays; ventral fin (V) with I unbranched and 8 branched rays; caudal fin (C) with 16-17 rays. Scales are relatively small (about 4.5% SL), on lateral line the scale number is (37)38-40(43), the number of gill rakers on the first gill arch vary from 11-14(18), pharyngeal teeth formulae 3.5-5.3 (Vuković, 1977; Prusina *et al*., 2009; Marčić *et al*., 2012).

The percentual relation between some plastic characteristics and standard length are: head length 26.60%, depth of head at occiput 19.98%, anterodorsal distance 57.38%, postdorsal distance 32.37%, body depth 29.88%, the smallest body depth 10.78%, length of caudal peduncle 17.96%; in relation to the head length the following was determined: eye diameter 22.23%, antieye distance 31.90%; and posteye distance 51,08%. The differences between the mean values of the measured morphometric characteristics in the males and females were not statistically significant. Modes were identical in males and females for most analyzed morphometric relationships. There were no differences in meristic characters, overall shape, coloration pattern between sexes, thus the male and female Neretva rudd population is homogeneous (Prusina *et al*., 2009).

Habitat and Ecology

Scardinius plotizza is a benthopelagic species, non-migratory, which prefers well-vegetated areas with a slow current like river backwaters, floodplain zones, oxbows, ponds and lakes in karstic areas, with a temperature between 13° – 22°C. Juveniles in schools inhabit shallow water areas rich with submerged vegetation; adults individually or in smaller schools live in the open and deeper waters (Tutman *et al*., 2012). Neretva rudd can tolerate low oxygen concentration and high water temperatures (up to 28°C during summer); in the lower parts of the River Neretva it enters in the euryhaline zone (Mrakovčić *et al*., 2006).

Biology

The maximum size of *S. plotizza* is up to 40 cm (*cca* 1000 g), but it is usually 15 – 20 cm (200 – 500 g); females ranging from 10.4 – 39 cm and males 9.9 – 34.5 cm. (Prusina *et al*., 2009). Maximum observed age is 10 years (Tutman *et al*., 2012). The parameters of the allometric length-weight relationship as estimated by Dulčić *et al*. (2009) are a = 0.0051 (0.0037 – 0.0067), b = 3.31 (3.20 – 3.42) and the correlation coefficient r^2=0.9888. It spawns from March to June with a peak in May, depending on weather conditions. Fecundity varies from 100.000 to 200.000 eggs with the relative fecundity of 214.7±33.5 (Tutman *et al*., 2012). Eggs of 1.5 mm in diameter females attach to underwater plants. This is an omnivorous species which mostly feeds on submersed herbal material and benthic invertebrate fauna (Mrakovčić *et al*., 2006).

Populations

Although no population trends estimates are available in the literature for *S. plotizza*, as this species is not specialized in its habitat requirements and is ecologically adaptable, the population is estimated as stable (Mrakovčić *et al*., 2006; Tutman *et al*., 2012). Notwithstanding, negative effects of anthropogenic activities are highly expressed (water capacity lowering, habitat loss) (Tutman *et al*., 2012). Within its distribution area it can be sporadically numerous, especially in lakes, like in Hutovo blato wetland, Bosnia and Herzegovina were represented 3.5% of the total fish abundance (Tutman *et al*., 2012).

Threats

Despite the general attention that has been given to the karstic freshwater ecosystems, it is apparent that a great deal of general knowledge concerning *S. plotizza*, although it is endemic, is still lacking. Major threats are its very limited distributional area, loss of environmental quality by hydrological changes in the Neretva River regime, fragmentation and loss of habitat. *S. plotizza* is very sensitive to organic pollution, river regulation and draining of wetland areas (Mrakovčić *et al*., 2006). Additionally, the Neretva River basin is faced with more potential changes in the hydrological regime, expected from the planned development of hydropower facilities in their upper stream area (second phase of Integral Hydro system Trebišnjica, so-called Upper Horizons). As part of their basin, Hutovo blato wetland is faced with water capacity lowering which in some areas results in a reduction of depth due to siltation. This phenomenon has led to a declining trend in their number in some wetland areas (Tutman *et al*., 2012).

Use and trade

Little information is available on the utilization of the species as *S. plotizza* has no market value and is of very limited economic interest. Only in the area of the Hutovo blato wetland, larger specimens were occasionally fishing for subsistence (Tutman *et al*., 2012).

Conservation Actions

According to the status in IUCN Red List is listed as of Least Concern (LC) (Freyhof & Kottelat, 2008). However, in the Red Book of freshwater fish of Croatia it is listed as Data Deficient (DD) (Mrakovčić *et al*., 2006), and until now there has been no data for Bosnia and Herzegovina. Although strictly protected in Croatia, no conservation actions were ever implemented; on the other side it is unprotected in Bosnia and Herzegovina.

Conservation recommendations

The effects of conservation management on population dynamics depend on the environmental and biological characteristics of *S. plotizza*. Therefore, improved knowledge about its life-history strategies to establish the distributional range and phylogenetic status, following habitat protection, water pollution control and restriction of introductions and control of non-indigenous fish species are strongly recommended. Although precise assessments of the species status often suffer from a lack of comprehensive study, population genetic studies are still lacking. Finally, a long-term monitoring of populations and changes in the hydrological regime are to be carried out.

In conclusion, this paper identified major life-cycle traits of this endemic species which can be selected as an indicator to monitor habitat quality and biodiversity management in the short, medium and long term. Endemic species are essential in balancing ecological processes and if are not adequately preserved, the entire ecosystem becomes vulnerable. The combination of biological information and population vulnerability can be a useful tool for indicating threats in the ecosystem, and also for suggesting effective actions in the conservation management.

NERETVANSKA VRSTA KRAPOVCA *SCARDINIUS PLOTIZZA* HECKEL & KNER, 1858 (CYPRINIDAE), ENDEMIČNE RIBJE VRSTE IZ JADRANSKEGA POVODJA; BIOLOŠKO-EKOLOŠKE IN NARAVOVARSTVENE ZNAČILNOSTI

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POVZETEK

Krapovec vrste Scardinius plotizza *je endemična ciprinidna vrsta, ki jo najdemo v jadranskem povodju (bazen reke Neretve) na Hrvaškem in v Bosni in Hercegovini. O bioloških in ekoloških značilnostih, pojavljanju in razširjenosti te vrste je le malo znanega, zato je v hrvaški Rdeči knjigi ovrednotena s statusom pomanjkljivo poznane vrste ("data deficient" DD). Zaradi zelo ozkega območja razširjenosti je opredeljena kot stenoendemična vrsta. Na podlagi napisanega je potrebno zbrati več podatkov o življenjskem ciklu te vrste za pripravo primernih strategij za njeno ohranitev. Najbolj jo ogrožajo zelo ozko območje razširjenosti, pomanjkljivo poznavanje o njeni biologiji, občutljivost na organsko onesnaževanje in regulacija rek ter izsuševanje mokrišč. V prispevku avtorji poročajo o taksonomiji, biološko-ekološkem statusu vrste, recentnih populacijskih trendih in značilnostih, potrebnih za ohranjanje. Prispevek predstavlja pregled trenutnega védenja o vrsti s posebnim poudarkom na izzivih za njeno ohranitev.*

Ključne besede: *Scardinius plotizza,* endemična vrsta, reka Neretva

REFERENCES

Ćaleta, M., I. Buj, M. Mrakovčić, P. Mustafić, D. Zanella, Z. Marčić, A. Duplić, T. Mihinjač & I. Katavić (2015): Endemic fishes of Croatia. Croatian Environment Agency, Zagreb, 116 p.

Dulčić, J., P. Tutman, I. Prusina, S. Tomšić, B. Dragičević, E. Hasković & B. Glamuzina (2009): Length-weight relationships for six endemic freshwater fishes from Hutovo blato wetland (Bosnia and Herzegovina). J. Appl. Ichthyol., 25 (4), 499-500.

Economidis, P.S. (2002): Biology of rare and endangered non-migratory fish species: problems and constraints. In: Collares-Pereira, M.J., M.M. Coelho & I.G. Cowx (eds.): Conservation of Freshwater Fishes: Options for the Future, Blackwell Science, Fishing News Book, Oxford, pp 81-89.

Freyhof, J. & M. Kottelat (2008): *Scardinius plotizza*. The IUCN Red List of Threatened Species 2008: e.T135624A4164478.

http://dx.doi.org/10.2305/IUCN.UK.2008.RLTS.T135624A4164478.en

Heckel, J. & R. Kner (1858): Die Süsswasserfische der Österreichischen Monarchie. Verlag von Wilhelm Engelmann. Leipzig, 388 p.

Ketmaier, V., P.G. Bianco, M. Cobolli & E. De Matthaeis (2003): Genetic differentiation and biogeography in southern European populations of the genus *Scardinius* (Pisces, Cyprinidae) based on allozyme data. Zool. Scr. 32, 13–22.

Kosorić, Đ. (1978): The composition of fish populations in the Hutovo blato wetland. Godišnjak Biološkog instituta Univerziteta u Sarajevu, 31, 69-81. [In Serbo-Croatian/Croato-Serbian].

Kosorić, Đ., T. Vuković, N. Kapetanović, N. Guzina & D. Mikavica (1983): The composition of the Neretva River fishes in Bosnia and Herzegovina. Godišnjak Biološkog instituta Univerziteta u Sarajevu, 36, 117-128. [In Serbo-Croatian/Croato- Serbian].

Kottelat, M. & J. Freyhof (2007): Handbook of European Freshwater Fishes. Cornol: Kottelat, Switzerland, and Berlin: Freyhof, Germany, 646 p.

Marčić, Z., P. Tutman, M. Ćaleta, B. Glamuzina & J. Dulčić (2012): Morphometric analysis of pharyngeal teeth of Neretva rudd, *Scardinius plotizza* Heckel & Kner, 1858 (Pisces, Cyprinidae) from Hutovo blato wetland in Bosnia and Herzegovina. In: Jelaska, S.D., G.I.V. Klobučar, L. Šerić Jelaska, D. Leljak Levanić & Ž. Lukša, (eds.): 11th Croatian ichthyological congress; 2012, Šibenik, Croatian Biological Society 1885, 115 p.

Mrakovčić, M., A. Brigić, I. Buj, M. Ćaleta, P. Mustafić & D. Zanella (2006): Red Book of freshwater fish of Croatia. Ministry of culture, State institute for nature protection, Republic of Croatia, 253 p. [In Croatian].

Perea, S., M. Böhme, P. Zupančić, J. Freyhof, R. Šanda, M. Özuluğ, A.Abdoli & I. Doadrio (2010): Phylogenetic relationships and biogeographical patterns in Circum-Mediterranean subfamily Leuciscinae (Teleostei, Cyprinidae) inferred from both mitochondrial and nuclear data. BMC Evol. Biol., 10, 265 p. doi:10.1186/1471-2148-10-265

Prusina, I., P. Tutman & B. Glamuzina (2009): Morphological and meristical properties of endemic Neretva rudd, *Scardinius plotizza* Heckel & Kner, 1858 (Actinopterygii, Cyprinidae) from the Hutovo Blato wetland, Neretva River basin, Bosnia and Herzegovina. In: Kontautas, A. (ed.): 13th European congress of ichthyology, 2009, Klaipeda, Klaipedos Universitetas, 95-96.

Tutman, P., M. Ćaleta, B. Glamuzina & J. Dulčić (2012): Biological and ecological characteristics, distribution and conservation status of Neretva rudd, *Scardinius plotizza* (Heckel and Kner, 1858) (Pisces, Cyprinidae) in the Hutovo blato wetland, Bosnia and Herzegovina. Croatian Journal of Fisheries, 70 (Suppl. 1), 15-28. [In Croatian with English Summary].

Vuković, T. (1977): Fishes of Bosnia and Herzegovina. IGKRO „Svjetlost", Sarajevo, 197 p. [In Serbo-Croatian/Croato-Serbian].

Vuković, T. & B. Ivanišević (1962): The existence of two morphologically different populations of *Scardinius erythrophthalmus scardafa* (Bonaparte) in the lower Neretva and Skadar Lake. Godišnjak Biološkog instituta Univerziteta u Sarajevu, 15 (1-2), 141-145. [In Serbo-Croatian/Croato-Serbian].

Vuković, T. & B. Ivanović (1971): Freshwater fishes of Yugoslavia. Zemaljski muzej Sarajevo, SRBiH, 268 p. [In Serbo-Croatian/Croato-Serbian].

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CLINITRACHUS ARGENTATUS (RISSO, 1810) (PERCIFORMES: CLINIDAE) – A LESS KNOWN FISH SPECIES IN SLOVENIAN COASTAL WATERS (ADRIATIC SEA)

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ABSTRACT

*The data regarding the occurrence of the Cline (*Clinitrachus argentatus*) in the Adriatic Sea are scarce, limited and sporadic. In the Slovenian sea only three specimens were observed in the past decades. The paper presents new findings of the species from 2013 to 2016, when some specimens were occasionally manually collected in shallow waters. Data about habitat preferences, depth range, total lengths and meristic counts are reported. The aim of the study is also to discuss the reasons for the underestimation of the occurrence of* C. argentatus *in the area.*

Key words: *Clinitrachus argentatus,* shallow waters, overlooked species, habitat preferences, Adriatic Sea

CLINITRACHUS ARGENTATUS (RISSO, 1810) (PERCIFORMES: CLINIDAE) – UNA SPECIE ITTICA MENO CONOSCIUTA IN ACQUE COSTIERE SLOVENE (MARE ADRIATICO)

SINTESI

*I dati riguardanti la presenza della bavosella d'alga (*Clinitrachus argentatus*) nel mare Adriatico sono scarsi, limitati e sporadici. Nel mare sloveno sono stati osservati solo tre esemplari negli ultimi decenni. L'articolo presenta nuovi ritrovamenti della specie nel periodo dal 2013 al 2016, quando alcuni esemplari sono stati raccolti per caso manualmente in acque poco profonde. Sono inoltre riportati i dati inerenti: preferenze di habitat, intervallo di profondità, lunghezze totali e conteggi meristici. Lo scopo dello studio è anche quello di discutere le ragioni della sottostima della presenza di* C. argentatus *nell'area.*

Parole chiave: *Clinitrachus argentatus,* acque poco profonde, specie trascurata, preferenze ambientali, mare Adriatico

INTRODUCTION

Clinitrachus argentatus (Risso, 1810), commonly named the Cline, belongs to the family Clinidae and is the only known species of this genus. It is named after the shape of four apophyses of the sfenoid bone at the base of the skull (from Greek, *klinein, klines* = sloping and bed) (Froese & Pauly, 2016). The species is commonly found in shallow waters along the Atlantic coasts of Portugal and Marocco, and along Mediterranean coasts. Its habitat even extends into the Sea of Marmara and the Bosporus Strait (Wirtz & Zander, 1986). The species is included in the Checklist of the Adriatic Sea Fishes (Lipej & Dulčić, 2010). Although specific population data are not available, the population is considered as stable, and since there are no current known threats, the Cline is assessed as Least Concern (Yokes *et al*., 2016).

The body of this small fish is covered with cycloid scales embedded into skin, and can reach a maximum length of 10 cm (Wirtz & Zander, 1986). The head is more pointed than in fish from the family Blenniidae. The dorsal fin is divided into two parts, the first of which consists of three spines and is inserted immediately behind the eyes (Fig. 1). The body is flattened laterally and the caudal peduncle is thin. The second part of the dorsal fin has increasing height, similar to the anal fin, while the caudal fin is small and convex. There is a tiny tentacle above the eye. The fish coloration is dark green or brownish with a marbled pattern, and white or silver spots on the sides. The species is known to feed primarily on benthic invertebrates hiding among dense algal cover in rocky habitat types (Wirtz & Zander, 1986; Pallaoro & Števčić, 1989).

The data regarding the occurrence of *C. argentatus* in the Adriatic Sea are scarce, limited and sporadic. Patzner (1985) reported the finding of two specimens in the harbor of the Laboratory of Marine Biology in Aurisina (near Trieste). Pallaoro & Števčić (1989) and Pallaoro (1989) mentioned the presence of the species near Venice, Trieste, and islands Hvar, Korčula and Šolta. For Slovenian marine waters the first information was reported by Lipej & Richter (1999), who observed two specimens of *C. argentatus* in the mediolittoral belt near Piran. After that, in 2004, one specimen was captured in a breakwater area in Koper (Lipej *et al.,* 2005; 2008a).

From 2006 to 2016, specimens of *C. argentatus* were never found in any visual surveys of benthic habitat types and coastal fish assemblage regularly performed by SCUBA diving in Slovenian coastal waters (Lipej *et al.,* 2007, 2008b; Orlando-Bonaca *et al*., 2012; and *unpublished data*). However, some specimens were occasionally manually collected in recent years. The aim of the study is to present new data about the presence of *C. argentatus* in Slovenian coastal waters and to discuss the reasons for its underestimation of the occurrence in this area.

Fig. 1: A specimen of** Clinitrachus argentatus **found in Slovenian coastal waters (Photo: Domen Trkov).
Sl. 1: Primerek vrste** Clinitrachus argentatus **najden v slovenskih obalnih vodah (Foto: Domen Trkov).

MATERIAL AND METHODS

The Slovenian coastal sea is a shallow semi-enclosed part of the Gulf of Trieste with a maximum depth of ca. 37 m. Its diverse coastline is approximately 46.7 km long. In recent decades the Slovenian natural shoreline has been modified by many human activities, like urbanisation, intensive hinterland farming and massive tourism. Nowadays, less than 18% of the coastline is in its natural state (Turk, 1999).

During occasional surveys of the Slovenian lower mediolittoral / upper infralittoral belt performed in the period 2013-2016, few specimens of *C. argentatus* were manually collected and taken alive to the Marine Biology Station of the National Institute of Biology in Piran. Total lengths (L_T) were measured to the nearest mm, while meristic counts for two specimens were verified in Marčeta (1999). One fish is kept in the aquarium of the institute.

RESULTS AND DISCUSSION

All together, six specimens of *C. argentatus* were captured in Slovenian coastal waters in the period from July 2013 to August 2016 (Tab. 1). The first specimen was noticed while resting on a frond of a brown alga from the genus *Cystoseira* C. Agardh, in shallow waters near the lighthouse in Isola (Fig. 2). The second fish was observed in the same locality and at the same depth range, but resting on round stones, not covered by any vegetation. The third specimen was captured in the area of submerged breakwater of the main pier in Koper. These three fishes, captured in 2013, were found in the late afternoon. The fourth specimen, very small, was accidentally captured while collecting macroalgae with a small manual net, near the pier in the San Simon

Tab. 1: Sampling date, hour, location, habitat, depth and total length (L_T) of the specimens of** Clinitrachus argentatus **found from 2013 to 2016 in Slovenian coastal waters.
Tab. 1: Datum vzorčenja, ura, lokacija, habitat, globina in celokupna dolžina (L_T) primerkov vrste** Clinitrachus argentatus **najdenih med 2013 in 2016 v slovenskih obalnih vodah.

Specimen	Date	Hour range	Location	Habitat	Depth (m)	LT (mm)
1	15.7.2013	17:00-18:00	lighthouse (Izola)	on *Cystoseira* sp.	0.7	76
2	8.8.2013	17:00-18:00	lighthouse (Izola)	on round stones	0.5	61
3	9.8.2013	17:00-18:00	breakwater of the main pier (Koper)	within the turf layer on a boulder	0.5	78
4	17.6.2016	11:00-12:00	near the pier in the San Simon Bay (Izola)	on *Dictyota dichotoma*	0.5-0.7	14
5	30.7.2016	15:00-16:00	Sv. Jernej Bay	on mixed benthic vegetation	0.5-1.0	43
6	17.8.2016	11:00-12:00	near the coastal road Koper-Izola	on *Halopithys incurva*	0.5	29

Bay (Izola). It was hiding on a thallus of the brown alga *Dictyota dichotoma* (Hudson) J. V. Lamouroux. The fifth fish was also accidentally captured in the Sv. Jernej Bay near cape Debeli rtič, in a manual net that was dredged through mixed benthic vegetation. It is therefore impossible to determine if the specimen was hiding between *Cymodocea nodosa* (Ucria) Ascherson leaves or on a thallus of the red alga *Halopithys incurva* (Hudson) Batters. The sixth and the last specimen was found clinging on a frond of *H. incurva,* in shallow waters next to the coastal road between Koper and Izola.

It seems that the macroalgal assemblage play a major role in the habitat occupancy and distribution of this small benthic species. Especially *Cystoseira* spp. are known to have an important role as ecosystem-engineers (Cormaci 1995; Gianni *et al*., 2013). Their benthic communities display a three-dimensional structure that provides habitat and shelter for smaller algae and invertebrates (Ballesteros et al. 2009; Antit *et al*., 2013; Mačić & Svirčev 2014; Pitacco *et al*., 2014), but also to fish (Lipej *et al*., 2003, 2009; Orlando-Bonaca & Lipej 2005, 2007; Orlando-Bonaca *et al*., 2008b; Vergés *et al*., 2009; Cheminée *et al*., 2013). In the Gulf of Trieste associations with *Cystoseira* species are limited to the shallow coastal area (Orlando-Bonaca *et al.,* 2008a).

The meristic counts were done on two specimens. The first was the one captured on a breakwater in Koper in 2004, and kept in the fish collection of the Marine Biology Station in Piran. The meristic formula of the rays in fins was: D (dorsal) III+XXIX/3, A (anal) II/19, P (pectoral) 9, V (pelvic) 2. The counts of this specimen are not in total accordance with Marčeta (1999), since there is one extra ray in the second part of the dorsal fin (XXIX instead of XXVIII). The second meristic counts were done on the fish captured on the 30.7.2016, which is kept alive in the aquarium of the institute. The meristic formula is: D III+XXVIII/3, A II/20, P 9, V 2, and is in total accordance with Marčeta (1999).

Unfortunately, literature on the ecology and biology of *C. argentatus* is very scarce, therefore it was not possible to compare our data with other studies. Only two papers were found that specifically targeted *C. argentatus*. The first focused mostly on its reproductive

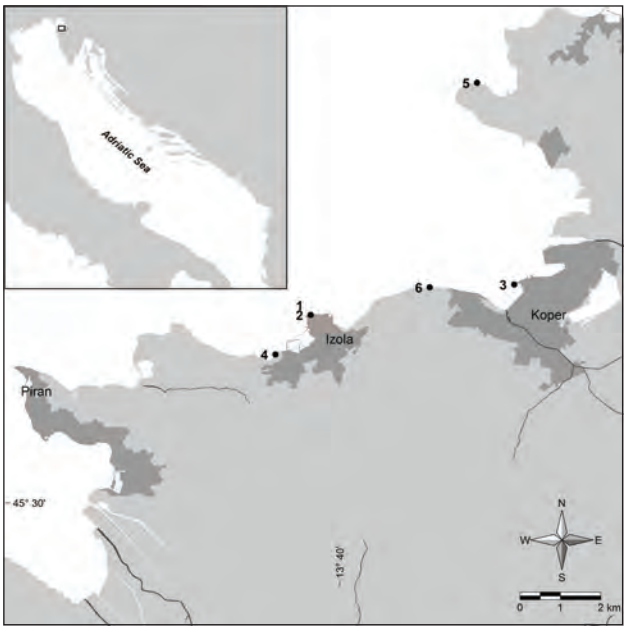

Fig. 2: Sampling locations of the specimens of** Clinitrachus argentatus **from 2013 to 2016 in Slovenian coastal waters. For explanations see Tab. 1.
Sl. 2: Lokacije vzorčenj primerkov vrste** Clinitrachus argentatus **med 2013 in 2016 v slovenskih obalnih vodah. Za razlago glej Tab. 1.

behaviour (Guitel, 1893), while the second on its diet (Ozen *et al*., 2010). The range of the total length of specimens in our study is comparable with the meristic data published in the study of Ozen *et al*. (2010). The length of the specimens from Slovenian waters varied between 14 mm and 78 mm, while between 28 mm and 57 mm for the specimens caught in the northern Aegean and Marmara Seas. Ozen *et al*. (2010) reported that the diet of *C. argentatus* consists mainly of amphipods, copepods, isopods and decapods in this marine area. We are also regularly observing how the specimen kept in the aquarium of the institute, feeds on amphipods, isopods and other small invertebrates collected among algal thalli.

The fact that in Slovenian coastal waters *C. argentatus* was not found between 2005 and 2012, and since it was reported only occasionally in not very recent reports for other Adriatic areas (Patzner, 1985; Pallaoro & Števčić, 1989; Pallaoro, 1989), could lead us to the conclusion that the species is very rare. However, the species is considered as widespread in Mediterranean inshore waters and the population is defined as not-fragmented (Yokes *et al*., 2016). The reason for its apparent scarcity or absence in our area is likely to be due to its cryptic way of life among the fronds of macroalgae. According to our observations, the species is able to cling on to the thallus by twisting the body and the use of fins. The most useful for this purpose are probably the ventral fins that the species uses also to walk on algae and on rocky substrata (*pers. obs*.), as already reported by Guitel (1893) for specimens found near Banyuls-sur-Mer. Even when vigorously shaking the seaweed, the fish does not lose its grip. Moreover, the color pattern of the fish is very variable. The ventral part is frequently tinted with green, but can vary according to the macroalgal species that the fish uses as a hiding place, and could be brown, reddish or purplish (*pers. obs*.). Therefore, we can conclude that the species is only seemingly rare, since, due to its cryptic coloration, relatively small size and hiding within the macroalgal vegetation, it remains mostly unnoticed.

Further work needs to be carried out to clarify the habitat occupancy, distribution, abundance and behaviour of *C. argentatus* in the Gulf of Trieste, as well as in the whole Adriatic area. The study of the predation pressure on this species and of its feeding habits would help us to identify feeding requirements in relation to the habitat choice in this shallow and unstable coastal environment. Moreover, special attention should be paid to the conservation of *Cystoseira* associations, since they are of primary importance for the survival of *C. argentatus*. Many authors have observed that coastal ecosystems are subjected to multiple anthropogenic stressors (like nutrient enrichment and urbanization), which can result in the loss of long-living genera of the order Fucales (Thibaut *et al*., 2005, 2015; Mangialajo *et al*., 2008; Airoldi & Bulleri, 2011; Iveša *et al*., 2016) that are often replaced by persistent, smaller and less complex turf-forming algae (Airoldi *et al*., 2008; Perkol-Finkel & Airoldi, 2010; Connell *et al*., 2014). Strain *et al*. (2014) concluded that, in order to prevent shifts from canopy to turf-forming taxa, priority should be given especially to the management of nutrients levels.

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CLINITRACHUS ARGENTATUS (RISSO, 1810) (PERCIFORMES: CLINIDAE) – MANJ ZNANA VRSTA RIB V SLOVENSKIH OBALNIH VODAH (JADRANSKO MORJE)

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POVZETEK

*Podatki o pojavljanju srebrnice (*Clinitrachus argentatus*) v Jadranskem morju so redki, omejeni in občasni. V zadnjih desetletjih so bili v slovenskem morju opaženi le trije primerki. V prispevku predstavljamo nove najdbe te vrste med leti 2013 in 2016, ko smo posamezne primerke ročno ujeli v plitvem obalnem morju. Prav tako podajamo podatke o habitatnih preferencah, globinskem razponu, celotni dolžini telesa in merističnem štetju plavutnic. V razpravi podajamo tudi razloge za podcenjevanje prisotnosti vrste* C. argentatus *na območju Jadranskega morja.*

Ključne besede: *Clinitrachus argentatus*, plitke vode, spregledana vrsta, habitatne preference, Jadransko morje

REFERENCES

Airoldi, L., D. Balata & M.W. Beck (2008): The Gray Zone: relationships between habitat loss and marine diversity and their applications in conservation. J. Exp. Mar. Biol. Ecol., 366, 8–15.

Airoldi, L. & F. Bulleri (2011): Anthropogenic Disturbance Can Determine the Magnitude of Opportunistic Species Responses on Marine Urban Infrastructures. PLoS One, 6(8), e22985.

Antit, M., A. Daoulatli, J. Rueda & C. Salas (2013): Temporal variation of the algae-associated molluscan assemblage of artificial substrata in Bay of Tunis (Tunisia). Mediterranean Marine Science, 14(2), 390-402.

Ballesteros, E., J. Garrabou, B. Hereu, M. Zabala, E. Cebrian & E. Sala (2009): Deep-water stands of *Cystoseira zosteroides* C. Agardh (Fucales, Ochrophyta) in the Northwestern Mediterranean: insights into assemblage structure and population dynamics. Estuarine Coastal and Shelf Science, 82, 477-484.

Cheminée, A., E. Sala, Jé. Pastor, P. Bodilis, P. Thiriet, L. Mangialajo, J.-M. Cottalorda & P. Francour (2013): Nursery value of *Cystoseira* forests for Mediterranean rocky reef fishes. Journal of Experimental Marine Biology and Ecology, 442, 70-79.

Connell, S.D., M.S. Foster & L. Airoldi (2014): What Are Algal Turfs? Towards a Better Description of Turfs. Marine Ecology Progress Series, 495, 299-307.

Cormaci, M. (1995): Struttura e periodismo dei popolamenti a *Cystoseira* (Fucophyceae, Fucales) del Mediterraneo. Giornale Botanico Italiano, 129(1), 357-366.

Froese, R. & D. Pauly (*Eds.*) (2016): FishBase. *Clinitrachus argentatus* (Risso, 1810). http://www.fishbase.org/summary/1793. Accessed: 30.8.2016.

Gianni, F., F. Bartolini, L. Airoldi, E. Ballesteros, P. Francour, P. Guidetti, A. Meinesz, T. Thibaut & L. Mangialajo (2013): Conservation and Restoration of Marine Forests in the Mediterranean Sea and the Potential Role of Marine Protected Areas. Advances in Oceanography and Limnology, 4(2), 83-101.

Guitel, F. (1893): Observations sur les mœurs de trois Blenniidés: *Clinus argentatus, Blennius montagui* et *Blennius sphinx*. Arch. Zool. Expér. génér.,, Ser. III, 1, 325–384.

Iveša, L., T. Djakovac & M. Devescovi (2016): Long-term fluctuations in *Cystoseira* populations along the west Istrian Coast (Croatia) related to eutrophication patterns in the northern Adriatic Sea. Marine Pollution Bulletin, doi:10.1016/j.marpolbul.2016.03.010.

Lipej, L. & M. Richter (1999): Blennioides (Blennioidea) of the Slovenian coastal waters. Annales, Ser. Hist. Nat., 9, 15–24.

Lipej, L., M. Orlando-Bonaca & M. Šiško (2003): Coastal fish diversity in three marine protected areas and one unprotected area in the Gulf of Trieste (Northern Adriatic). Marine Ecology, 24(4), 259-273.

Lipej, L., M. Orlando-Bonaca & M. Richter (2005): New contributions to the marine coastal fish fauna of Slovenia. Annales, Ser. Hist. Nat., 15(2), 165–172.

Lipej, L., Ž. Dobrajc, J. Forte, B. Mavrič, M. Orlando-Bonaca & M. Šiško (2007): Kartiranje habitatnih tipov in popis vrst na morskih zavarovanih območjih NS Debeli rtič, NR Strunjan in NS Rt Madona. Zaključno poročilo. Poročila Morska biološka postaja, NIB, 92, 56 pp.

Lipej, L., M. Orlando-Bonaca & T. Makovec (2008a): Jadranske babice. Nacionalni inštitut za biologijo, Morska biološka postaja Piran, 208 pp.

Lipej, L., Ž. Dobrajc, J. Forte, B. Mavrič, M. Orlando-Bonaca & M. Šiško (2008b): Kartiranje habitatnih tipov in popis vrst izven zavarovanih območij. 2. fazno zaključno poročilo. Poročila Morska biološka postaja, NIB, 10 pp.

Lipej, L., M. Orlando-Bonaca, B. Ozebek & J. Dulčić (2009): Nest characteristics of three labrid species in the Gulf of Trieste (northern Adriatic Sea). Acta Adriatica, 50(2), 139-150.

Lipej, L. & J. Dulič (2010): Checklist of the Adriatic Sea Fishes. Zootaxa, 2589, 1–92.

Mačić, V. & Z. Svirčev (2014): Macroepiphytes on *Cystoseira* species (Phaeophyceae) on the coast of Montenegro. Fresenius Environmental Bulletin, 23(1), 29-34.

Mangialajo, L., M. Chiantore & R. Cattaneo-Vietti (2008): Loss of Fucoid Algae Along a Gradient of Urbanisation, and Structure of Benthic Assemblages. Marine Ecology Progress Series, 358, 63-74.

Marčeta, B. (1999): Luskaste babice, Clinidae. In: Kryštufek, B. & Janžekovič F. (Eds.): Ključ za določanje vretenčarjev Slovenije, DZS, pp. 167-168.

Orlando-Bonaca, M. & L. Lipej (2005): Factors affecting habitat occupancy of fish assemblage in the Gulf of Trieste (Northern Adriatic Sea). Marine Ecology, 26(1), 42-53.

Orlando-Bonaca, M. & L. Lipej (2007): Microhabitat preferences and depth distribution of combtooth blennies (Blenniidae) in the Gulf of Trieste (North Adriatic Sea). Marine Ecology, 28(3), 418-428.

Orlando-Bonaca, M., L. Lipej & S. Orfanidis (2008a): Benthic macrophytes as a tool for delineating, monitoring and assessing ecological status: the case of Slovenian coastal waters. Marine pollution bulletin, 56(4), 666-676.

Orlando-Bonaca, M., R. Turk, B. Ozebek & L. Lipej (2008b): Evaluation of the association with *Cystoseira* in the Strunjan Nature Reserve using fish fauna as indicator. Varstvo Narave, 21, 61-72.

Orlando-Bonaca, M., L. Lipej, A. Malej, J. Francé, B. Čermelj, O. Bajt, N. Kovač, B. Mavrič, V. Turk, P. Mozetič, A. Ramšak, T. Kogovšek, M. Šiško, V. Flander Putrle, M. Grego, T. Tinta, B. Petelin, M. Vodopivec, M. Jeromel, U. Martinčič & V. Malačič (2012a): Začetna presoja stanja slovenskega morja. Poročilo za člen 8 Okvirne direktive o morski strategiji. Zaključno poročilo za leto 2012. Poročila MBP 140. Morska biološka postaja, Nacionalni Inštitut za Biologijo, Piran, 345 pp.

Ozen, O., A. Altin & H. Ayyildiz (2010): The diet of *Clinitrachus argentatus* (Blennioidei: Clinidae) in the northern Aegean and Marmara Seas. J Fish Biol., 76(6), 1516-1519.

Pallaoro, A. (1989): Blennioidea (Pisces, Perciformes) Jadranskog mora s posebnim osvrtom na otok Šoltu. Ichthyologia, 21(1), 57–69.

Pallaoro, A. & Z. Števčić (1989): A check-list of species of Adriatic Blennioidea (Pisces, Teleostei, Perciformes). Studia Marina, 20, 51–74.

Patzner, R.A. (1985): The Blennies (Pisces, Blennioidea) at the Marine Biological Station of Aurisina (Gulf of Trieste, Italy). Nova Thalassia, 7, 109–119.

Perkol-Finkel, S. & L. Airoldi (2010): Loss and Recovery Potential of Marine Habitats: An Experimental Study of Factors Maintaining Resilience in Subtidal Algal Forests at the Adriatic Sea. PLoS One, 5(5), e10791.

Pitacco, V., M. Orlando-Bonaca, B. Mavrič, A. Popovič & L. Lipej (2014): Mollusc fauna associated with the *Cystoseira* algal associations in the Gulf of Trieste (northern Adriatic Sea). Mediterranean Marine Science, 15(2), 225-238.

Strain, E.M., R.J. Thomson, F. Micheli, F.P. Mancuso & L. Airoldi (2014): Identifying the Interacting Roles of Stressors in Driving the Global Loss of Canopy-Forming to Mat-Forming Algae in Marine Ecosystems. Global Change Biology, 20, 3300-3312.

Thibaut, T., S. Pinedo, X. Torras & E. Ballesteros (2005): Long-Term Decline of the Populations of Fucales (*Cystoseira* spp. and *Sargassum* spp.) in the Alberes Coast (France, North-Western Mediterranean). Marine Pollution Bulletin, 50, 1472-1489.

Thibaut, T., A. Blanfuné, C.F. Boudouresque, & M. Verlaque (2015): Decline and local extinction of Fucales in French Riviera: the harbinger of future extinctions? Mediterranean Marine Science, 16(1), 206-224.

Turk, R. (1999): Ocena ranljivosti slovenskega obrežnega pasu in njegova kategorizacija z vidika (ne) dopustnih posegov, dejavnosti in rabe. Annales, Ser. hist. nat., 15, 37-50.

Vergés, A., T. Alcoverro & E. Ballesteros (2009): Role of fish herbivory in structuring the vertical distribution of canopy algae *Cystoseira* spp. in the Mediterranean Sea. Marine Ecology Progress Series, 375, 1-11.

Wirtz, P. & C. D. Zander (1986): Clinidae. In: Whitehead, P.J.P. *et al.* (Eds): Fishes of the North-eastern Atlantic and the Mediterranean. Unesco. Vol. III, p. 1117.

Yokes, B., D. Pollard, C. Bizsel, M. Goren, M.H. Kara, J. Williams & M. Craig (2014): *Clinitrachus argentatus*. The IUCN Red List of Threatened Species 2014: e.T185155A1773287.

http://dx.doi.org/10.2305/IUCN.UK.2014-3.RLTS.T185155A1773287.en. Downloaded on 01 September 2016.

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SCUBA OBSERVATIONS REVEAL A WIDER DISTRIBUTION RANGE FOR *THOROGOBIUS MACROLEPIS* (TELEOSTEI: GOBIIDAE)

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ABSTRACT

The Mediterranean Sea endemic goby Thorogobius macrolepis *was observed during scuba dives at three localities along the Aegean Sea and one locality at the northern Levant coast of Turkey, increasing the currently available knowledge on the distribution of this species. This is the first record of* T. macrolepis *from the central and northern Aegean Sea, while the single observation from Kekova region substantiates its occurrence at the Levant basin.*

Key words: *Thorogobius macrolepis*, Gobiidae, Aegean Sea, Mediterranean Sea

OSSERVAZIONI SUBACQUEE RIVELANO UNA ZONA DI DISTRIBUZIONE PIÙ AMPIA PER *THOROGOBIUS MACROLEPIS* (TELEOSTEI: GOBIIDAE)

SINTESI

Il Ghiozzo gattopardo Thorogobius macrolepis*, endemico del mar Mediterraneo, è stato osservato durante le immersioni subacquee effettuate in tre località lungo le coste del mar Egeo e una località lungo la costa settentrionale della Turchia nel mar di Levante, aumentando le conoscenze attualmente disponibili sulla distribuzione di questa specie. Le segnalazioni di* T. macrolepis *riportate sono le prime per il mar Egeo centrale e settentrionale, mentre l'unica osservazione nella regione di Kekova ne dimostra la presenza nel bacino del mar di Levante.*

Parole chiave: *Thorogobius macrolepis*, Gobiidae, mar Egeo, mar Mediterraneo

INTRODUCTION

Despite of their high species diversity, gobies are one of the most scarcely known taxa along the Mediterranean coastline. A recent research has shown that the disparity of Mediterranean gobiid distribution is most likely due to unequal sampling efforts exerted, rather than to actual numerical rarity of the species (Kovačić *et al*., 2012). The traditional fishery methods are often useless for collecting particular goby species because of their small sizes and mostly cryptic life styles, so they are generally unexplored even in well studied areas. With the increased use of scuba and underwater photography techniques, many goby species became more visible than before, enhancing to better understand their actual zoogeographical affinities (Colombo & Langaneck, 2013). Positive identification of gobies is mainly based on the exhaustive examination of head canal pores and papillae rows of the lateral line system (Kovačić, 2008a), although accurate *in situ* determination to species level is also possible based on the unique colour patterns of some gobies (Francour *et al*., 2007). *Thorogobius macrolepis* is one of those goby species with unmistakable body coloration that has recently been observed at several localities along the Turkish coasts and reported herein for the first time from central and northern Aegean Sea shores.

Fig. 1: *Thorogobius macrolepis* ***individual with an approximate total length of 4.0 cm observed at Karaburun Peninsula, central Aegean Sea (above). An immediate escape behaviour was observed upon approach by the diver (below) (Photos: M. Bilecenoglu).***
Sl. 1: Osebek 4,0 cm dolgega veleluskastega glavača, opazovanega ob polotoku Karaburun v osrednjem Egejskem morju (zgoraj). Ko se mu je potapljač približal, je sunkovito pobegnil (spodaj) (Foto: M. Bilecenoglu).

MATERIAL AND METHODS

During a marine biodiversity study carried out at the Ayvalik Islands Nature Park (Edremit Bay, north Aegean Sea) between August and October 2012, one specimen per site of *Thorogobius macrolepis* (Kolombatović, 1891) were observed in two adjacent localities (39.4098667°- 026.7138139° and 39.4185944°- 026.7289750°, at depths of 30 and 43 m, respectively). Habitats at both sites were coralligenous, the deeper one being characterized by the existence of two coral species (*Eunicella cavolini* and *Paramuricea clavata*).

The species was later observed at the Karaburun Peninsula (outer section of Izmir Bay, central Aegean Sea, October 2013, 38.6592139°- 026.5092750°) within a small cave at a depth of about 25 m, in the Sigacik Bay (southern Aegean Sea, December 2014, 38.1240083°- 026.8207972°), where the depth was about 30 m, and at 24 m on the western coast of the Sicak Peninsula (Kekova, Antalya, northern Levant Sea, July 2014, 36.140318°- 029.762748°), on a rocky bottom encircled by a patch of sand. At each locality mentioned above, only a single specimen of *T. macrolepis* was observed,

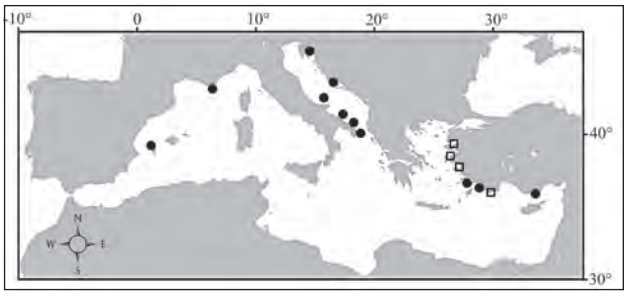

Fig. 2: Updated distribution of *Thorogobius macrolepis* ***in the Mediterranean Sea (previous records indicated with full dots following Ahnelt & Kovačić (1997), Guidetti*** *et al.* ***(2006) and Francour*** *et al.* ***(2007); open squares denote new locality records).***
Sl. 2: Dopolnjeno območje razširjenosti veleluskastega glavača v Sredozemskem morju (predhodne najdbe Ahnelt & Kovačić (1997), Guidetti *et al.* ***(2006) in Francour*** *et al.* ***(2007) so označene s polnimi krogci; kvadratki pa označujejo podatke na novih lokalitetah).***

while we were not able to capture any specimens. Underwater photographs are available only for the species observed at the Karaburun Peninsula (Fig. 1).

RESULTS AND DISCUSSION

Until two decades ago, the Mediterranean endemic *Thorogobius macrolepis* was known only by three specimens collected in the western Mediterranean (Balearic Islands and France) and in the Adriatic Sea (Miller *et al*., 1973; Ahnelt & Kovačić, 1997). Later studies carried out in the Adriatic Sea indicated that the species is possibly far more common than previously thought (Guidetti *et al*., 2006; Colombo & Langeneck, 2013), while underwater observations of Francour *et al*. (2007) expanded the known range of the species as far as to the north-eastern Levant Sea. In the present study *T. macrolepis* was recorded for the first time along the central and northern Aegean Sea coasts of Turkey, which represents a significant northerly range expansion of the species (Fig. 2). Recent observations lead us to suspect of a continuous spread of *T. macrolepis* through suitable habitats of the entire Aegean Sea sublittoral, although occurrence of the species is not yet reported from the Aegean shores of Greece (Papaconstantinou, 2014).

The core data of the present study is solely based on scuba diving observations and just a single individual from the Karaburun Peninsula (central Aegean Sea) was photographed. Anyhow, a positive identification of *Thorogobius macrolepis* is quite possible during divings, since this small sized goby has a unique colour pattern, characterized by having irregular orange spots on head, nape and dorsolateral region, also with 4-5 brownish blotches along the lateral midline. Among other orange spotted gobies of the Mediterranean Sea, *Gobius kolombatovici* Kovačić & Miller, 2000 has a black blotch in the first dorsal fin and a typical Y shaped pattern on the nape (Guidetti *et al*., 2006), *Vanneaugobius dollfusi* Brownell, 1978 has a dark blotch at the D1 base between spines I and V (Kovačić, 2008b), *Gobius gasteveni* Miller, 1974 has light dots on cheek and opercle, and dark L-shaped blotch longer than broader at the origin of pectoral fins (Ahnelt *et al.,* 2011), *Lesueurigobius friesii* (Malm, 1874) has yellow/orange spots also on the caudal fin (*pers. obs.*).

The species has a distinctive habitat preference to soft sediments (pure sand, detritic coarse sand and

Tab. 1: Habitat and depth preferences of *Thorogobius macrolepis* ***(References: [1]Ahnelt & Patzner, 1996; [2]Ahnelt & Kovačić, 1997; [3]Patzner, 1999; [4]Guidetti*** *et al., 2006;* ***[5]Francour*** *et al., 2007;* ***[6]Fischer*** *et al., 2007;* ***[7]Colombo & Langeneck, 2013; [8]present study).***
Tab. 1: Podatki o habitatu in globinski razširjenosti vrste *Thorogobius macrolepis* ***(Reference: [1]Ahnelt & Patzner, 1996; [2]Ahnelt & Kovačić, 1997; [3]Patzner, 1999; [4]Guidetti*** *et al., 2006;* ***[5]Francour*** *et al., 2007;* ***[6]Fischer*** *et al., 2007;* ***[7]Colombo & Langeneck, 2013; [8]pričujoče delo).***

Locality/Reference	Date	Habitat	Depth (m)
W. Mediterranean (Balearic Islands, Spain)[1]	1990-1994	Sandy bottoms of rock overhangs	42
N. Adriatic (Rijeka, Croatia)[2]	1994/1995	Sandy substrate near crevices with vertical rock faces; coralligenous bioceonosis	6-40
W. Mediterranean (Balearic Islands, Spain)[3]	1988-1997	Caves with a sandy bottom	37-45
S. Adriatic and Ionian Seas (SE Apulia and Tremiti Archipelago, Italy)[4]	N/A	Coarse, detritic sand at the basis of coralligenous formations	25-30
S. Aegean and N. Levant Seas (Mugla & Mersin, Turkey)[5]	2003-2006	Sandy bottoms and sloping rock walls	20-26
W. Mediterranean (Balearic Islands, Spain)[6]	1998-2007	Sandy bottom in the rear third of caves	37-45
N. Tyrrhenian Sea (Tuscany, Italy)[7]	2012	Area between coralligenous shoal and sandy bottom	40
N. & C. Aegean Sea (Balikesir & Izmir, Turkey)[8]	2012-2014	Sandy substrate near coralligenous habitat and sloping rock walss	25-43
N. Levant Sea (Antalya, Turkey)[8]	2014	Sandy bottom of a rocky substrate	24

small gravel) in the close vicinity of small caves, sloping rocky bottoms and coralligenous grounds (Tab. 1). We observed the species at depths ranging from 24 to 43 m, but depths of up to 60 m were recently recorded (Glavičić & Kovačić, 2016). There was an immediate escape behaviour of the species into holes and cavities, especially when the diver tries to approach, as also mentioned by Guidetti *et al*. (2006).

POTAPLJAŠKA VZORČEVANJA ODKRIVAJO ŠIRŠE OBMOČJE RAZŠIRJENOSTI VELELUSKASTEGA GLAVAČA *THOROGOBIUS MACROLEPIS* (TELEOSTEI: GOBIIDAE)

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POVZETEK

Endemičnega sredozemskega glavača Thorogobius macrolepis *so potapljači opazovali na treh lokalitetah vzdolž Egejskega morja in na eni lokaliteti na severni levantski obali v Turčiji in tako dopolnili aktualno poznavanje območja razširjenosti te vrste. Pričujoči zapis obravnava prvi podatek o pojavljanju vrste* T. macrolepis *v osrednjem in severnem Egejskem morju, medtem ko opazovanje na območju Kekova potrjuje prisotnost vrste v levantskem bazenu.*

Ključne besede: *Thorogobius macrolepis*, Gobiidae, Egejsko morje, Sredozemsko morje

REFERENCES

Ahnelt, H. & M. Kovačić (1997): A northern Adriatic population of *Thorogobius macrolepis* (Teleostei: Gobiidae). Cybium, 21, 149-162.

Ahnelt, H., J. Löffler, G.A.C. Balma & G.B. Delmastro (2011): On the occurrence of the rare deepwater gobiid fish *Gobius gasteveni* Miller, 1974 in the western Mediterranean (Italy). J. App. Ichth., 27, 1128-1130.

Ahnelt, H. & R.A. Patzner (1996): Kryptobenthische Meergrundeln von den Balearen (Westliches Mittelmeer) mit Anmerkungen zum Unterartstatus von *Chromogobius zebratus levanticus* Miller, 1971. Ann. Naturhist. Mus. Wien, 98B, 529-544.

Colombo, M. & J. Langeneck (2013): The importance of underwater photography in detecting cryptobenthic species: new in situ records of some gobies (Teleostei: Gobiidae) from Italian Seas with ecological notes. Acta Adriat., 54, 101-110.

Fischer, S., R.A. Patzner, C.H.G. Müller & H.M. Winkler (2007): Studies on the ichthyofauna of the coastal waters of Ibiza (Balearic Islands, Spain). Rostocker Meeresbiologische Beiträge, 18, 30-62.

Francour, P., M. Bilecenoglu & M. Kaya (2007): *In situ* observations on new and rare gobies from the eastern Mediterranean Sea. Rapp. Comm. Int. Mer Médit., 38, 478.

Glavičić I. & M. Kovačić M (2016): A quantitative sampling method for assessment of deep cryptobenthic ichthyofauna using trimix diving. Acta Ichthyol. Piscat. 46 (1): 43–47

Guidetti, P., S. Bussotti, M. Kovačić (2006): First record of the large-scaled goby, *Thorogobius macrolepis* (Pisces, Gobiidae), in italian seas. Thalassia Salentina, 29, 41-45.

Kovačić, M (2008a): The key for identification of Gobiidae (Pisces: Perciformes) in the Adriatic Sea. Acta Adriat., 49, 245-254.

Kovačić, M (2008b): Live colouration, morphology and habitat of *Vanneaugobius dollfusi* (Gobiidae) in the northern Adriatic Sea. J. Fish Biol., 73, 1019-1023.

Kovačić, M., R. Šanda, M. Kirinčić **& D. Zanella (2012):** Geographic distribution of gobies (Gobiidae) in the Adriatic Sea with thirteen new records for its southern part. Cybium, 36, 435-445.

Miller, P.J., A.L. Rice & A.D.F. Johnstone (1973): A western Scottish population of the leopard-spotted goby, *Thorogobius ephippiatus* (Lowe) (Teleostei: Gobioidea). J. Fish Biol., 5, 233-239.

Papaconstantinou, C. (2014): Fauna Graeciae. An updated checklist of the fishes in the Hellenic Seas. Monographs on Marine Sciences 7, Athens, HCMR, 340 p.

Patzner, R.A. (1999): Habitat utilization and depth distribution of small cryptobenthic fishes (Blenniidae, Gobiesocidae, Gobiidae, Tripterygiidae) in Ibiza (western Mediterranean Sea). Env. Biol. Fish., 55, 207–214.

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FIRST RECORD OF HOLLOWSNOUT GRENADIER *COELORINCHUS CAELORHINCUS* (OSTEICHTHYES: MACROURIDAE) FROM THE SYRIAN COAST (EASTERN MEDITERRANEAN)

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ABSTRACT

This paper reports the first record of two specimens of the hollowsnout grenadier Coelorinchus caelorhincus *(Risso, 1810) from the Syrian coast. This record confirms the occurrence of* C. caelorhincus *in the eastern Mediterranean and suggests that a viable population is successfully established in this region. Its apparent rarity is due to the fact that the species inhabits deep bottoms, and does not present an economical value.*

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

PRIMA SEGNALAZIONE DEL PESCE SORCIO *COELORINCHUS CAELORHINCUS* (OSTEICHTHYES: MACROURIDAE) LUNGO LA COSTA DELLA SIRIA (MEDITERRANEO ORIENTALE)

SINTESI

L'articolo riporta la prima segnalazione di due esemplari del pesce sorcio Coelorinchus caelorhincus *(Risso, 1810) lungo la costa siriana. Questo ritrovamento conferma la presenza di* C. caelorhincus *nel Mediterraneo orientale e suggerisce che una popolazione vitale si sia stabilita con successo in questa regione. La sua apparente rarità è dovuta al fatto che le specie vive su fondali profondi e non presenta alcun valore economico.*

Parole chiave: descrizione, misurazioni morfometriche, conte meristiche, distribuzione, acque marine profonde, Mediterraneo orientale

INTRODUCTION

The family Macrouridae comprises at least 300 species generally found at depth, between 200 and 2000 m, and occurring throughout seas and oceans of the world, except the high Arctic (Cohen *et al.*, 1990). In all, 17 genera are found in the FNAM area (*sensu* Whitehead *et al.*, 1984-1986) and most of them are known in the Mediterranean Sea, and apparently, distributed only in the western Basin (Geistdoerfer, 1986).

Tab. 1: Morphometric measurements (mm) and their percentage of total length (% TL), meristic counts and weight (gram) recorded in the 2 specimens of hollowsnout grenadier *Coelorinchus caelorhincus* ***caught off the Syrian coast.***
Tab. 1. Morfometrične meritve (mm) in njihov delež glede na celotno dolžino telesa (% TL), meristika ter teža (gram) dveh primerkov grenadirja *Coelorinchus caelorhincus,* ***ujetih ob sirski obali.***

Specimens	**2266M.S.L**		**2267M.S.L**	
Morphometric measurements	**mm**	**%TL**	**mm**	**%TL**
Total length	197	100.0	210	100.0
Head length	49	24.9	48	22.9
Interorbital space	11	5.6	11	5.2
Eye horizontal diameter	14	7.1	14	6.7
Eye vertical diameter	11	5.6	11	5.2
Snout length	14	7.1	14	6.7
Maxilla length	14	7.1	16	7.6
Upper jaw length	15	7.6	14	6.7
Lower jaw length	11	5.6	10	4.8
Pectoral fin length	27	13.7	24	11.4
First dorsal fin length	29	14.7	27	12.9
Second dorsal fin length	94	47.7	130	61.9
Pelvic fin length	20	10.2	18	8.6
Anal fin length	116	58.9	142	67.6
Body depth	31	15.7	31	14.8
Suborbital depth	10	5.1	8	3.8
Meristic counts				
First dorsal fin rays	I + 8		I + 8	
Second dorsal rays	48		49	
Pelvic fin rays	I + 6		I + 6	
Anal fin rays	III + 51		II + 57	
Pectoral fin rays	I + 16		I + 16	
Lateral line scales	67		70	
Total weight (g)	**40.4**		**34.1**	

No macrourid species were reported to date in the Syrian waters (Saad, 2005), however surveys conducted in the same area since 2000 allowed to collect for the first time two specimens of hollownout grenadier *Coelorinchus caelorhincus* (Risso, 1810). In this paper, we present a description of both specimens, comment the actual status of the species from the Syrian coast and throughout the eastern Mediterranean.

MATERIAL AND METHODS

Two specimens of *Coelorinchus caelorhincus* were caught by trawl on 24 February 2016, 6 km from off Raas Albassit (35°51′ E and 35°54′ N), at depth of about 650 m, on muddy bottom (Fig. 1). The specimens were measured to the nearest mm and weighed to the nearest gram. Morphometric measurements with percentages of total length (TL) and meristic counts were recorded following Geistdoerfer (1986) and Cohen *et al.* (1990), (see Tab. 1).

Samples were preserved in 10% buffered formalin and deposited in the Ichthyological Collection of the Marine Sciences Laboratory, Agriculture Faculty at Tishreen University, Syria, with the catalogue numbers: 2266 M.S.L. (Fig. 2), and 2267 M.S.L.

RESULTS AND DISCUSSION

Both Syrian specimens of *C. caelorhincus* were identified by the following combination of main character-

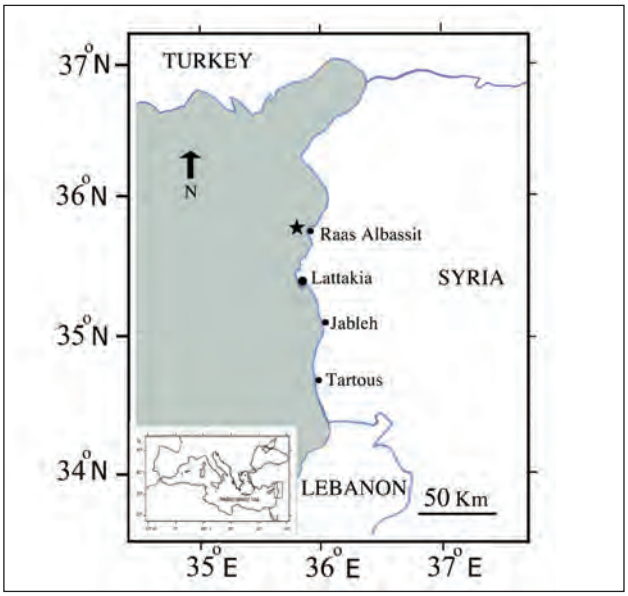

Fig. 1: Map of the Mediterranean Sea and of the coast of Syria, pointing out the capture site of the hollowsnout grenadier *Coelorinchus caelorhincus* ***(black star).***
Sl. 1: Zemljevid Sredozemskega morja in sirske obale z označeno lokaliteto, kjer sta bila ujeta primerka grenadirja (črna zvezdica).

Fig. 2: The hollowsnout grenadier *Coelorinchus caelorhincus* ***captured off the Syrian coast (specimen referenced 2266 M.S.L, in the Ichthyological Collection of Tishreen University, Syria); scale bar = 20 mm.***
Sl. 2: Grenadir *Coelorinchus caelorhincus****, ujet blizu sirske obale (osebek označen s kataloško številko 2266 M.S.L, v ihtiološki zbirki Univerze v Tishreenu; merilo = 20 mm).***

istic features following Geistdoerfer (1986) and Cohen *et al*. (1990): moderately deep and compressed body, tapering behind short trunk to form a long tail ending in a point, head moderate or bulky, snout sharply pointed with prominent body ridge with anterolateral margin incompletely supported by bone, underside of bone, naked medially, a broad area dorsally on either side with thin spinulated scales, chin barbell smooth, small and protactile, anus at the origin of anal fin. Colour tawny to swarthy, with purplish tinges and serie of broad sadles marks, oral cavity darkish, branchial cavity blackish, first dorsal and pectoral fins dusky, pelvic fin black with pale outer ray, anal fin edged with black stripes.

Morphometric measurements (including percentages of TL), meristic counts, morphology and colour agree with Geistdoerfer (1986) and Cohen *et al*. (1990). These findings of *C. caelorhincus* increase the number of fish species already recorded in the same area to date 276, including 43 elasmobranch species and 233 teleost species. However, the eastern extension range of *C. caelorhincus* seems to be not limited, especially in the Levant Basin following Golani (2005). The species is also found from the Aegean Sea (Filiz *et al*., 2006; Sever *et al*., 2008), the Mediterranean coast of Turkey (Bilecenoglu *et al*., 2014) and the Sea of Marmara (Artüz *et al*., 2010). Mouneimne (1979) noted the species occurrence off the Lebanese coast where it appears to be rarely captured; conversely, Saad (2005) did not report it among the bony fishes caught from the Syrian marine waters. This rarity is probably due to the fact that *C. caelorhincus* inhabits deep waters which are poorly explored by usual fishing gears: additionally, the species has no economical interest and specimens are generally discarded at sea by fishermen soon after their capture.

On the other hand, Capapé (1980), Carrassón *et al*. (1992) and Rafrafi-Nouira (2016) noted that *C. caelorhincus* constitutes the main prey for bathyal sharks, similar trophic relationships occur for elasmobranch species living in the Syrian deep waters. However, predatory pressure semingly does not affect negatively the homeostasis of its population, therefore, *C. caelorhincus* is not intrinsically vulnerable to depletion, and could not be considered to date as an endangered species (IUCN, 2014). In conclusion, this record confirms the presence of the species in the entire eastern Mediterranean where a viable population seems to be established.

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The authors wish to thank two anonymous referees for their useful and helpful comments allowing to improve the MS.

PRVI PODATEK O POJAVLJANJU GRENADIRJA *COELORINCHUS CAELORHINCUS* (OSTEICHTHYES: MACROURIDAE) OB SIRSKI OBALI (VZHODNO SREDOZEMSKO MORJE)

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POVZETEK

Avtorji poročajo o prvem podatku o pojavljanju dveh grenadirjev Coelorinchus caelorhincus *(Risso, 1810) ob sirski obali. Ta podatek potrjuje navzočnost vrste* C. caelorhincus *v vzhodnem Sredozemskem morju z ustaljeno viabilno populacijo v regiji. Navidezna redkost te vrste je posledica dejstva, da gre za globokomorsko vrsto brez ekonomske vrednosti.*

Ključne besede: opis, morfometrične meritve, meristika, razširjenost, globokomorsko okolje, vzhodno Sredozemsko morje

REFERENCES

Artüz, L., Z. Erdogan Z., H. Torcu Koç, B. Snmez & A. Aydemir (2010): First record of the hollowsnout grenadier, *Coelorhynchus coelorhyncus* (Risso, 1810), from the Sea of Marmara, Turkey. J. Appl. Ichthyol., 26, 128–130.

Bilecenoglu, M., M. Kaya, B. Cihangir B. & E. Çiçek **(2014):** An updated check list of the marine fishes of Turkey. Turk. J. Zool., 38, 901-929.

Capapé, C. (1980): Nouvelle description de *Heptranchias perlo* (Bonnaterre, 1788) (Pisces, Pleurotremata, Hexanchidae). Données sur la biologie de la reproduction et le régime alimentaire des spécimens des côtes tunisiennes. Bull. Off. natn Pêch., Tunisie, 4(2), 231-264.

Carrassón, M., C. Stefanescu & J.E. Cartes (1992): Diets and bathymetric distributions of two bathyal sharks of the Catalan deep sea (western Mediterranean). Mar. Ecol. Prog. Ser. 82, 21-30.

Cohen, D.M., T. Inada, T. Iwamoto & N. Scialabba (1990): FAO species catalogue. Vol. 10. Gadiform fishes of the world (Order Gadiformes). An annotated and illustrated catalogue of cods, hakes, grenadiers and oser gadiform fishes known to date. FAO Fisheries Synopsis. No.125, Vol. 10, 442 pp.

Filiz, H., G. Bilge G., M. Irmak, M. Togulga, D. Uckun & S. Akalin (2006): Age and growth of the hollowsnout grenadier, *Coelorhynchus coelorhyncus* (Risso, 1810), in the Aegean Sea. J. Appl. Ichthyol., 2, 285-287.

Geistdoerfer, P. (1986): Macrouridae. 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. 2. Unesco, Paris, pp. 644-676.

Golani, D. (2005): Check-list of the Mediterranean Fishes of Israel. Zootaxa, 2005(947): 1-200.

IUCN (2014): IUCN Red List of Threatened Species. Version 2014.1. IUCN 2014. IUCN Red List of Threatened Species.

Mouneimne, M. (1979): Poissons nouveaux pour les côtes libanaises. Cybium, 6, 105-110.

Rafrafi-Nouira, S. (2016): Catalogue raisonné des espèces de poissons capturées devant Ras Jebel et autres régions marines de Tunisie septentrionale: aspects morphologiques, biométriques et bio-écologiques. Thesis, University of Bizerte (Tunisia), 509 pp.

Saad, A. (2005): Check-list of bony fish collected from the coast of Syria. Turk. J. Fish. Aquat. Sci., 5(2), 99-106.

Sever, T.M., H. Filiz, B. Beyhan & E. Taskavak (2008): Food habits of the hollowsnout grenadier, *Coelorhynchus coelorhyncus* (Risso, 1810), in the Aegean Sea, Turkey. Belg. J. Zool., 138: 81-82.

Whitehead, J. P. J., M.-L. Bauchot, J.-C. Hureau, J. Nielsen & E. Tortonese (1984-1986): Fishes of the North-eastern Atlantic and the Mediterranean. Vol. 1, pp. 7-510. Vol. 2, pp.517-1007. Vol. 3, pp.1015-1473. Unesco, Paris.

RECENTNE SPREMEMBE V SREDOZEMSKI BIODIVERZITETI

CAMBIAMENTI RECENTI NELLA BIODIVERSITÀ MEDITERRANEA

RECENT CHANGES IN THE MEDITERRANEAN BIODIVERSITY

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FIRST RECORD OF THE TRIPLETAIL *LOBOTES SURINAMENSIS* (PISCES: LOBOTIDAE) IN THE LAGOON OF MARANO AND GRADO (GULF OF TRIESTE, NORTHERN ADRIATIC SEA)

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ABSTRACT

On 18th July 2016 one specimen of tripletail Lobotes surinamensis *(Bloch, 1790) (Lobotidae) was caught by fishermen in the Lagoon of Marano and Grado (Gulf of Trieste). This is the first record in the northernmost area of the Adriatic Sea and Mediterranean, too.*

Key words: tripletail, *Lobotes surinamensis*, Lagoon of Marano and Grado, Gulf of Trieste, northern Adriatic Sea.

PRIMA SEGNALAZIONE DEL PESCE FOGLIA *LOBOTES SURINAMENSIS* (PISCES: LOBOTIDAE) NELLA LAGUNA DI MARANO E GRADO (GOLFO DI TRIESTE, ALTO ADRIATICO)

SINTESI

Il 18 luglio 2016 un esemplare di pesce foglia Lobotes surinamensis *(Bloch, 1790) (Lobotidae) è stato catturato dai pescatori nella Laguna di Marano e Grado (Golfo di Trieste). Questa cattura rappresenta la prima segnalazione nell'area più settentrionale del Mare Adriatico, Mediterraneo compreso.*

Parole chiave: pesce foglia, *Lobotes surinamensis*, Laguna di Marano e Grado, Golfo di Trieste, Alto Adriatico

INTRODUCTION

The tripletail *Lobotes surinamensis* (Bloch, 1790) has a worldwide distribution in marine and brackish tropical and subtropical waters (Sazima *et al*., 2009 and reference therein), whereas in the Mediterranean Sea is considered a rare species (Akyol & Kara, 2012).

The first written record of this fish in the Mediterranean basin comes from Sicilian waters (Doderlein, 1875), since then its presence was mainly recorded in the southern area: Ben-Tuvia (1953) and Golani (1996, 1997) in Israeli waters; Bini (1968) off Calabria (Italy); Tortonese (1975) off Rhodes (Greece), Turkey and Lebanon; Palom (1991) in Barcelona waters (first record for the Iberic ichthyofauna); Bradaï (2000) in Tunisian waters and Hemida *et al*. (2003) off Algeria. The first record in the Adriatic Sea arose to June 2010, when a specimen was caught off Island Biševo (Central Adriatic) (Dulčić & Dragičević, 2011), whereas in December 2011 a male was captured in Mali Ston Bay, southern Adriatic (Dulčić *et al*., 2014a); on May 2013 it was recorded in the northern Adriatic Sea (Raša Bay, southern coast of Istrian Peninsula) (Dulčić *et al*., 2014b).

Fig. 1: *Lobotes surinamensis* ***caught in the Lagoon of Marano and Grado (Photo: P. Dal Forno).***
Sl. 1: Primerek vrste *Lobotes surinamensis****, ujet v maranski in gradeški laguni (Foto: P. Dal Forno).***

The present paper represents the first record in the Lagoon of Marano and Grado and for the Gulf of Trieste, which is the northernmost area of the Adriatic Sea and Mediterranean too.

MATERIAL AND METHODS

One specimen of *L. surinamensis* was caught on 18th July 2016, using the fyke nets. As the fishermen sold it immediately, we were able to obtain only the total weight from the fish market of Marano Lagunare, whereas the total length can be approximately estimated by the expanded polystyrene box used for fish packaging (50 x 32 cm) (Fig. 1). The species identification was based on the photograph, according to Rounds & Feeney (1993): the distinctive shape of the dorsal and anal fins along with the caudal fin gives the tail a 'trilobed' appearance.

RESULTS AND DISCUSSION

The capture of *Lobotes surinamensis* was located 1 km off Stella River mouth in the Lagoon of Marano and Grado (Fig. 2), at a depth of approximately 1 m, on muddy sediment. The total weight was 2.9 kg and the total length about 500 mm. The one who bought this specimen has observed the presence of eggs mass inside, therefore we could speculate it was a female. Strelcheck *et al*. (2004) noted that fifty percent of female analyzed in the Gulf of Mexico reached sexual maturity by 494 to 594 mm of total length and approximately 1 to 2 years of age. In this way the specimen caught in the lagoon can represent the first adult female caught in the Adriatic Sea, compared to previous records of Dulčić & Dragičević (2011), Dulčić *et al*. (2014b) and Dulčić *et al*. (2014a), who found two relatively juvenile individuals and a male specimen respectively. In October 2015 a

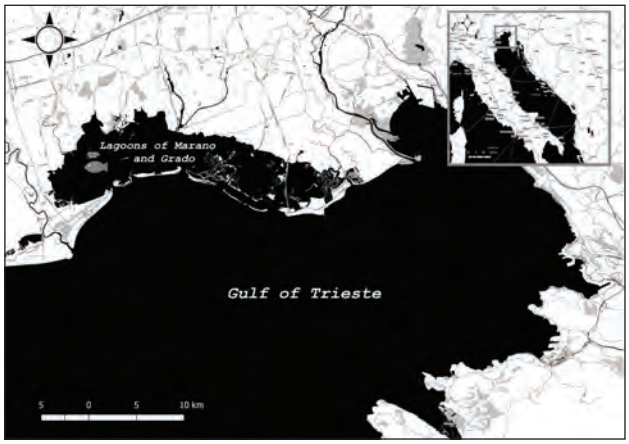

Fig. 2: Map of the Gulf of Trieste with the location of the record in the Lagoon of Marano and Grado.
Sl. 2: Zemljevid Tržaškega zaliva z označeno lokaliteto ulova v maranski in gradeški laguni.

specimen was officially recorded for the first time in the Italian Adriatic coast (Manfredonia, southern Adriatic), but size data are not available (Dailianis *et al*., 2016).

Tripletails usually occur in bays (Myers, 1999) and brackish estuaries (Brown-Peterson & Franks, 2001; Strelcheck *et al*., 2004) or sometimes in the open sea where they can be associated with floating objects (Massuti & Renones, 1994). Juvenile specimens may occur in floating Sargassum and mimic a floating leaf to camouflage against predators (Myers, 1999). Similar behavior is also known for adults, which are often observed floating on their sides at the surface probably to avoid predators and to ambush their prey (Massuti & Renones, 1994). The maximum total length reported for this species is 1 m, adults are bentho-pelagic and feed on small fishes and benthic crustaceans (Dailianis *et al*., 2016), which are very abundant in the Lagoon of Marano and Grado (Bettoso *et al*., 2013). Ounifi-Ben Amor *et al*. (2016) found large quantities of spheromatid isopods and amphipods in the stomach content of two females caught in the Tunis southern lagoon. In addition Merriner & Foster (1974) state that *L. surinamensis* feeds mainly on clupeids, whereas Franks *et al*. (2003) reported a diet composition constituted by 49.4% of crustaceans and 50.6% of bony fishes. Finally Zava *et al*. (2007) found two specimens of *Naucrates ductor* in the stomach of a tripletail caught in the southern Tyrrhenian Sea.

Findings of *L. surinamensis* in the Adriatic Sea are probably a consequence of increased abundance of this species in the southern Mediterranean waters amplified by the changes in hydrological conditions in the area (Dulčić *et al*., 2014a). It seems that this species recently established its population in the area of Maltese islands which is indicated by the presence of juveniles (Deidun *et al*., 2010). This record reveals its appearance in the northernmost area of the Mediterranean Sea. Further observations will be necessary to learn more about the ecology of the tripletail in this basin.

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PRVI ZAPIS O POJAVLJANJU VRSTE *LOBOTES SURINAMENSIS* (PISCES: LOBOTIDAE) V MARANSKI IN GRADEŠKI LAGUNI (TRŽAŠKI ZALIV, SEVERNI JADRAN)

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POVZETEK

Osemnajstega julija 2016 so ribiči ujeli primerek ribje vrste Lobotes surinamensis *(Bloch, 1790) (Lobotidae) v maranski in gradeški laguni (Tržaški zaliv). To je prvi zapis o pojavljanju te vrste v najsevernejšem predelu Jadranskega in obenem Sredozemskega morja.*

Ključne besede: trirepka, *Lobotes surinamensis*, maranska in gradeška laguna, Tržaški zaliv, severni Jadran.

REFERENCES

Akyol, O. & A. Kara (2012): Record of the Atlantic tripletail, *Lobotes surinamensis* (Bloch, 1790) in the Bay of Izmir, northern Aegean Sea. J. Appl. Ichthyol., 28 (4), 645-646.

Ben-Tuvia, A. (1953): Mediterranean fishes of Israel. Bull. Fish. Stat., 8, 1-40.

Bettoso, N., A. Acquavita, A. D'Aietti & G. Mattassi (2013): The Marano and Grado Lagoon: a brief synopsis on the aquatic fauna and fisheries resources. Annales, ser. Hist. Nat., 23 (2), 135-142.

Bini, G. (1968): Un pesce perciforme raro per i mari italiani (*Lobotes surinamensis* Bloch, 1790). Atti Soc. Pelorit. Sci. Fis. Mat. Nat., 14 (1-2), 49-53.

Bradaï, M. N. (2000): Diversité du peuplement ichtyque et contribution à la connaissance des sparidés du golfe de Gabès. PhD Thesis, University of Sfax, Tunisia, 600 pp.

Brown-Peterson, N. J. & J. S. Franks (2001): Aspects of the reproductive biology of tripletail, *Lobotes surinamensis*, in the northern Gulf of Mexico. Proc. of 52nd Gulf and Caribbean Institute, 586–597.

Dailianis, T., O. Akyol, N. Babali, M. Bariche, F. Crocetta *et al.* (2016): New Mediterranean biodiversity records (July 2016). Medit. Mar. Sci., 17 (2), 608-626.

Deidun, A., P. Vella, A. Sciberras & R. Sammut (2010): New records of *Lobotes surinamensis* (Bloch, 1790) in Maltese coastal waters. Aquatic Invasions, 5 (1), S113–S116.

Doderlein, P. (1875): Descrizione di una specie del genere esotico *Lobotes* preso nelle acque dei contorni di Palermo. Atti Accad. Sci. Palermo, 5 (3), 1-12.

Dulčić, J. & B. Dragičević (2011): First record of the Atlantic tripletail, *Lobotes surinamensis* (Bloch, 1790), in the Adriatic Sea. J. Appl. Ichthyol., 27, 1385-1386.

Dulčić, J., B. Dragičević, N. Antolović, J. Sulić-Šprem, V. Kožul & R. Grgičević (2014a): Additional records of *Lobotes surinamensis*, *Caranx crysos*, *Enchelycore anatina*, and *Lagocephalus sceleratus* (Actinopterygii) in the Adriatic Sea. Acta Ichthyol. Piscat., 44 (1), 71-74.

Dulčić, J., B. Dragičević, L. Lipej & M. Štifanić (2014b): Range extension of tripletail *Lobotes surinamensis* (Lobotidae) in the Adriatic Sea. A northernmost record in the Mediterranean. Cybium, 38 (2), 153-154.

Franks, J. S., K. E. Vander Kooy & N. M. Garber (2003): Diet of tripletail, *Lobotes surinamensis*, from Mississippi coastal waters. Gulf Caribb. Res., 15, 27-32.

Golani, D. (1996): The marine ichthyofauna of the eastern Levant. History, inventory and characterization. Isr. J. Zool., 42, 15-55.

Golani, D. (1997): Handbook of the fishes of Israel. Keter Publishing House, Jerusalem, 269 pp. (in Hebrew)

Hemida, F., D. Golani, Y. Diatta & C. Capapé (2003): On the occurrence of the tripletail, *Lobotes surinamensis* (Bloch, 1790), off the coast of Algeria (southern Mediterranean). Annales, ser. Hist. Nat., 13 (2), 145-148.

Massuti, E. & O. Renones (1994): Observations on the pelagic fish community around floating objects in the open sea off Mallorca. Bol. Inst. Esp. Oceanogr., 10, 81–93.

Merriner, J. V. & W. A. Foster (1974): Life history aspects of the tripletail, *Lobotes surinamensis* (Chordata-Pisces-Lobotidae), in North Carolina waters. J. Elisha Mitchell Sci. Soc., 90 (4), 121-124.

Myers, R. F. (1999): Micronesian reef fishes: a comprehensive guide to the coral reef fishes of Micronesia, 3rd revised and expanded edition. Coral Graphics, Barrigada, Guam, 330 p.

Ounifi-Ben Amor, K., M. M. Ben Amor, J. Ben Souissi & C. Capapé (2016): Unusual records of tripletail *Lobotes surinamensis* (Osteichthyes: Lobotidae) from the Tunis southern Lagoon (North-eastern Tunisia, Central Mediterranean Sea). Annales, ser. Hist. Nat., 26 (1), 13-18.

Palom, O. (1991): Primera cita de *Lobotes surinamensis* (Pisces, Lobotidae) para la ictiofauna Ibérica. Misc. Zool., 15, 240-242.

Rounds, J. M. & R. F. Feeney (1993): First record of the tripletail (*Lobotes surinamensis*, family Lobotidae) in California waters. Calif. Fish and Game, 79 (4), 167-168.

Sazima, I., A. Grossman, A. Carvalho-Filho & C. Sazima (2009): First record of the tripletail or blackfish (*Lobotes surinamensis*) from an oceanic island in the South Atlantic. Mar. Biodivers., Rec. 2, e97 doi:10.1017/S1755267209001195.

Strelcheck, A. J., J. B. Jackson, J. H. Cowan Jr & R. L. Shipp (2004): Age, growth, diet, and reproductive biology of the tripletail, *Lobotes surinamensis*, from the north-central Gulf of Mexico. Gulf Mex. Sci., 22, 45–53.

Tortonese, E. (1975): Osteichthyes, pesci ossei, parte 2. In: Fauna d'Italia, 12, 1-686.

Zava, B., P. Gianguzza & S. Riggio (2007): Nuova cattura di *Lobotes surinamensis* (Bloch, 1790) in Tirreno Meridionale (Osteichthyes: Lobotidae). Biol. Mar. Medit., 14 (2), 370-371.

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HISTORICAL DISPERSAL OF THE GREAT WHITE SHARK, *CARCHARODON CARCHARIAS*, AND BLUEFIN TUNA, *THUNNUS THYNNUS*, IN TURKISH WATERS: DECLINE OF A PREDATOR IN RESPONSE TO THE LOSS OF ITS PREY

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ABSTRACT

Based on the results of recent studies and the addition of unpublished historical records of 7 great white sharks, Carcharodon carcharias*, in Bosphorus waters, altogether 54 specimens were recorded in Turkish waters between 1881 and 2014. The highest number of great white shark specimens was recorded in the Sea of Marmara. The Atlantic bluefin tuna,* Thunnus thynnus*, which is closely associated with the movements of the great white shark in the Mediterranean Sea, is apparently not present in the Sea of Marmara. The drastic decline and the consequent absence of bluefin tuna from Marmara and Bosphorus waters exhibit a remarkable synchrony with the great white shark's decline and absence from the same regions.*

Key words: White shark, *Carcharodon carcharias*, bluefin tuna, *Thunnus thynnus*, Turkey, distribution, trophic, conservation

DISPERSIONE STORICA DEL GRANDE SQUALO BIANCO, *CARCHARODON CARCHARIAS*, E DEL TONNO ROSSO, *THUNNUS THYNNUS*, IN ACQUE TURCHE: DECLINO DI UN PREDATORE IN RISPOSTA ALLA PERDITA DELLA SUA PREDA

SINTESI

*Sulla base dei risultati di studi recenti e di documenti storici inediti su 7 grandi squali bianchi (*Carcharodon carcharias*) nelle acque del Bosforo, complessivamente 54 individui sono stati rilevati nelle acque della Turchia tra il 1881 e il 2014. Il numero più alto di grandi esemplari di squali bianco è stato registrato nel Mar di Marmara. Il tonno rosso atlantico, Thunnus thynnus, che è strettamente associato con i movimenti del grande squalo bianco nel mare Mediterraneo, è apparentemente assente nel Mar di Marmara. Il drastico declino e la conseguente assenza del tonno rosso nelle acque di Marmara e del Bosforo indica una notevole sincronia con il declino e l'assenza del grande squalo bianco nelle stesse regioni.*

Parole chiave: squalo bianco, *Carcharodon carcharias*, tonno rosso, *Thunnus thynnus*, Turchia, distribuzione, trofico, conservazione

INTRODUCTION

Animal migration certainly ranks as one of the nature's most visible and widespread phenomena (Wilcove & Wikelski, 2008). Droves of animals, seasonally moving between distant parts of the globe for biological purposes like foraging or reproduction create epic sceneries on land and in the sky. The marine environment also offers amazing examples of long-distance migrations, with a variety of animals crossing the entire ocean basins to reach fertile foraging grounds or secure breeding areas (Luschi, 2013). Marine animals can migrate in the oceanic environment solitarily (*e.g.*, the great white shark, *Carcharodon carcharias*) or in large schools (*e.g.*, Atlantic bluefin tuna, *Thunnus thynnus*) aiming at specific targets (Bonfil *et al.*, 2005; Fromentin, 2009; De Maddalena & Heim, 2012; Carlisle *et al.*, 2012). This infinite flow of life, in which the hunter is in pursuit of its prey, is an interconnected story of different lives.

In the past, the migration range of *T. thynnus*, one of the largest and most valuable bony fishes, extended to the northernmost areas of Turkish waters, including the Black Sea (Deveciyan, 1926). According to Deveciyan (1926), bluefin tuna schools migrating from the Atlantic Ocean into the Mediterranean Sea approached the Anatolian coast, than headed to the Sea of Marmara, the Bosphorus Strait, and eventually entered the Black Sea. During this seasonal spawning migration, Bosphorus fishermen, including hand-liners, harpooners and trappers, caught hundreds of tons of bluefin tuna (Deveciyan, 1926). The seasonal occurrence and the historical captures of the great white shark, *C. carcharias*, in Marmara and Bosphorus waters between late 1800s and the mid-1980s always occurred during the migration of bluefin tuna (Üner, 1984; Kabasakal, 2003, 2014).

It is a well-known fact that the movements of the great white shark in the Mediterranean are tightly linked to those of the Atlantic bluefin tuna (De Maddalena & Heim, 2012). The decline of the Atlantic bluefin tuna stocks in several parts of the Mediterranean Sea is known to have negatively affected the great white shark population (*e.g.*, De Maddalena, 2000; Barrull & Mate, 2001; Soldo & Jardas, 2002; Morey *et al.*, 2003).

This article reviews the spatial and temporal changing of the coexistence of *C. carcharias* and *T. thynnus* in Turkish waters in light of available data. Based on the limits of historical dispersal ranges of the two species in the waters of Turkey, as well as current fisheries data, the author discusses the probable future threats to the occurrence of the great white shark in this region.

MATERIAL AND METHODS

The data on historical and contemporary occurrences, as well as fisheries status of *C. carcharias* and *T. thynnus* in Turkish waters were obtained from the

Tab. 1: Summary of the catch data from 7 unpublished records of** Carcharodon carcharias **caught in Bosphorus waters.
Tab. 1: Povzetek podatkov o zapisih sedmih ulovljenih belih morskih volkov iz voda bosporske ožine.

No	Date	Location	TL (cm)	W (kg)	Sex	Remarks
1	21.03.1937	Büyükada	?	1700	?	Harpooned by fishermen set sail for catching swordfish. Landed at the fishmarket for public display.
2	1939	Büyükada	?	ca. 3000	?	Caught by the tuna handliner Karnilyas and delivered to the fishmarket.
3	01.02.1955	Ortaköy	?	1500	?	Caught by the fisherman Mr. Hayri Kuloğlu, after struggling nearly 4 and half hours. Almost 50 kg of bonito, *Sarda sarda* found in the stomach contents.
4	15.04.1956	Ahırkapı	?	2500	?	Caught by the handliner Mr. Necdet Şarcı. According to newspaper report, fisherman struggled the shark nearly 8 hours before harpooned it.
5	05.03.1958	Prince Islands	500	2500	F	Delivered to fishmarket for public display and auction.
6	19.03.1962	Ortaköy	?	3000	F	Caught by the fishermen Mr. Hayri Kuloğlu and Mr. Ziya Zeki Zayni.
7	13.01.1966	Kumkapı	?	?	?	Incidentally caught by tuna handliners and harpooned. Auctioned at the fishmarket for its liver oil.

following sources: i) scientific journals, ii) grey literature (*e.g.*, project technical reports, symposium proceedings, doctoral theses) and iii) popular literature (*e.g.*, daily newspapers, Internet, fishing magazines and books). Furthermore, unpublished records of 7 great white sharks incidentally captured in Bosphorus waters between the 1930s and the 1960s were also included in this review. The fishing data of the Atlantic bluefin tuna in the waters of Turkey during the first quarter of the 20th century and in the last decade were extracted from Deveciyan (1926) and TUIK (2015), respectively.

RESULTS AND DISCUSSION

Historical and contemporary records of *Carcharodon carcharias* in Turkish waters

The historical and contemporary occurrence of *C. carcharias* in Turkish waters is clarified following a number of studies published since the beginning of the 2000s (Kabasakal, 2003, 2008, 2014; Kabasakal & Gedikoğlu, 2008; Kabasakal & Kabasakal, 2015; Kabasakal *et al*., 2009). According to the results of two recent studies (Kabasakal, 2014; Kabasakal & Kabasakal, 2015), 47 great white sharks were recorded in waters of Turkey between 1881 and 2014. As a result of ongoing research, unpublished historical records of 7 great white sharks in Bosphorus waters were also obtained (Tab. 1). Therefore, combining the unpublished and published records, the number of great white sharks recorded in Turkish waters in the mentioned time period increases to 54 (Fig. 1).

With reference to Fig. 1, the highest number of *C. carcharias* specimens was recorded in the Sea of Marmara (n = 38; 70.3%), followed by Turkish Aegean Sea (n = 14; 25.9%) and the Levantine Sea (n = 2; 3.7%) (Kabasakal, 2014; Kabasakal & Kabasakal, 2015; and unpublished records). However, records of the great white shark in the Sea of Marmara only include historical data (Kabasakal, 2003, 2008; and unpublished records), and no contemporary data of *C. carcharias* is present in Marmaric waters since 1985 (date of last confirmed record). Therefore, in a recent review of the status of sharks in the Sea of Marmara, the authors concluded that *C. carcharias* is currently absent from this area (Kabasakal & Karhan, 2015). On the other hand, contemporary occurrence of *C. carcharias* in Turkish Aegean and Mediterranean waters was confirmed following several studies (Kabasakal & Gedikoğlu, 2008; Kabasakal *et al*., 2009; Kabasakal, 2014; Kabasakal & Kabasakal, 2015). The most recent capture of *C. carcharias* in the Turkish Aegean Sea dates to 19th September 2014 (Kabasakal & Kabasakal, 2015). Thus, *C. carcharias* is a rare but still regular resident of Turkish waters.

For 31 great white sharks, the exact dates of capture are available. Based on this data, the majority of the specimens (n = 26; 83.8%) were caught between November and May, and the remaining 5 specimens were caught between July and September (Fig. 2). The highest number of *C. carcharias* in Turkish waters was recorded in February (n = 6; 19.3%), followed by April (n = 5; 16.1%), December (n = 4; 12.9%), and March (n = 4; 12.9%) (Fig. 2).

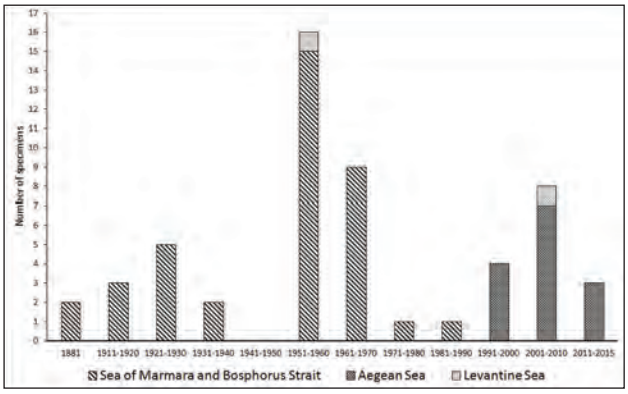

Fig. 1: Temporal and regional distribution of *Carcharodon carcharias* ***catches in the waters of Turkey between 1881 and 2014 (54 great white sharks in total).***
Sl. 1: Časovna in prostorska razporeditev ulovov belega morskega volka v turških vodah med 1881 in 2014 (skupno 54 belih morskih volkov).

The majority of the contemporary records of the great white shark in Turkish Aegean waters (n = 8; 57.1%) is comprised of newborn and young specimens (Kabasakal, 2014; Kabasakal & Kabasakal, 2015). Newborns were incidentally caught in the mentioned waters (Bay of Edremit) for the first time in July 2008 (Kabasakal & Gedikoğlu, 2008). Several other newborn and young great white sharks were also caught in the vicinity of the Bay of Edremit (Gökçeada, Babakale and Foça coasts)

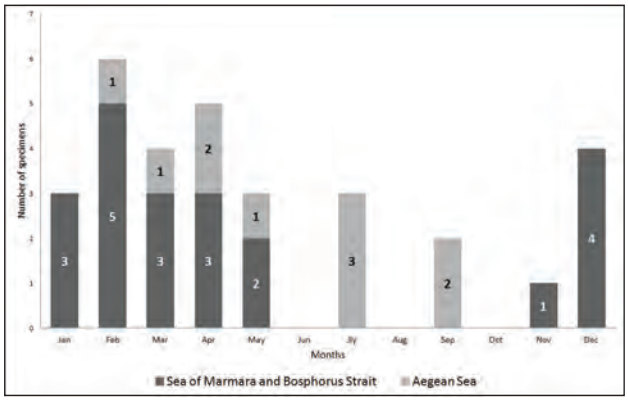

Fig. 2: Seasonal distribution of *Carcharodon carcharias* ***catches in Turkish waters.***
Sl. 2: Sezonska razširjenost ulova belih morskih volkov *Carcharodon carcharias* ***v turških vodah.***

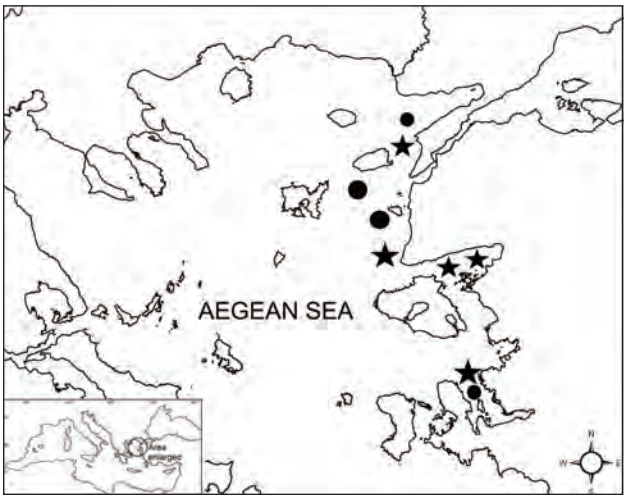

Fig. 3: Map showing the approximate limits of the potential breeding and nursery grounds of *Carcharodon carcharias* ***in the northern Aegean Sea off Turkey's coast. (★) denotes the capture sites of newborn and young great white sharks; (●) denotes the site of capture or sighting of adult specimens.***
Sl. 3: Zemljevid z označenimi potencialnimi razmnoževalnimi okolji v severnem Egejskem morju ob turški obali. (★) ponazarja lokaliteto, kjer so bili ujeti novorojeni in mladi beli morski volkovi; (●) ponazarja lokaliteto, kjer so ujeli ali opazovali odrasle bele morske volkove.

in subsequent years (Kabasakal *et al*., 2009; Kabasakal, 2014; Kabasakal & Kabasakal, 2015). Occurrences of newborn and young specimens since 2008 suggest the possibility of a breeding and nursery grounds of the great white shark off the Turkish coast of the northern Aegean Sea (Fig. 3).

General remarks on the *Thunnus thynnus* fishery in Turkish waters

The history of Atlantic bluefin tuna fishery in Turkey dates back to ancient times (Deveciyan, 1926). It has been an especially important source of income since the Byzantine era (Karakulak & Oray, 2009). Like Mediterranean fishermen, who had been exploiting the bluefin tuna seasonal migration since the first millennium before Christ (Fromentin, 2009), Bosphorus and Marmara fishermen caught bluefin tuna both in the Byzantine and Ottoman eras (Karakulak & Oray, 2009).

The tuna trap is a passive gear, hardly modified over the centuries, which catches *T. thynnus* during their annual spawning migration (Ravier & Fromentin, 2001). The history of bluefin tuna fishery with traps in Marmara and Bosphorus waters dates back to the 15th century (Karakulak & Oray, 2009). Besides traps, other artisanal fishing techniques like hand-lining and harpooning were also used by Marmara and Bosphorus fishermen. According to Deveciyan (1926), the annual average landings of bluefin tuna in Bosphorus fish traps was 131.8 tons between 1909 and 1923, peaking in 1913 with 537.4 tons. One of the remarkable characteristics of the historical bluefin tuna fishery in the Bosphorus Strait was the size of the bluefin tunas caught, with huge specimens weighing 450 kg (Deveciyan, 1926). Historically, bluefin tuna fishery in Bosphorus waters continued all year round, but peaked in: i) November-January, ii) March-April, and iii) July-August (Karakulak & Oray, 2009).

In parallel with the decline of bluefin tuna fishery with traps in the 1950s, purse-seiners started fishing bluefin tuna in Marmara and Bosphorus waters (Karakulak & Oray, 2009). In the 1980s, the government implemented a new policy for the development of fisheries (Karakulak & Oray, 2009), which resulted in a tremendous increase in the fishing power of Marmara purse-seiners, and bluefin tuna purse-seine fishery was no exception. In truth, Marmara and Bosphorus purse-seine fishery for bluefin tuna was a typical example of "boom and bust" fishery. Mass captures of bluefin tuna in the Sea of Marmara were last recorded in 1986, and since then, large schools of bluefin tuna were never observed again either in Marmara waters or in the Bosphorus Strait (Karakulak & Oray, 1994).

Following the collapse of Marmara and Bosphorus bluefin tuna fisheries, purse-seiners started catching bluefin tuna in the northern Aegean Sea in 1989, later gradually moving into the southern parts of the sea (Karakulak & Oray, 2009). In contrast to the Marmara and Bosphorus titans, Aegean Sea bluefin tuna fishery is characterised by the capture of small to medium sized specimens (25 to 45 kg). In 1994, purse-seiners started operating in the Mediterranean Sea. Since 2000, Turkey's bluefin tuna fishery has been carried out in May and June in the eastern Mediterranean (Karakulak & Oray, 2009).

TUIK (2015) statistics exhibit a fluctuation in the annual amount of bluefin tuna caught in Turkish waters in the period from 2005 to 2014. After peaking in 2005 with 990 tons, bluefin tuna fishery in Turkish waters gradually decreased to an annual catch of 555 tons in 2014 (TUIK, 2015). In the 1950s and 1960s, bluefin tuna landings were composed of large specimens, as previously seen in many other fish species; however, the situation is now reversed, as most of the larger bluefin tuna have been removed from the marine ecosystem (Ulman *et al*., 2013).

Contemporary distribution of *C. carcharias* and *T. thynnus* in Turkish waters

According to Öztürk & Öztürk (1996), the Bosphorus Strait used to be one of the biologically richest and most productive region of Turkish marine fishery. Recently,

however, much of the habitat on which of these species depend has been altered or lost to urbanization, which exhibited a remarkable intensification especially during the beginning of the second half of the 20th century. Overfishing, illegal fishing methods, vessel-originated pollution and ecological impacts, such as the invasion of an alien comb jelly *Mnemiopsis leidyi*, are considered as the major causes of the decline of the Bosphorus fish populations (Öztürk & Öztürk, 1996). Since the beginning of the 20th century, estuaries, bays and near shore habitats along the Bosphorus Strait have been subjected to numerous environmental impacts due to industrial, commercial and residential development, as well as severe oil spills following maritime accidents (Öztürk & Öztürk, 1996; Sezgin & Kadıoğlu, 2000; Oral & Öztürk, 2006). These areas were important grounds for foraging, predator avoidance and physiological transition for various migratory fish species including bonito (*Sarda sarda*) and bluefish (*Pomatomus saltator*), as well as tuna (*T. thynnus*), mackerel (*Scomber scombrus*) and swordfish (*Xiphias gladius*), until their decline or disappearance in the strait in the 1970s (Öztürk & Öztürk, 1996).

The Atlantic bluefin tuna, which is closely associated with the movements of the great white shark in the Mediterranean Sea, is apparently absent from the Sea of Marmara. Although (insignificant) amounts of bluefin tuna were caught around Marmara Island (southwestern Sea of Marmara) in the late 1990s and in 2013 (Karakulak & Oray, 2009; Hakan Kabasakal *pers. obs.*), large schools of bluefin tuna have not been observed in Marmara waters since 1987 (Karakulak & Oray, 1994). Similarly, the last confirmed observation of the great white shark in the Sea of Marmara was reported in 1985. The drastic decline and the consequent absence of bluefin tuna in Marmara and Bosphorus waters exhibit a remarkable synchrony with the decline and the following absence of the great white shark in the two regions. The contemporary absence of *C. carcharias* and *T. thynnus*, top predators of the marine ecosystem, from Marmara and Bosphorus waters, is a typical example of the loss of a predator in response to the loss of its coexisting preferred prey.

Since the contemporary occurrence of *C. carcharias* in Turkish waters has been recorded from the Aegean and the western coast of the Levantine Sea (Kabasakal, 2014; Kabasakal & Kabasakal, 2015), the contemporary distribution range of *C. carcharias* in Turkish waters coincides with the current fishing localities of *T. thynnus* in the same waters. With reference to Fig. 2, the great white shark was recorded in February-May, July and September, in Aegean and Levantine waters off Turkey. According to Karakulak & Oray (2009), the fishing season of the Turkish bluefin tuna fleet in these waters lasts from winter to the end of May, which is correlated with the period of seasonal occurrence of the great white shark in the Aegean Sea. Although, Turkey's fishermen catch bluefin tuna in the eastern Levantine Sea in May and June, the contemporary absence of the great white shark from the region could be the consequence of the rarity of *C. carcharias* in the eastern Mediterranean. According to available literature, only 5 great white sharks were recorded in the eastern Mediterranean between 1934 and 2011 (Ben-Tuvia, 1971; Fergusson, 1996; Damalas & Megalofonou, 2012; Kabasakal, 2014).

Reproduction is supposed to be a triggering factor for great white shark migrations (Bonfil *et al*., 2005; Carlisle *et al*., 2012). According to Bonfil *et al*. (2005), transoceanic return migrations of great white sharks between South Africa and Australia provide direct evidence of philopatry in *C. carcharias*. Furthermore, Carlisle *et al*. (2012) suggested that the migration of great white sharks from the highly productive waters of the California Current to the oligotrophic waters of the Central Pacific can be related to reproduction.

Incidental captures of newborn and young great white sharks off Turkey's coast of the northern Aegean Sea in June and early July of almost every year between 2008 and 2014 (Kabasakal, 2008; Kabasakal & Gedikoğlu, 2008; Kabasakal, 2014; Kabasakal & Kabasakal, 2015) suggest the possibility of a breeding and nursey grounds in the region. In previous years, adult females (TL 5-5.5 m) were also observed or caught in the vicinity of the potential breeding and nursery grounds, between March and May (Kabasakal, 2014). Based on available data, a breeding season of *C. carcharias* in the northern Aegean Sea, lasting from early spring to mid-summer can be assumed, which also coincides with the fishing season of bluefin tuna in these waters (Karakulak & Oray, 2009). Apparently, seasonal occurrence of *C. carcharias* in northern Aegean waters is associated both with foraging and reproduction. A bluefin tuna was found in the stomach contents of an adult female great white shark (TL 5 m) caught off Foça coast (northern Aegean Sea) in 1990 (Kabasakal, 2009). In the Mediterranean, there are pronounced periodic increases in white shark abundance in some regions, which are correlated with *T. thynnus* concentrations. It is not surprising that in the Mediterranean, as mentioned by De Maddalena & Heim (2012), white sharks are more frequently recorded in the areas where *T. thynnus* aggregations are more abundant. According to De Maddalena & Heim (2012), fish form the main diet of the Mediterranean great whites. Among the 37 records of feeding on bony fish (De Maddalena & Heim, 2012), 19 refer to unidentified *Thunnus* sp., 2 refer to *T. thynnus* and 1 refers to *T. alalunga*. Furthermore, Fergusson (1996) reported that in the Mediterranean Sea, predation on teleosts by *C. carcharias* is confined to swordfish, *Xiphias gladius* and tuna, *Thunnus* sp., both scavenging from commercial fisheries and pursuing free-swimming prey.

According to Gubili *et al*. (2010), the Mediterranean stock of *C. carcharias* has little or no contemporary immigration from the Atlantic, which would suggest that its Mediterranean populations are extraordinarily vulnerable. Considering this extraordinary vulnerability,

untargeted captures of Mediterranean great white sharks increase the threats to the survival of *C. carcharias* in the overall region. Most of the major impacts of fishing on the ecosystems that are recorded around the world occur in the Mediterranean, and *C. carcharias* seem to have been in general decline in Mediterranean waters since 1960 (Tudela, 2004). Therefore, uninterrupted migration of the great white sharks headed for breeding and nursery grounds is of vital importance for the survival of the vulnerable Mediterranean stock.

CONCLUSIONS

The remarkable loss of biodiversity and especially top predators in Turkey's marine fishery creates an alarming situation (Ulman *et al*., 2013). Evidence of a similar loss of large predatory elasmobranchs in the Mediterranean Sea was previously provided by Ferretti *et al*. (2008). According to a study carried out by the World Wildlife Fund in just five years, from 2002 to 2007 the breeding population of bluefin tuna in Turkish waters was halved, implying a possible local extinction unless the fishery is strongly reduced or closed (Ulman *et al*., 2013). Fishery statistics reported by TUIK (2015) underline a clear decline of Turkey's bluefin tuna fishery in the last decade, which may trigger the decline or even the loss of the great white shark in Turkish waters. To protect the contemporary occurrence of *C. carcharias* in the waters of Turkey, the following measures should be implemented as first steps: i) protection of the potential breeding and nursery grounds in the northern Aegean Sea; ii) encouragement of fishermen to release the great white sharks that are incidentally caught alive; and iii) implementation of strict measures for the management of bluefin tuna fishery to preserve one of the main preys of the Mediterranean great whites. We should learn our lesson from the historical coexistence and synchronous decline and loss of these two top predators in Marmara and Bosphorus waters.

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ZGODOVINSKI PREGLED POJAVLJANJA BELEGA MORSKEGA VOLKA, *CARCHARODON CARCHARIAS*, IN MODROPLAVUTEGA TUNA, *THUNNUS THYNNUS*, V TURŠKIH VODAH: UPAD PLENILCA KOT ODZIV NA IZGUBO PLENA

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POVZETEK

Na podlagi podatkov novejših raziskav in novougotovljenih zgodovinskih zapisov o sedmih belih morskih volkovih, Carcharodon carcharias*, v bosporski ožini, je bilo doslej v turških vodah zabeleženo 54 primerkov te vrste med leti 1881 in 2014. Največje število belih morskih volkov je bilo ugotovljeno v Marmarskem morju. Modroplavutega tuna,* Thunnus thynnus*, ki je v Sredozemskem morju pogosto povezan s premiki belih morskih volkov, v Marmarskem morju ni. Drastični upad in posledično izginotje modroplavutega tuna v Marmarskem morju in vodah bosporske ožine dobro sovpada z upadom in izginotjem belega morskega volka.*

Ključne besede: beli morski volk, *Carcharodon carcharias*, modroplavuti tun, *Thunnus thynnus*, Turčija, razširjenost

REFERENCES

Barrull, J.& I. Mate (2001): Presence of the great white shark, *Carcharodon carcharias* (Linnaeus, 1758) in the Catalonian Sea (NW Mediterranean): Review and discussion of records, and notes about its ecology. Annales, ser. hist. nat., 11, 3-12.

Ben-Tuvia, A. (1971): Revised list of the Mediterranean fishes of Israel. Isr. J. Zool., 20, 1-39.

Bonfil, R., M. Meÿer, M.C. Scholl, R. Johnson, S. O'Brien, H. Oosthuizen, S. Swanson, D. Kotze & M. Paterson (2005): Transoceanic migration, spatial dynamics, and population linkages of white sharks. Science, 310, 100-103.

Carlisle, A.B., S.L. Kim, B.X. Semmens, D.J. Madigan, S.J. Jorgensen, C.R. Perle, S.D. Anderson, T.K. Chapple, P.E. Kanive & B.A. Block (2012): Using stable isotope analysis to understand the migration and trophic ecology of northeastern Pacific white sharks (*Carcharodon carcharias*). PLoS ONE, 7, doi:10.1371/journal.pone.0030492.

Damalas, D. & P. Megalofonou (2012): Occurrences of large sharks in the open waters of the southeastern Mediterranean Sea. J. Nat. Hist., 46, 2701-2723.

De Maddalena, A. (2000): Historical and contemporary presence of the great white shark, *Carcharodon carcharias* (Linnaeus, 1758), in the northern and central Adriatic Sea. Annales, ser. hist. nar., 10, 3-18.

De Maddalena, A. & W. Heim (2012): Mediterranean great white sharks: a comprehensive study including all recorded sightings. Jefferson, McFarland, 242 pp.

Deveciyan, K. (1926): Pêche et Pécheries en Turquie. İstanbul, Imprimerie de l'Administration de la dette publique Ottomane, 459 pp.

Fergusson, I.K. (1996): Distribution and autecology of the white shark in the eastern North Atlantic Ocean and the Mediterranean Sea. In: Klimley, A.P. & D.G. Ainley (eds). Great white sharks: the biology of *Carcharodon carcharias*. San Diego, Academic Press, pp. 321-345.

Ferretti, F., R.A. Myers, F. Serena & H.K. Lotze (2008): Loss of large predatory sharks from the Mediterranean Sea. Conserv. Biol., 22, 952-964.

Fromentin, J.-M. (2009): Lessons from the past: investigating historical data from bluefin tuna fisheries. Fish Fish., 10, 197-216.

Gubili, C., R. Bilgin, E. Kalkan, S.Ü. Karhan, C.S. Jones, D.W. Sims, H. Kabasakal, A.P. Martin & L.R. Noble (2010): Antipodean white sharks on a Mediterranean walkabout? Historical dispersal leads to genetic discontinuity and an endangered anomalous population. Proc. R. Soc. B., doi:10.1098/rspb.2010.1856.

Kabasakal, H. (2003): Historical records of the great white shark, *Carcharodon carcharias* (Linnaeus, 1758) (Lamniformes: Lamnidae), from the Sea of Marmara. Annales, ser. hist. nat., 13, 173-180.

Kabasakal, H. (2008): Two recent records of the great white sharks, *Carcharodon carcharias* (Linnaeus, 1758) (Chondrichthyes: Lamnidae), caught in Turkey's waters. Annales, ser. hist. nat., 18, 11-16.

Kabasakal, H. (2014): The status of the great white shark (*Carcharodon carcharias*) in Turkey's waters. Mar. Biodivers. Rec., 7, doi:10.1017/S1755267214000980.

Kabasakal, H. & S.Ö. Gedikoğlu (2008): Two newborn great white sharks, *Carcharodon carcharias* (Linnaeus, 1758) (Lamniformes; Lamnidae) from Turkey's waters of the north Aegean Sea. Acta Adriat., 49, 125-135.

Kabasakal, H. & Ö. Kabasakal (2015): Recent record of the great white shark, *Carcharodon carcharias* (Linnaeus, 1758), from central Aegean Sea off Turkey's coast. Annales, ser. hist. nat., 25, 11-14.

Kabasakal, H. & S.Ü. Karhan (2015): Shark biodiversity in the Sea of Marmara: departures and arrivals over a century. Mar. Biodivers. Rec., 8, doi:10.1017/S1755267215000342.

Kabasakal, H., A. Yarmaz & S.Ö. Gedikoğlu (2009): Two juvenile great white sharks, *Carcharodon carcharias* (Linnaeus, 1758) (Chondrichthyes; Lamnidae), caught in the northeastern Aegean Sea. Annales, ser. hist. nat., 19, 127-134.

Karakulak, S. & I.K. Oray (1994): The lenght-weight relationship of the bluefin tunas (*Thunnus thynnus* L., 1758) caught in Turkey's waters. Istanbul University, Journal of Aquatic Products, 8, 159-171.

Karakulak, F.S. & I.K. Oray (2009): Remarks on the fluctuations of bluefin tuna catches in Turkish waters. Collect. Vol. Sci. Pap. ICCAT, 63, 153-160.

Luschi, P. (2013): Long-distance animal migrations in the oceanic environment: orientation and navigation correlates. ISRN Zool., http://dx.doi.org/10.1155/2013/631839, 23 pp.

Morey, G., M. Martínez, E. Massutí & J. Moranta (2003): The occurrence of white sharks, *Carcharodon carcharias*, around the Balearic Islands (western Mediterranean Sea). Env. Biol. Fish., 68, 425-432.

Oral, N. & B. Öztürk (2006): The Turkish Straits. Maritime safety, legal and environmental aspects. İstanbul, Turkish Marine Research Foundation, Publication No. 25, 160 pp.

Öztürk, B. & A.A. Öztürk (1996): On the biology of the Turkish straits system. Bull. Inst. océanogr. Monaco, nº spécial, 17, 205-221.

Ravier, C., & J.-M. Fromentin (2001): Long-term fluctuations in the eastern Atlantic and Mediterranean bluefin tuna population. ICES J. Mar. Sci., 58, 1299-1317.

Sezgin, F. & M. Kadıoğlu (2000): Statistical analysis of sea accidents in the Bosphorus. In: Öztürk, B., M. Kadıoğlu & H. Öztürk (eds). Proceedings of Marmara Denizi 2000 Symposium, İstanbul, TUDAV, pp. 149-160.

Soldo, A. & I. Jardas (2002): Occurrence of great white shark, *Carcharodon carcharias* (Linnaeus, 1758) and basking shark, *Cetorhinus maximus* (Gunnerus, 1765) in the Eastern Adriatic and their protection. Period. Biol., 104, 195-201.

Üner, S. (1984): Balık avcılığı ve yemekleri. İstanbul, Say Yayıncılık, 142 pp.

Tudela, S. (2004): Ecosystem effects of fishing in the Mediterranean: an analysis of the major threats of fishing gear and practices to biodiversity and marine habitats. Studies and Reviews. General Fisheries Commission for the Mediterranean. No. 74. Rome, FAO, 44 pp.

TUIK (2015): Turkey's marine fishery statistics. http://www.tuik.gov.tr/PreTablo.do?alt_id=1005 (last accessed: 3 June 2016).

Ulman, A., Ş. Bekışoğlu, M. Zengin, S. Knudsen, V. Ünal, C. Mathews, S. Harper, D. Zeller & D. Pauly (2013): From bonito to anchovy: a reconstruction of Turkey's marine fisheries catches (1950-2010). Medit. Mar. Sci., 14, 309-342.

Wilcowe, D.S. & M. Wikelski (2008): Going, going, gone: is animal migration disappearing? PLoS Biol., 6, 1361-1364.

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ADDITIONAL RECORD OF *ALECTIS ALEXANDRINA* (CARANGIDAE) FROM THE NORTH-WESTERN LEVANTINE SEA (FETHIYE, TURKEY)

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ABSTRACT

A specimen of Alectis alexandrina *(425 mm TL) was caught on 26th of May 2016 by a commercial gillnet from the Katrancı Cove, Fethiye, north-western Levantine Sea, at a depth of 70 m. This is the third finding of this species for the area.*

Keywords: *Alectis alexandrina,* new record, measurement, Fethiye, Mediterranean Sea

NUOVA SEGNALAZIONE DI *ALECTIS ALEXANDRINA* (CARANGIDAE) NEL MAR DI LEVANTE NORD-OCCIDENTALE (FETHIYE, TURCHIA)

SINTESI

Un esemplare di Alectis alexandrina *(lunghezza totale di 425 mm) è stato catturato il 26 maggio 2016 con una rete da posta commerciale nella baia Katranci, Fethiye, nel Mar di Levante nord-occidentale, ad una profondità di 70 m. Si tratta del terzo ritrovamento della specie per l'area in questione.*

Parole chiave: *Alectis alexandrina,* nuova segnalazione, misurazioni, Fethiye, mare Mediterraneo

INTRODUCTION

Alexandria pompano, *Alectis alexandrina* (Geoffroy Saint-Hilaire, 1817), is a bentho-pelagic marine fish species and its young individuals (up to 20 cm) characterized by very long and filamentous anterior rays of dorsal and anal fin (Golani *et al*., 2006). Adults are solitary in coastal waters near bottom to at least 50 m and strong swimmers, while young usually pelagic and drifting. It feeds on squid and fishes (Smith-Vaniz, 1986).

A. alexandrina is an Atlanto-Mediterranean originated species distributing from Spain to Angola, southern parts of Mediterranean (Syria, Israel, Malta, southern Spain, and Morocco) and eastern Atlantic off Morocco (Smith-Vaniz, 1986; Golani *et al*., 2006). A specimen of *A. alexandrina* with 205 mm TL was collected from Split, the Adriatic Sea in 1973 (Dulčić, 2005). Torcu *et al*. (2001) mentioned only by name of *A. alexandrina* within Northern Cyprus fish fauna. Some specimens have also been reported from Italy (Smith-Vaniz & Carpenter, 2015).

In the certain areas of Turkish seas, an *A. alexandrina* specimen with 347 mm TL has been recorded from Gökova Bay, with limited data (Öğretmen et al., 2005). On 22 August 2015, a juvenile with 21.4 mm TL has been reported from Ekincik port, Muğla, Turkey by Y. Özvarol (see Crocetta *et al*., 2015). All successive records of *A. alexandrina*, mentioned above seem that it can be considered as a rare species.

This paper presents the third report of the rare *A. alexandrina* from the coasts of Fethiye, north-western Levantine Sea, in the Mediterranean Sea.

MATERIAL AND METHODS

On 26th of May 2016, a specimen of *Alectis alexandrina* with a total length (TL) of 425 mm (Fig. 1) was captured by a commercial gillnet off Katrancı Cove, Fethiye (Coordinates: 36°42′N-29°04′E, Fig. 2) at a depth of 70 m. The specimen was fixed in 10% formaldehyde solution and deposited in the fish collection of the Fisheries Faculty, Ege University (ESFM-PIS/2016-07).

RESULTS AND DISCUSSION

The specimen was measured to the nearest millimeter (Tab. 1). Brief description of the specimen: body very compressed and deep. Anterior soft rays of dorsal and anal fins are filamentous, besides pectoral fins are longer than head. No scales on body and some parts of head, and cycloid scales are very small and difficult to see where present. Scutes in straight line are relatively small. The color is silvery with a light metallic blue tint on the upper third of the body and head. All measurements, counts,

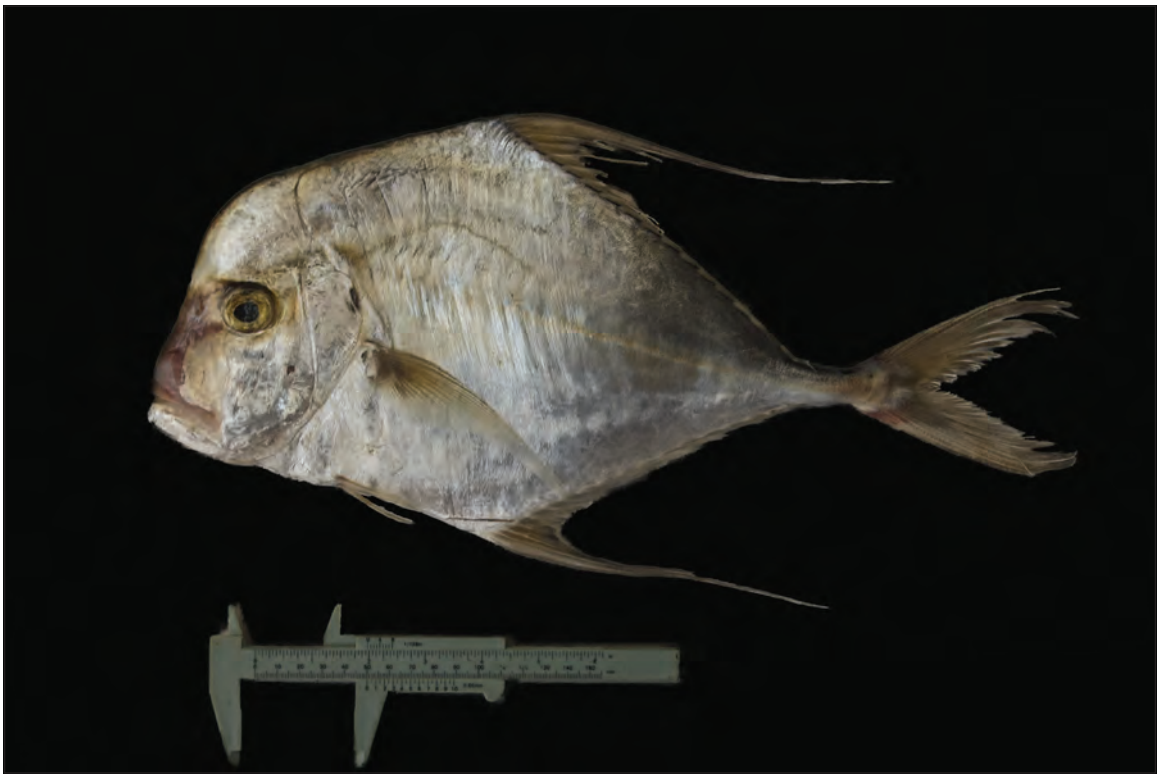

Fig. 1: *Alectis alexandrina****, caught from Fethiye, NW Levantine Sea (Photo: T. Ceyhan)***
Sl. 1: *Alectis alexandrina****, ujet na lokaliteti Fethiye, SZ Levantsko morje (Foto: T. Ceyhan)***

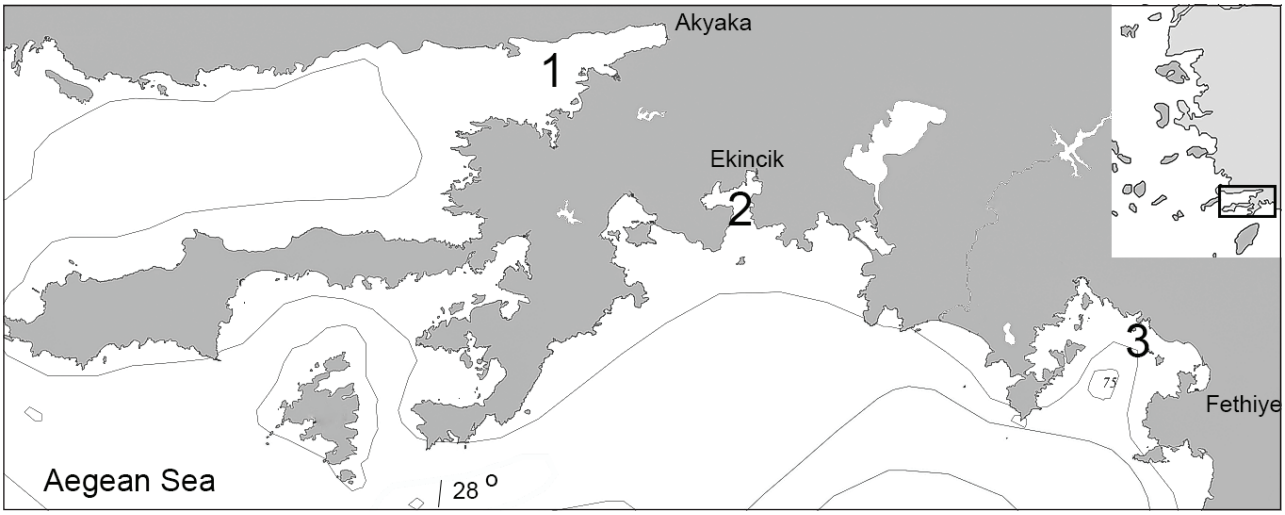

Fig. 2: Map showing successive records of *Alectis alexandrina* ***from north-western Levantine Sea, Turkey. Localities: 1: Gökova; 2: Ekincik; 3: present study.***
Sl. 2: Zemljevid pojavljanja vrste *Alectis alexandrina* ***v severozahodnem Levantskem morju v Turčiji. Lokalitete: 1: Gökova; 2: Ekincik; 3: pričujoče delo.***

Tab. 1: Morphometric measurements as percentage of total length (%TL) and meristic counts recorded in *Alectis alexandrina****, captured from Fethiye, NW Levantine Sea.***
Tab. 1: Morfometrične meritve in delež celotne dolžine (%TL) ter meristična štetja pri primerku vrste *Alectis alexandrina****, ujetem pri lokaliteti Fethiye, SZ Levantsko morje.***

Reference	**ESFM-PIS/2016-07**	
Measurements	**Size (mm)**	**Proportion (%)**
Total length (TL)	425	100.0 TL
Fork length (FL)	350	82.4 TL
Standard length (SL)	335	78.8 TL
Maximum body depth	197	46.4 TL
Pectoral fin length	130	30.6 TL
Pre-dorsal fin length	151	35.5 TL
Pre-pectoral fin length	93	21.9 TL
Pre-anal fin length	140	32.9 TL
Head length (HL)	98	23.1 TL
Eye diameter	24	24.5 HL
Pre-orbital length	32	32.7 HL
Meristic counts		
Dorsal fin rays	VIII+20	
Anal fin rays	III+18	
Ventral fin rays	I+5	
Pectoral fin rays	17	

and color patterns determined are in accordance with the descriptions of Smith-Vaniz (1986), Dulčić (2005), Golani *et al*. (2006), and Froese & Pauly (2016).

The presence of 3 specimens of *A. alexandrina* in the close localities (*i.e.* coastal waters of Gökova, Ekincik and Fethiye, Fig. 2) and occurrence of a juvenile form (21.4 mm) in the area gives the sign of a naturally breeding population along the north-western Levant. In addition, this ichthyological note represents the largest specimen among the records of *A. alexandrina* in Turkey.

DODATEN ZAPIS O POJAVLJANJU VRSTE *ALECTIS ALEXANDRINA* (CARANGIDAE) IZ SVEROZAHODNEGA LEVANTSKEGA MORJA (FETHIYE, TURČIJA)

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POVZETEK

Primerek vrste Alectis alexandrina *(425 mm TL) so ujeli 26. maja 2016 v stoječo komercialno mrežo v zalivu Katrancı, Fethiye v severozahodnem Levantskem morju na globini 70 m. To je tretji podatek o najdbi te vrste na obravnavanem območju.*

Ključne besede: *Alectis alexandrina, nov zapis*, merjenja, Fethiye, Sredozemsko morje

REFERENCES

Crocetta, F., D. Agius, P. Balistreri, M. Bariche, Y.K. Bayhan, M. Çakır, S. Ciriaco, M. Corsini-Foka, A. Deidun, R. El Zrelli, D. Ergüden, J. Evans, M. Ghelia, M. Giavasi, P. Kleitou, G. Kondylatos, L. Lipej, C. Mifsud, Y. Özvarol, A. Pagano, P. Portelli, D. Poursanidis, L. Rabaoui, P.J. Schembri, E. Taşkın, F. Tiralongo & A. Zenetos (2015): New Mediterranean biodiversity records (October 2015). Medit. Mar. Sci., 16, 682-702.

Dulčić, J. (2005): On the record of the African threadfish *Alectis alexandrinus* (Pisces: Carangidae) from the Adriatic Sea. J. Mar. Biol. Ass. U.K., 85, 1013-1014.

Froese, R. & D. Pauly (2016): FishBase. World Wide Web electronic publication [version 01/2016]. http://www.fishbase.org.

Golani D., B. Öztürk & N. Başusta (2006): The fishes of the eastern Mediterranean. Turkish Marine Research Foundation, Publication No. 24, Istanbul, 259 p.

Öğretmen, F., F. Yılmaz & H. Torcu Koç (2005): An investigation on fishes of Gökova Bay (Southern Aegean Sea). BAÜ Fen Bil. Enst. Dergisi, 7, 19-36.

Smith-Vaniz, W.F. (1986): Carangidae. In: Whitehead, P.J.P., M.-L. Bauchot, J.-C. Hureu, J. Nielsen & E. Tortonose (eds.): Fishes of the North-eastern Atlantic and the Mediterranean. Vol. 2. Unesco, Paris, pp. 815-844.

Smith-Vaniz, W.F. & K.E. Carpenter (2015): *Alectis alexandrina*. The IUCN Red List of Threatened Species 2015: e.T198772A43071024. (Accessed date: 06 June 2016).

Torcu, H., Z. Aka & A. Işbilir (2001): An investigation on fishes of the Turkish Republic of Northern Cyprus. Turk. J. Vet. Anim. Sci., 25, 155-159.

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IS THE PORT OF KOPER AN INHOSPITABLE ENVIRONMENT FOR THE SETTLEMENT OF NON-INDIGENOUS MACROPHYTES?

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ABSTRACT

The area of the Port of Koper was sampled for benthic macroalgae within the BALMAS project, in order to prepare an overview of native and non-indigenous species (NIS). In the mediolittoral and upper-infralittoral belts of the port area, 28 algal taxa were found (21 Rhodophyta, 6 Chlorophyta and 1 Ochrophyta). Only one algal NIS was identified, the tetrasporophyte of the red algae Asparagopsis armata. *The species was found in low abundances only in autumn samples, collected in the lower mediolittoral and upper infralittoral belt. The aim of this paper is to discuss the limited presence and abundance of algal NIS in the area of the Port of Koper.*

Key words: macrophytes, non-indigenous species, *Asparagopsis armata,* Port of Koper, Adriatic Sea

IL PORTO DI CAPODISTRIA È UN AMBIENTE INOSPITALE PER L'INSEDIAMENTO DELLE MACROFITE NON-INDIGENE?

SINTESI

Le macroalghe bentoniche sono state campionate nell'area del porto di Capodistria al fine di preparare una panoramica delle specie autoctone e non-indigene (NIS), nell'ambito del progetto BALMAS. Nei piani mediolitorale e infralitorale superiore della zona del porto, sono stati trovati 28 taxa algali (21 Rhodophyta, 6 Chlorophyta e 1 Ochrophyta). Tra questi è stata identificata una sola NIS, il tetrasporofito dell'alga rossa Asparagopsis armata. *La specie è stata trovata in abbondanze minime solo nei campioni autunnali raccolti nei piani mediolitorale inferiore e infralitorale superiore. Lo scopo di questo lavoro è quello di discutere la presenza e l'abbondanza limitate delle alghe NIS nella zona del porto di Capodistria.*

Parole chiave: macrofiti, specie non-indigene, *Asparagopsis armata,* porto di Capodistria, mare Adriatico

INTRODUCTION

Through human-induced activities marine plants have been largely introduced to non-native locations around the world (Wonham & Carlton, 2005), and Williams & Smith (2007) recently prepared a global review on seaweeds invasions. The dominant vectors of introductions of NIS macrophytes are believed to be maritime traffic (with ballast waters, sediments in ballast tanks, hull fouling, sediments attached to anchors/chains, commercial fishing nets and gear) and aquaculture (Gollasch & Leppäkoski, 1999; Rilov & Crooks, 2009; Micael *et al*., 2014). Among marine NIS, some are recognized to be invasive, thus they have a negative impact on biodiversity (displacing native species, changing community structure and modifying habitats), ecosystem services, human health and local economies (Katsanevakis *et al*., 2014). The introduction of non-indigenous (NIS) macrophytes in the Mediterranean Sea have been quite well reviewed in the last decades (Verlaque, 2001; Boudouresque & Verlaque, 2002; Ribera-Siguan, 2002; Tsiamis *et al*., 2008; Galil, 2009; Orlando-Bonaca, 2001; Lipej *et al*., 2012; Tsiamis *et al*. 2013; Corsini-Foka *et al*., 2015).

Nowadays, the presence of 44 introduced macrophytes was reported in the northern Adriatic Sea (Orlando-Bonaca, 2001; Krmac, 2009; Curiel *et al.,* 2002; Verlaque *et al*., 2015) and four of them were found also in Slovenian waters (Orlando-Bonaca, 2010; Lipej *et al*., 2012). While *Bonnemaisonia hamifera* Hariot was found only in 1995 and *Ulva scandinavica* Bliding (Battelli & Tan, 1998) was found to be a taxonomic synonym of *Ulva rigida* C. Agardh, *Asparagopsis armata* Harvey (*Falkenbergia rufolanosa* phase) and *Codium fragile* subsp. *fragile* (Suringar) Hariot are considered to be established in Slovenian shallow coastal waters, even if both were always found in low number of specimens, with low coverage on hard substrata, and only in few localities (Battelli, 2000; Orlando-Bonaca, 2010). Within the implementation of the Marine Strategy Framework Directive (MSFD, 2008/56/EC) the Environmental status (ES) of Slovenian marine waters has been assessed also according to Descriptor 2 (Non-indigenous species). The ES was evaluated as Good since, so far, none of the NIS detected in the Slovenian Sea has shown to have a negative impact on native species and habitats (Orlando-Bonaca *et al.,* 2012).

During 2014 the area of the Port of Koper was sampled according to the Port Baseline Protocol (PBS) prepared within the BALMAS project (IPA Adriatic Cross-Border Cooperation Programme), in order to prepare an overview of native species, NIS, harmful aquatic organisms and pathogens (HAOP) in the 12 biggest ports of the Adriatic Sea. The aim of this study was to verify how many non-indigenous macrophytes are established in marine waters of the Port of Koper and to discuss their limited presence and abundance in the Port area.

MATERIAL AND METHODS

Study area

The Port of Koper is a Slovenian multi-purpose seaport, situated in the northern part of the Adriatic Sea, connecting mainly markets of Central and Southeast Europe with the Mediterranean Sea and Far East. The marine part of the cargo port is composed of three basins (Fig. 1) and associated mooring piers and 12 specialized loading terminals. The 1st basin is designed for container cargo, with a depth at mooring piers down to 11 m. The 2nd basin is intended for the transhipment of oil, petroleum products and wood (depth down to 14 m), while in the inner part of the basin there is the mouth of the Rižana River, carrying urban and industrial waste waters. The southern part of the 3rd basin is designed for trans-shipment of iron ore and coal, with a depth down to 17 m (Geodetski Inštitut Slovenije, 2016).

In 2015, 20 million tones of goods were handled in the Port of Koper. The number of vessels was 4,611; 531 of them were passenger vessels and 4,080 were cargo vessels (Statistical Office of the Republic of Slovenia, 2016). According to David & Gollasch (2015) the discharged ballast water in the area of the Port of Koper originates almost totally from inside the Mediterranean Sea (70 % from the northern Adriatic, 15 % from the southern Adriatic, and 15% from non-Adriatic Medi-

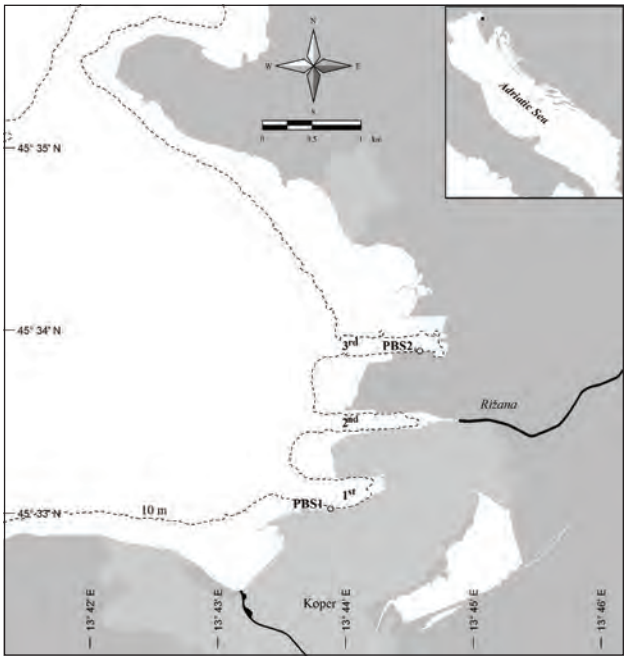

Fig. 1: *The area of the Port of Koper with basins (1st, 2nd and 3rd) and sampling stations for benthic macrophytes (PBS1 and PBS2).*
Sl. 1: Območje Luke Koper s tremi bazeni in vzorčnimi postajami za bentoške makrofite (PBS1 in PBS2).

Tab. 1: Average coverage of macroalgal taxa recorded in the Port of Koper in 2014. UM = Upper Mediolittoral; LM = Lower Mediolittoral; UI = Upper Infralittoral.
Tab. 1: Povprečna pokrovnost makroalg v Luki Koper v 2014. UM = zgornji mediolitoral; LM = spodnji mediolitoral; UI = zgornji infralitoral.

Sampling station		**Passenger terminal in the Port of Koper**					
Sampling belt and depth range (m)		UM (0-0.5)	LM (0.5-1)	UI (1-2)	UM (0-0.5)	LM (0.5-1)	UI (1-2)
Samping date		2.6.2014	2.6.2014	2.6.2014	7.10.2014	7.10.2014	7.10.2014
Phylum	**Taxa**	**Average coverage within three sampling frames (20 cm x 20 cm)**					
Chlorophyta	*Blidingia minima* (Nägeli ex Kützing) Kylin	1.33	0.00	0.00	0.00	0.00	0.00
Chlorophyta	*Cladophora coelothrix* Kützing	0.33	3.33	3.33	0.00	0.17	0.00
Chlorophyta	*Cladophora prolifera* (Roth) Kützing	0.00	0.00	0.00	0.00	0.00	0.67
Chlorophyta	*Cladophora* sp.	0.00	0.00	2.67	0.00	0.00	0.00
Chlorophyta	*Rhizoclonium riparium* (Roth) Harvey - Adriatic Sea (Sfriso. 2011)	0.07	0.00	0.00	2.00	0.10	0.00
Chlorophyta	*Valonia macrophysa* Kützing	0.00	0.00	0.00	0.00	0.00	0.33
Ochrophyta	*Sphacelaria fusca* (Hudson) S.F.Gray	0.33	0.00	0.00	0.00	0.17	0.00
Rhodophyta	*Aglaothamnion caudatum* (J.Agardh) Feldmann-Mazoyer	0.00	0.00	0.00	0.00	0.00	0.17
Rhodophyta	*Antithamnion cruciatum* (C.Agardh) Nägeli	0.00	0.00	0.17	0.00	0.00	0.00
Rhodophyta	*Ceramium codii* (H.Richards) Mazoyer	0.00	0.00	0.00	0.00	0.00	0.17
Rhodophyta	*Compsothamnion thuyoides* (Smith) Nägeli	0.00	0.83	0.17	0.00	0.17	0.33
Rhodophyta	*Dasya hutchinsiae* Harvey	0.00	0.33	0.00	0.00	0.33	0.50
Rhodophyta	*Dasya ocellata* (Grateloup) Harvey	0.33	0.00	0.33	0.00	0.17	0.17
Rhodophyta	*Erythrotrichia carnea* (Dillwyn) J.Agardh	0.00	0.00	0.00	0.00	0.07	0.00
Rhodophyta	***Asparagopsis armata* Harvey**	0.00	0.00	0.00	0.00	**2.00**	**2.00**
Rhodophyta	*Gelidium* sp.	0.00	0.00	0.00	0.00	0.00	0.17
Rhodophyta	*Gelidium spathulatum* (Kützing) Bornet	0.00	3.00	0.00	0.67	4.00	0.00
Rhodophyta	*Herposiphonia tenella* (C.Agardh) Ambronn	0.00	0.00	0.00	0.00	0.00	0.17
Rhodophyta	*Lithophyllum incrustans* Philippi	0.00	0.00	0.67	0.00	0.00	0.00
Rhodophyta	*Lomentaria verticillata* Funk	0.00	0.17	0.00	0.00	0.00	0.00
Rhodophyta	*Peyssonnelia rubra* (Greville) J.Agardh	0.00	1.33	3.67	0.00	0.00	4.00
Rhodophyta	*Peyssonnelia* sp.	0.00	0.00	0.00	0.00	0.00	1.00
Rhodophyta	*Polysiphonia* sp.	0.00	0.00	0.00	0.00	0.17	0.17
Rhodophyta	*Pterocladiella melanoidea* var. *filamentosa* (Schousboe ex Bornet) M.J.Wynne	1.00	0.33	0.33	0.00	0.67	0.00
Rhodophyta	*Pterosiphonia pennata* (C.Agardh) Sauvageau	0.00	0.00	0.00	0.00	0.50	0.17
Rhodophyta	*Pterothamnion crispum* (Ducluzeau) Nägeli	0.00	0.00	0.00	0.00	0.00	0.33
Rhodophyta	*Rhodymenia ardissonei* (Kuntze) Feldmann	0.00	5.67	10.67	0.00	4.00	5.00
Rhodophyta	*Titanoderma pustulatum* (J.V.Lamouroux) Nägeli	0.00	0.00	0.00	0.00	0.00	0.67
Total average coverage		**3.40**	**15.00**	**22.00**	**2.67**	**12.50**	**16.00**

terranean areas), while less than 1% from outside the Mediterranean basin.

Fieldwork and laboratory work

On the 2nd and 12th of June 2014, and on the 7th of October 2014, samplings of macroflora were performed in the first and third basin of the Port of Koper. The samplings were done on the wall of the passenger terminal (1st basin) and on three piles (3rd basin), by SCUBA diving. Three vertical transects at each station were performed during the period of high tide. Along every transect, one sampling frame (20 cm x 20 cm) was fixed to the pile or wall surface at different depths (upper mediolittoral down to 0.5 m of depth, lower mediolittoral down to 1.0 m, and upper infralittoral down to 2.0 m of depth). Such a surface (400 cm^2) is considered to be the minimal sampling area in the case of the Mediterranean communities (Boudouresque & Belsher, 1979). Quantitative sampling was performed by carefully scraping all organisms inside these nine sampling frames (three per each depth) per sampling station into collecting bags. On the research vessel, each collected sample was immediately sieved through a 0.5 mm mesh and fixed in formalin (4-5 %).

All material was transported to the Marine Biology Station of the National Institute of Biology laboratory for analysis. Species identification of macroalgae was carried out in the laboratory by using a binocular microscope, in accordance with Ribera *et al*. (1992), Gallardo *et al*. (1993), Gómez Garreta *et al*. (2001), and Bressan & Babbini (2003). Each sample was sorted carefully and the surface covered by each species (the vertical projection) was quantified in cm^2 (4 cm^2 = 1 % of the sampling surface; Orlando-Bonaca *et al*., 2008). Species names were checked in AlgaeBase (Guiry & Guiry, 2016).

RESULTS

On three sampled piles under the pier in the third basin of the port of Koper (on the 12th of June 2014), no macrophyte specimens were found, while on the wall of the passenger terminal (in the first basin) 28 algal taxa were found (Tab. 1). Among them, 21 were Rhodophyta, 6 were Chlorophyta and only one was Ochrophyta. In June 2014 only 15 taxa were collected, while in October of the same year 23 taxa were determined. Totally, seven species were present in the upper mediolittoral belt, 15 in the lower mediolittoral belt and 22 in the upper infralittoral belt.

The coverage of macroalgae was quite low in all sampled belts and in both seasons (Tab. 1). The lowest coverage value was calculated as the average coverage of three samples collected in the upper mediolittoral belt in October, while the highest value was the average coverage of three samples collected in the upper infralittoral belt in June. Among all taxa, *Rhodymenia ardissonei* (Kuntze) Feldmann had the highest average coverage (10.67% in the upper infralittoral belt in June). The most frequently found species were *Cladophora coelothrix* Kützing, *Compsothamnion thuyoides* (Smith) Nägeli, *Dasya ocellata* (Grateloup) Harvey, *Pterocladiella melanoidea* var. *filamentosa* (Schousboe ex Bornet) M.J.Wynne, and *R. ardissonei*.

Only one NIS was identified, the tetrasporophyte (*Falkenbergia rufolanosa* phase) of *Asparagopsis armata*. The species was found only in October's samples, collected in the lower mediolittoral and upper infralittoral belt. The abundance of the species was low in all samples – with an average coverage of 2% of the sampling surface (Tab. 1).

DISCUSSION

The algal community found in the Port of Koper in 2014 resulted to have lower species richness and coverage than other ten sampling sites along the hard bottom Slovenian coastline, sampled with the same methodology and in the same depth range in June 2008 (Quaggiotto, 2010; Pitacco *et al*., 2013). During those surveys performed in non-port areas, 14 algal taxa were found in the upper and 27 in the lower mediolittoral subbelt (Pitacco *et al*., 2013), while 39 taxa were collected in the upper infralittoral belt (Quaggiotto, 2010), and no algal NIS was found. In June 2009, the sampling station in the first basin of the Port of Koper was surveyed with the same methodology, and two algal taxa in the upper mediolittoral, five taxa in the lower mediolittoral, and nine taxa in the upper infralittoral belt were found, but no algal NIS was collected (Orlando-Bonaca *et al*., 2010). From our results therefore appears that from 2009 to 2014 the number of algal species in the Port of Koper area slightly raised, and that in this period one NIS algal species settled down on the vertical wall of the first basin. The tetrasporophyte of *A. armata* was recorded for the first time in Slovenian coastal waters and in the northern Adriatic Sea in 1991 (M. Richter, *pers. comm*. in Orlando-Bonaca, 2001). The alga, which originates from Australia and New Zealand, was introduced to the Mediterranean Sea unintentionally with oysters (Ribera & Boudouresque, 1995). In 1997 gametophyte thalli of *A. armata* were recorded in Croatian waters near Senj (M. Richter, *pers. comm*.), but were never found in Slovenian waters.

The evidence that *A. armata* was recently collected within the Port of Koper during target surveys, leads to the assumption that in the Port's area other NIS algal taxa could settle down in the nearby future. Potentially, around 30 NIS could arrive from Italian Adriatic waters (Verlaque *et al*., 2015). Among them, at least 11 species were confirmed to be established in the Venetian Lagoon. The most invasive are *Undaria pinnatifida* (Harvey) Suringar, *Sargassum muticum* (Yendo) Fensholt, and *Antithamnion pectinatum* (Montagne) J.Brauner (Curiel *et al*., 1994, 1995, 1996, 1998), that were introduced

in the late 1960s into European waters with *Crassostrea gigas* (Critchley *et al*., 1983; Rueness, 1989). Other 8 NIS macroalgae are also well known for the Venetian Lagoon: three brown algae (*Sorocarpus* sp., *Ectocarpus siliculosus* var. *hiemalis* (P.L.Crouan & H.M.Crouan) Gallardo, and *Punctaria tenuissima* (C.Agardh) Greville), and five red algae (*Polysiphonia morrowii* Harvey, *Polysiphonia mottei* Lauret, *Desmarestia willii* Reinch, *Lomentaria hakodatensis* Yendo, and *Aglaothamnion feldmanniae* Halos) (Curiel *et al*., 1999, 2002, 2003, 2006). Moreover, the presence of the NIS red alga *Acrothamnion preissii* (Sonder) E.M. Wollaston was reported from the Marano and Grado Lagoon (Falace *et al*., 2009). Eventually, two NIS are confirmed to be established in the Italian part of the Gulf of Trieste: *C. fragile* subsp. *fragile*, and the tetrasporophyte of *A. armata* (Falace, 2000; Ceschia *et al*., 2007).

Among the 16 NIS macroalgae confirmed in Croatian marine waters (Pećarević *et al*., 2013), two are considered to be established and invasive in northern Adriatic waters. The most invasive is the green alga *Caulerpa cylindracea* Sonder (Žuljević *et al*., 2003; Despalatović *et al*., 2008) that was recently found very near to the Croatian-Slovenian border (Sladonja & Banovac-Kuča, 2014; Iveša *et al*., 2015). The species is however affecting less than 1% of the entire west Istrian coastline, probably because low winter seawater temperatures (8°C) cause an abrupt decrease of *C. cylindracea* biomass (Iveša *et al*., 2015). The probability that the species will be found in the nearby future in the Slovenian sea is therefore high, but given the low winter temperatures of the area, it may not find the environment suitable to settle down and become established. Secondly, the invasive red alga *Womersleyella setacea* (Hollenberg) R. E. Norris is frequently found all along the Croatian coastline, where its dense monospecific turfs are covering native algal assemblages (Battelli & Arko Pijevac, 2005; Despalatović *et al*., 2008, Nikolić *et al*., 2010). Lastly, *Caulerpa taxifolia* (M. Vahl) C. Agardh was considered highly invasive during the first period of its introduction, but later it proved to have a lower invasive potential, and was partially eradicated from Adriatic areas (Žuljević & Antolić, 1998). Nowadays, it seems that the species has disappeared from the northern Adriatic Sea (*A. Žuljević, pers. obs*.). However, green algae like several *Caulerpa* species, *Codium fragile* subsp. *fragile* and subsp. *atlanticum,* are known to be highly successful invaders that compete directly with native species also in other marine areas (Williams & Smith, 2007).

When the results of all sampling surveys performed during the BALMAS project will become available, it will be possible to evaluate how many of these NIS are present also in Adriatic port's areas, since according to Williams & Smith (2007) hull fouling is a very important vector of introduction of seaweeds, especially of filamentous and weedy corticated foliose genera, while ballast water introductions are less common for seaweeds than documented for other marine species. Despite the high diversity of algal non-native species in adjacent Adriatic areas, some limiting factors appear to prevent the colonization of algal NIS on hard substrata in the Port of Koper. The reduced light availability due to the high resuspension rate of sediments (Orlando-Bonaca *et al*., 2010) could be assumed to be the most important limiting factor for the settlement of native and NIS macroalgae in Port waters. This hypothesis is supported by the low coverage of macroalgae recorded in the upper infralittoral belt at the Port's sampling stations. In shallow areas outside the Port of Koper, the macroalgal coverage in this depth range could be also higher than 100% (Quaggiotto, 2010). Moreover, the evidence that no macroalge were found growing on the three sampled piles in the third basin of the port of Koper, suggests that the construction of the piers on piles would be helpful in the prevention of the settlement of algal NIS in such areas. Since the piles are located under the pier, the light that reaches them seems to be insufficient for the growth of any macroalgae.

Regardless the low presence and abundance of algal NIS in Slovenian waters, at least the Port's area should be regularly sampled in order to quickly report any new settlement of non-native algal species, since the number of taxonomic units involved in bio-invasion is currently underestimated (Provan *et al*., 2008). It should be considered also that the Mediterranean Sea and the NE Atlantic support the highest number of successful algal introductions (Williams & Smith, 2007). Therefore, a regular national monitoring program for NIS should be established in accordance with MSFD requirements, accompanied by a scientific evaluation of key environmental factors, in order to develop effective management solutions in the case of introduction and establishment of invasive species. As the future of introduced NIS is unpredictable, the enforcement of the international collaboration in the Adriatic Sea, such as within the BALMAS project, is crucial to constantly update the global data bank on NIS and HAOP, in order to prevent or at least decrease their potentially negative impacts on native species and receptive habitats along Adriatic coasts.

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JE KOPRSKO PRISTANIŠČE NEGOSTOLJUBNO OKOLJE ZA NASELJEVANJE TUJERODNIH MAKROFITOV?

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POVZETEK

Na območju Luke Koper so avtorji vzorčili bentoške makroalge z namenom, da v okviru projekta BALMAS pripravijo pregled avtohtonih in tujerodnih vrst (NIS). V mediolitoralu in zgornjem infralitoralu so na območju pristanišča ugotovili 28 taksonov alg (21 Rhodophyta, 6 Chlorophyta in 1 Ochrophyta). Med temi je bila le ena NIS in sicer tetrasporofit rdeče alge Asparagopsis armata. *Le-ta se je pojavljala v nizkih abundancah in v jesenskih vzorcih, nabranih v spodnjem mediolitoralu in zgornjem infralitoralu. V članku avtorji razpravljajo o omejeni prisotnosti in nizki številčnosti NIS alg na območju Luke Koper.*

Ključne besede: makrofiti, tujerodne vrste, *Asparagopsis armata,* Luka Koper, Jadransko morje

REFERENCES

Battelli, C. & I. H. Tan (1998): *Ulva scandinavica* Bliding (Chlorophyta): a new species for the Adriatic Sea. Annales, Ser. Hist. Nat., 13, 121-124.

Battelli, C. (2000): Priročnik za spoznavanje morske flore Tržaškega zaliva (Manual for the determination of the marine flora of the Gulf of Trieste). Institute for Education of the Republic of Slovenia, Ljubljana, 170 pp.

Battelli, C. & M. Arko Pijevac (2005): Development of the invasive turf-forming red alga *Womersleyella setacea* (Hollenberg) R.E. Norris on subtidal shores of Rijeka Bay (Northern Adriatic Sea). Annales, Ser. Hist. Nat., 15, 215-222.

Boudouresque, C.F. & T. Belsher (1979): Le peuplement algal du port de Port-Vendres: Recherches sur l'aire minimale qualitative. Cah. Biol. mar., 20, 259-269.

Boudouresque C.F. & M. Verlaque (2002): Biological pollution in the Mediterranean Sea: invasive versus introduced macrophytes. Mar. Pollut. Bull., 44, 32–38.

Bressan, G. & L. Babbini (2003): Corallinales del Mar Mediterraneo: Guida alla determinazione. Biol. Mar. Medit., 10(2), 237 pp.

Ceschia, C., A. Falace & R. Warwick (2007): Biodiversity evaluation of the macroalgal flora of the Gulf of Trieste (Northern Adriatic Sea) using taxonomic distinctness indices. Hydrobiologia, 580, 43–56.

Corsini-Foka, M., A. Zenetos, F. Crocetta, M.E. Çinar, F. Koçak, D. Golani, S. Katsanevakis, K. Tsiamis, E. Cook, C. Froglia, M. Triandaphyllou, S. Lakkis, G. Kondylatos, E. Tricarico, A. Žuljević, M. Almeida, F. Cardigos, S. Çağlar, F. Durucan, A.M.D. Fernandes, J. Ferrario, I. Haberle, P. Louizidou, J. Makris, M. Marić, D. Micu, C. Mifsud, C. Nall, E. Kytinou, D. Poursanidis, D. Spigoli, G.

Stasolla, S. Yapici & H.E. Roy (2015): Inventory of alien and cryptogenic species of the Dodecanese (Aegean Sea, Greece): collaboration through COST action training school. Manag. Biol. Invasion., 6(4), 251-366.

Critchley, A. T., W. F. Farnham & S. L. Morrell (1983): A chronology of new European sites of attachment for the invasive brown alga, *Sargassum muticum*, 1973-1981. J. Mar. Biol. Ass. U. K., 63, 799-811.

Curiel, D., A. Rismondo, M. Marzocchi & A. Solazzi (1994): Distribuzione di *Undaria pinnatifida* (Harvey) Suringar (Laminariales, Phaeophyta) nella laguna di Venezia. Soc. Ven. Sc. Nat., 19, 121-126.

Curiel, D., A. Rismondo, M. Marzocchi & A. Solazzi (1995): Distribuzione di *Sargassum muticum* (Yendo) Fensholt (Phaeophyta) in laguna di Venezia. Acqua-Aria, 8, 831-834.

Curiel, D., M. Marzocchi & G. Bellemo (1996): First Report of Fertile *Antithamnion pectinatum* (Ceramiale, Rhodophyceae) in the North Adriatic Sea (Lagoon of Venice, Italy). Bot. Mar., 39, 19-22.

Curiel, D., G. Bellemo, M. Marzocchi, M. Scattolin & G. Parisi (1998): Distribution of introduced Japanese macroalgae *Undaria pinnatifida*, *Sargassum muticum* (Phaeophyta) and *Antithamnion pectinatum* (Rhodophyta) in the Lagoon of Venice. Hydrobiologia, 385 (1-3), 17-22.

Curiel, D., G. Bellemo, M. Iuri, M. Marzocchi & M. Scattolin (1999): First Report of the Genus *Sorocarpus* Pringsheim (Fucophyceae, Ectocarpaceae) in the Mediterranean. Bot. Mar., 42, 7-10.

Curiel, D., G. Bellemo, B. La Rocca, M. Scattolin & M. Marzocchi (2002): First report of *Polysiphonia morrowii* Harvey (Ceramiales, Rhodophyta) in the Mediterranean Sea. Bot. Mar., 45, 66–70.

Curiel, D., G. Bellemo, M. Scattolin, B. La Rocca & M. Marzocchi (2003): Ritrovamento in laguna di Venezia di specie algali nuove per l'Adriatico e rare per il Mediterraneo. Inf. Bot. Ital., 35(1), 7-11.

Curiel, D., G. Bellemo, M. Scattolin & M. Marzocchi (2006): First report of *Lomentaria hakodatensis* (Lomentariaceae, Rhodophyta) from the lagoon of Venice (Adriatic Sea, Mediterranean). Acta Adriat., 47(1), 65-72.

David, M. & S. Gollasch (2015): Ballast Water Management Decision Support System Model Application. In: M. David & S. Gollasch (Editors). Global Maritime Transport and Ballast Water Management: Issues and Solutions. Springer, pp. 261 – 291.

Despalatović M, I. Grubelić, V. Nikolić, B. Dragičević, J. Dulčić, A. Žuljević, I. Cvitković & B. Antolić (2008): Allochthonous warm water species in the benthic communities and ichthyofauna of the eastern part of the Adriatic Sea. In: F. Briand (Editor). Climate warming and related changes in Mediterranean marine biota. N° 35 in CIESM Workshop Monographs, Monaco, pp. 51-57.

Falace, A. (2000): Variazioni fisionomiche spazio-temporali della vegetazione sommersa del Golfo di Trieste: analisi delle principali influenze ambientali. Ph.D. Thesis, University of Trieste, 220 pp.

Falace, A., D. Curiel & A. Sfriso (2009): Study of the macrophyte assemblages and application of phytobenthic indices to assess the Ecological Status of the Marano-Grado Lagoon (Italy). Mar. Ecol., 30, 480–494.

Galil, B.S. (2009): Taking stock: inventory of alien species in the Mediterranean sea. Biol. Invasions, 11, 359–372.

Gallardo, T., A. Gómez-Garreta, M.A. Ribera, M. Cormaci, G. Furnari, G. Giaccone & C.F. Boudouresque (1993): Check-list of Mediterranean seaweeds. 2. Chlorophyceae. Bot. Mar., 36(5), 399-421.

Geodetski Inštitut Slovenije (2016): Koprsko (tovorno) pristanišče. Navtični vodnik slovenskega morja in obale (Koper (freight) port. Nautical Guide of the Slovenian sea and the coast). http://www.hidrografija.si/p4/3-2-6.php#, accessed on the 18th of April 2016.

Gollasch, S. & E. Leppäkoski (1999): Initial Risk Assessment of Alien Species in Nordic Coastal Waters. In: S. Gollasch & E. Leppäkoski (Editors). Initial Risk Assessment of Alien Species in Nordic Coastal Waters. Nordic Council of Ministers, Copenhagen, pp. 1-124.

Gómez Garreta, A., T. Gallardo, M.A. Ribera, M. Cormaci, G. Furnari, G. Giaccone & C.F. Boudouresque (2001): Checklist of the Mediterranean seaweeds. III. Rhodophyceae. Bot. Mar., 44, 425-460.

Guiry, M.D. & G.M. Guiry (2016): AlgaeBase. World-wide electronic publication, National University of Ireland, Galway. http://www.algaebase.org; searched on 20 July 2016.

Iveša, L., T. Djakovac & M. Devescovi (2015): Spreading patterns of the invasive *Caulerpa cylindracea* Sonder along the west Istrian Coast (northern Adriatic Sea, Croatia). Mar. Environ. Res., 107, 1-7.

Katsanevakis, S, I. Wallentinus, A. Zenetos, E. Leppäkoski, M.E. Çinar, B. Oztürk, M. Grabowski, D.l. Golani & A.C. Cardoso (2014): Impacts of invasive alien marine species on ecosystem services and biodiversity: a pan-European review. Aquat. Invasions, 9, 391–423.

Krmac, M. (2009): Tujerodne vrste v Jadranskem morju s posebnim poudarkom na vplive pomorskega prometa (Non-native species in the Adriatic Sea, with particular emphasis on the impact of maritime transport). Diplomska naloga (Thesis), Univerza v Ljubljani, Fakulteta za pomorstvo in promet, 72 pp.

Lipej, L., B. Mavrič, M. Orlando-Bonaca & A. Malej (2012): State of the art of the marine non-idigenous flora and fauna in Slovenia. Mediterr. Mar. Sci., 13, 243-249.

Micael, J., M. I. Parente & A.C. Costa (2014): Tracking macroalgae introductions in North Atlantic oceanic islands. Helgoland Mar. Res., 68(2), 209-219.

Marine Strategy Framework Directive (2008): Directive 2008/56/EC of the European Parliament and of the Council of 17 June 2008 establishing a framework for community action in the field of marine environmental policy.

Nikolić, V., A. Žuljević, B. Antolić, M. Despalatović & I. Cvitković (2010): Distribution of invasive red alga *Womersleyella setacea* (Hollenberg) R.E. Norris (Rhodophyta, Ceramiales) in the Adriatic Sea. Acta Adriat., 51, 195-202.

Orlando-Bonaca, M. (2001): A survey of the introduced non-indigenous species in the northern Adriatic Sea. Annales, Ser. Hist. Nat., 11(2), 149-158.

Orlando-Bonaca M., L. Lipej, S. Orfanidis (2008): Benthic macrophytes as a tool for delineating, monitoring and assessing ecological status: the case of Slovenian coastal waters. Mar. Pollut. Bull., 56 (4), 666-676.

Orlando-Bonaca, M. (2010): New records on non-indigenous algal species in Slovenian coastal waters. Annales, Ser. Hist. Nat., 20(2), 143-150.

Orlando-Bonaca M., L. Lipej, B. Mavrič, J. Francé, P. Mozetič, O. Bajt, M. Šiško, V. Flander-Putrle (2010): Program opredelitve ekološkega stanja morja v skladu z vodno direktivo (2000/60/ES) v letu 2009 (Program for the definition of the ecological status of the sea in accordance with the Water Framework Directive (2000/60/EC) in 2009). Poročila MBP, 116 (Final national report in Slovenian, Marine Biology Station Piran, National Institute of Biology), 76 pp.

Orlando-Bonaca M., L. Lipej, A. Malej, J. Francé, B. Čermelj, O. Bajt, N. Kovač, B. Mavrič, V. Turk, P. Mozetič, A. Ramšak, T. Kogovšek, M. Šiško, V. Flander-Putrle, M. Grego, T. Tinta, B. Petelin, M. Vodopivec, M. Jeromel, U. Martinčič & V. Malačič (2012): Določanje dobrega okoljskega stanja. Poročilo za člen 9 Okvirne direktive o morski strategiji (Determination of Good Environmental Status. Report for article 9 of the Marine Strategy Framework Directive). Poročila MBP, 141 (Final national report in Slovenian, Marine Biology Station Piran, National Institute of Biology), 177 pp.

Pećarević, M., J. Mikuš, A. Bratoš Cetinić, J. Dulčić & M. Čalić (2013): Introduced marine species in Croatian waters (Eastern Adriatic Sea). Mediterr. Mar. Sci., 14(1), 224-237.

Pitacco, V., B. Mavrič, M. Orlando-Bonaca & L. Lipej (2013): Rocky macrozoobenthos mediolittoral community in the Gulf of Trieste (North Adriatic) along a gradient of hydromorphological modifications. Acta Adriat., 54(1), 67-86.

Provan, J., D. Booth, N.P. Todd, G.E. Beatty & C.A. Maggs (2008): Tracking biological invasions in space and time: elucidating the invasive history of the green alga *Codium fragile* using old DNA. Divers. Distrib., 14(2), 343–354.

Quaggiotto, M.M. (2010): Macrozoobenthos community in the infralittoral belt along a hydromorphological gradient in the Slovenian part of Adriatic Sea. Master joint degree in marine biology thesis. University of Trieste, 94 pp.

Ribera, M.A., A. Gómez-Garreta, T. Gallardo, M. Cormaci, G. Furnari & G. Giaccone (1992): Check-list of Mediterranean Seaweeds. I. Fucophyceae. Bot. Mar., 35, 109-130.

Ribera, M. A. & C.F. Boudouresque (1995): Introduced marine plants, with special reference to macroalgae: mechanisms and impact. Progr. Phycol. Res., 11, 187-268.

Ribera-Siguan, M.A. (2002): Review of non-native marine plants in the Mediterranean Sea. In: E. Leppäkoski, S. Gollasch & S. Olenin (Editors). Invasive aquatic species of Europe. Distribution, impacts and management. Kluwer Academic Publishers, Dordrecht, pp. 291–310.

Rilov, G. & J.A. Crooks (2009): Biological invasions in marine ecosystems—ecological, management, and geographic perspectives. Springer, Berlin, 642 pp.

Rueness, J. (1989): *Sargassum muticum* and Other Introduced Japanese Macroalgae: Biological Pollution of European Coasts. *Mar. Pollut. Bull.,* 20(4), 173-176.

Sladonja, B. & V. Banovac-Kuča (2014): New records of *Caulerpa cylindracea* Sonder (Caulerpales, Chlorophyta) in Istria, Croatia. Annales, Ser. Hist. Nat., 24(2), 115-120.

Statistical Office of the Republic of Slovenia (2016): Port traffic, Slovenia, 2015. Available at: http://www.stat.si/StatWeb/en/show-news?id=6088&idp=22&headerbar=21.

Tsiamis, K., P. Panayotidis & A. Zenetos (2008): *Alien marine macrophytes in Greece: a review. Bot. Mar., 51, 237–246.*

Tsiamis, K., A. Economou-Amilli, C. Katsaros, P. Panayotidis (2013): First account of native and alien macroalgal biodiversity at Andros Island (Greece, Eastern Mediterranean). Nova Hedwig., 97(1-2), 209 – 224.

Verlaque, M. (2001): Checklist of the macroalgae of Thau Lagoon (Herault, France), a hot spot of marine species introduction in Europe. Oceanol. Acta, 24, 29–49.

Verlaque, M., S. Ruitton, F. Mineur & C.-F. Boudouresque (2015): CIESM Atlas of Exotic Species in the Mediterranean – Vol. 4 Macrophytes. F. Briand (Editor). CIESM Publisher, Monaco, 364 pp.

Williams, S.L. & J.E. Smith (2007): A global review of the distribution, taxonomy, and impacts of introduced seaweeds. Ann. Rev. Ecol. Evol. Syst., 38, 327–359.

Wonham, M.J. & J.T. Carlton (2005): Trends in marine biological invasions at local and regional scales: the Northeast Pacific Ocean as a model system. Biol. Invasions, 7, 369–392.

Žuljević, A. & B. Antolić (1998): Croatia. In: Proceedings of the workshop on invasive *Caulerpa* species in the Mediterranean. UNEP; MAP Technical Reports Series, 125, 227-230.

Žuljević, A, B. Antolić & V. Onofri (2003): First record of *Caulerpa racemosa* (Caulerpales: Chlorophyta) in the Adriatic Sea. J. Mar. Biol. Ass. U. K., 83 (4), 711-712.

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BATHYMETRIC CHART OF LAKE DERANE AS THE BASIS FOR DEFINING THE HYDRO-ECOLOGICAL OPTIMUM OF THE DERANSKO WETLANDS

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ABSTRACT

Lake Derane is the largest water body in the area of the Deransko wetlands. Since the hydrological regime of the entire wetland area mostly depends on the water level oscillation of Lake Derane, it was necessary to determine the capacity of the latter before setting it as the basis for defining the hydro-ecological optimum for the period of most intensive biological activities. The preparation of a bathymetric chart of Lake Derane and the related free water surfaces involved bathymetric measurements of the lake basin using a predefined point route. The geographical coordinates for each of the bathymetric points were determined in advance, while the depth values were obtained by terrain bathymetric measurements. As these were taken during the hydro-ecological optimum, the results also represent the corresponding hydrological regime. The bathymetric chart of Lake Derane was obtained through the method of interpolation.

Key words: Derane lake, Derane wetlands, water level oscillation, bathymetric measurements, interpolation.

BATIMETRIA DEL LAGO DERANSKO QUALE BASE PER LA DETERMINAZIONE DELL'OPTIMUM IDRO-ECOLOGICO DELLA ZONA UMIDA DERANSKO

SINTESI

Il lago Deransko è il più grande specchio d'acqua nella zona umida Deransko. Poiché il regime idrico dell'intera area dipende dalle fluttuazioni del corpo idrico, è stato necessario determinarne la capacità volumetrica, quale base per la determinazione dei punti ottimali idro-ecologici nel periodo della massima attività biologica. La preparazione della batimetria del lago e delle superfici associate d'acqua libera è stata condotta con misurazioni batimetriche del lago lungo un percorso predeterminato. Le coordinate geografiche per ogni punto batimetrico sono state definite in precedenza, mentre le misurazioni batimetriche sono state eseguite sul campo nel maggio del 2014, durante l'optimum idro-ecologico. In tal modo i risultati rispecchiano l'attuale regime idrologico. La batimetria del lago Deransko è stata *condotta con il metodo d'interpolazione.*

Parole chiave: lago Deransko, zona umida Deransko, fluttuazioni nel livello d'acqua, misurazioni batimetriche, interpolazione.

INTRODUCTION

The Deransko wetlands are part of Hutovo Blato, a larger morphological depression created under the influence of primary tangential neotectonic movements. The land underwent a process of lowering, as karst processes caused further erosion and, as a result, the formation of a large number of sinkholes at the bottom of the depression. At the end of the last glacial period, the Neretva River poured into this morphological depression and under the influence of subtropical climate the area developed into subtropical marshes consisting of two entities: Svitavsko Blato and Deransko Blato. The recent construction of the hydropower plant Čapljina interfered significantly with the natural hydrological regime: Svitavsko Blato was transformed into a storage pool, and Deransko Blato was seriously affected, too, due to the lack of water, through it has preserved its wetland characteristics and remains to date a natural system. For this reason, it is necessary to define the eco-hydrological acceptable flow rates that would ensure the preservation and an optimal development of biodiversity in the area, especially among the birds.

To determine what an ecologically acceptable water flow for the Deransko wetlands would be, it is necessary to consider the volume of the water mass in the Lake Derane basin, as this is the largest lake in the wetlands and, as a result, its hydrological regime directly affects the hydro-ecological relations in the entire area. Understanding all the elements of the lake's hydrological regime, particularly its hydro-bathymetrical relations, is therefore of crucial importance for a more precise definition of ecologically acceptable water flows in the Deransko wetlands. The leverage factors are particularly significant during the May–July period, at the time of the most important ecological-biological cycles between the (hydrophilic) vegetation, the ichthyofauna and the avifauna inhabiting the marshes. Significant disturbances in natural inflows of water have been recorded during such periods in the past decades, resulting from intensive hydro-technical works in the wider area of the Hutovo Blato marsh. The primary negative effects of such actions involved, above all, the collection of natural underground and surface watercourses into artificial canals and basins, and manifested as:

- a decrease in minimal water flows during the season of hydrological minimums (May–September),
- more prominent high flows during the season of hydrological maximums (November–March),
- greater water level oscillation in the regimes of the entire Hutovo Blato hydrological system.

The complexity of the water level variations in the wider zone of the Deransko wetlands is manifested by the average Kolmogorov Complexity Index (as the measurement that can indicate the variability and irregularity of some natural processes in a given time series) of the lower course of the Neretva River, which is 0.506 (for the 1981-2010 period) (Hydrological Station Žitomislići) (Mihailović *et al.*, 2015). This value indicates there is a significant number of factors impacting the natural hydrological regime in various ways.

Another significant factor with a negative impact on the natural hydrological regime is the climate changes, resulting in an increased occurrence and duration of dry periods in the prominent vegetation season. Additionally, the broader investigated area of Lake Derane falls under the climate subtype Cfax"s – characterised by a moderate warm and moist climate, with hot summers and without the dry season (Drešković & Mirić, 2014). The air temperature in the Mediterranean climate zone reaches 12.1 °C, while in the broader investigated area it increases to 13 °C during the vegetation period (Drešković & Mirić, 2016).

Further to the above stated facts concerning the hydro-ecological optimum, one of the most important hydro-ecological parameters to determine would be the capacity of Lake Derane, since it holds the largest amount of the water mass of the entire area of the Deransko wetlands. This way it would be possible to define the ecologically optimal water flows for certain water-levels measured at the Boljun-Kuk and Karaotok hydrological stations (HS) during the period of intensive biological activities.

Defining the bathymetrical relations in the area of the Deransko wetlands is also problematic because of the marsh vegetation, woody as well as herbaceous, which covers most of the area (over 80%) and entails a more intensive deposition of sediments. Consequently, the larger part of the Deransko wetland basin is only a few tens of centimetres deep. One of the negative effects of the overgrown marsh vegetation is the decrease of the water mass storage capacity of the Deransko wetland basin and the consequent continuous decrease of its own natural hydro-regulation capacity. Adding to this the disturbances to the natural hydrological regime of water supply, it can be concluded that the existing trend indicates the third, final phase of the hydrological development of wetland, which could lead to the disappearance of this marsh hydro system.

In accordance with the research goal, this paper presents concrete bathymetric relations of the free water bodies, supplemented by the estimated values of certain (previously defined) marsh types of land cover with the aim to estimate the capacity of the entire Deransko wetlands.

MATERIALS AND METHODS

The bathymetric relations of Lake Derane have been determined through direct field measurements, performed at the beginning of May 2014, during the season of the hydro-ecological optimum. In this way, it was possible to form spatial conceptions of the hydrological characteristics of the Deransko wetlands based on different points of view, including:

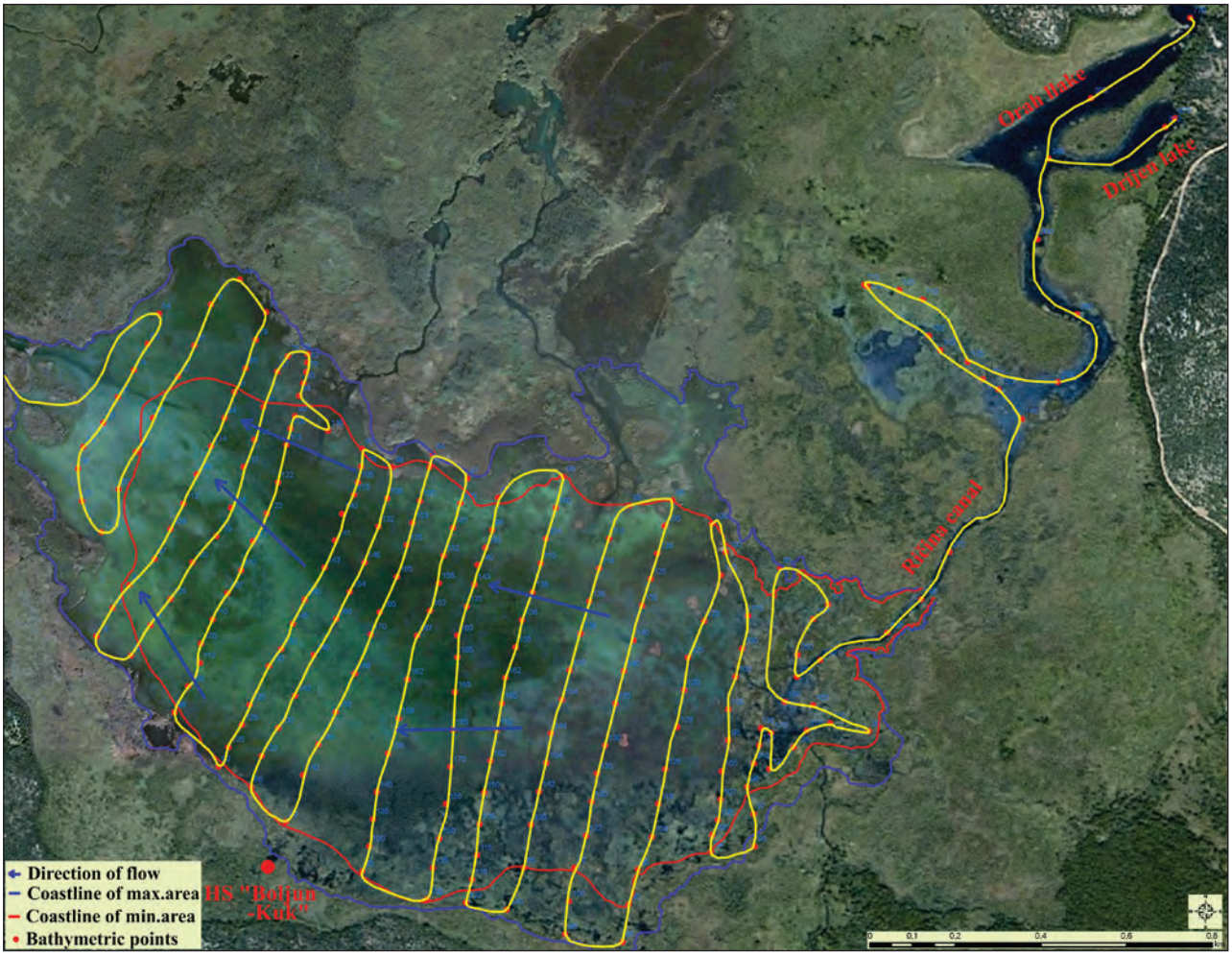

Fig. 1: Spatial position of bathymetric points with the movement route (Map background: Google Earth Imagery, Google, 2015).
Sl. 1: Zemljevid z batimetričnimi točkami in vzorčevalno potjo (Ozadje zemljevida: Google Earth Imagery, Google, 2015).

- the relative depth of Lake Derane and other directly related free water bodies,
- the water level of the flooded marsh vegetation during the season of the hydro-ecological optimum,
- the extent of flooded fields during the mentioned season.

The bathymetric measurements were performed using a digital echo sounder (Garmin fishfinder 250) and following a predefined route of bathymetrical points. The spatial position with geographical (φ, λ) and planar (x, y) coordinates had been previously determined for each of the points. Since the lakebed was significantly silted up, the investigation often combined echo sounder measurements with measurements employing a measuring rod in order to check the accuracy of the results. The average range between them decreased from 50 to 70 m (Fig. 1).

For the definition of the lake's banks and other elements on the bathymetric chart, additional sources were used: georeferenced Google Earth images of the area and orthophotographs of the Deransko wetland area, taken in two different seasons, spring and summer, at the scale of 1 : 5,000.

The bathymetric measurements were extended to free water bodies directly connected to Lake Derane: Ričina, Orah, and Drijen, as well as other neighbouring water bodies.

To find out the volume potentials of the water mass, a bathymetric chart with 10 cm contour intervals was prepared for Lake Derane (Hrelja, 2007).

The results of terrain measurements were then translated into the GIS data format, which above all implied the transformation of the position data from a geographical (WGS84) coordinate system into the national MGI-6 coordinate system. Each bathymetric point was assigned

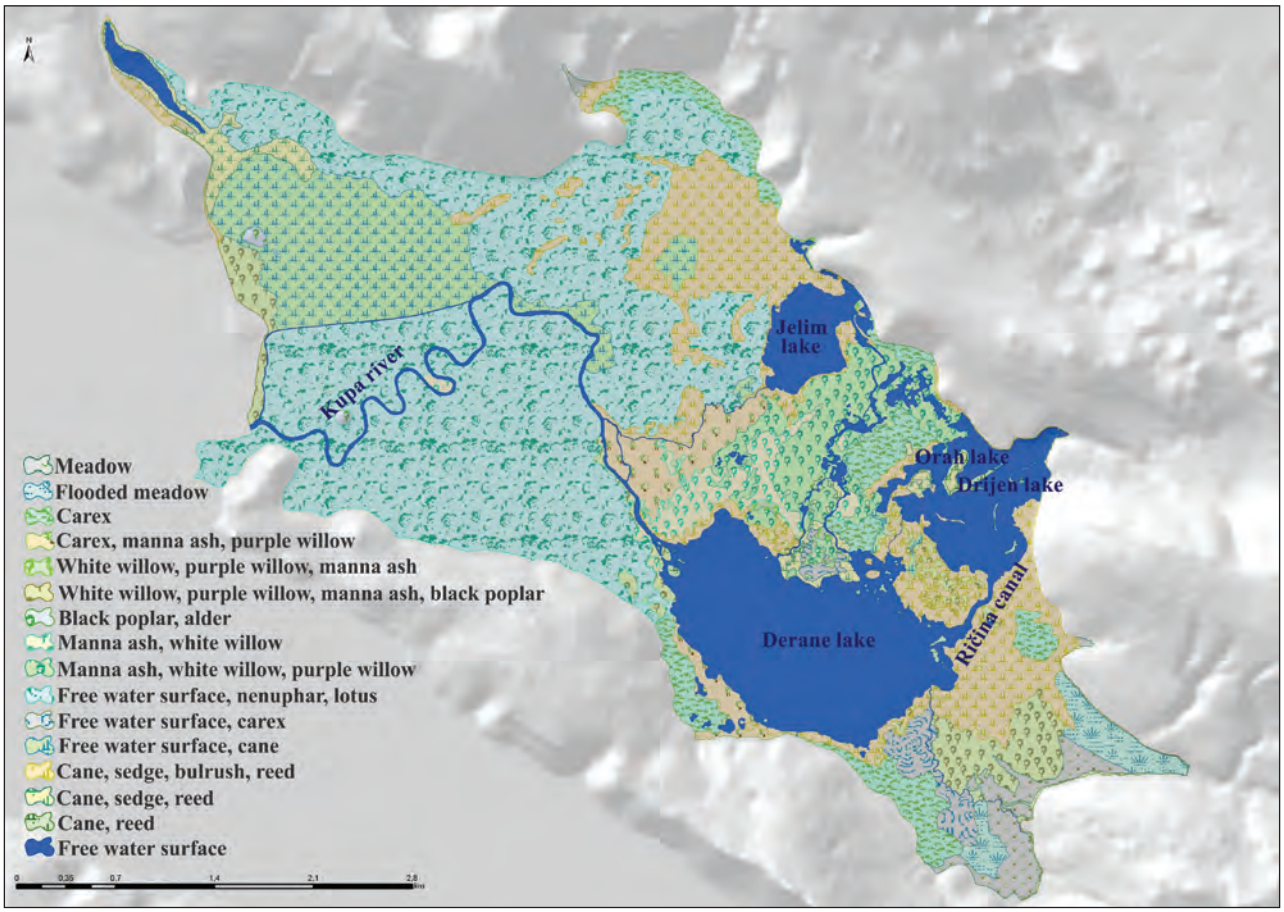

Fig. 2: Deransko wetlands land cover.
Sl. 2: Deransko mokrišče z vidika pokrovnosti.

the following characteristics: ordinal number, x, y, (position coordinates), h (relative depth).

Once the results had been processed, it was possible to apply the method of interpolation to the measured depths and prepare a bathymetric chart of Lake Derane and the neighbouring free water bodies. When analysed, the results obtained through measurement were combined with high resolution Google Earth images and orthophotographs thus providing the basis for determining the position of the banks of all continuous free water bodies.

However, since a comprehensive evaluation of water bodies and a clear image of the existing spatial relations in the lakeside environment would have to take into account the land cover types of the entire area of the Deransko wetlands, we first analysed those (Fig. 2).

The types of land cover were classified on the basis of the results of field work and an analysis of the orthophotographs. Sixteen different categories were determined, one denoting the free water bodies, and the remaining fifteen representing the dominant vegetation species and communities. The vegetation cover of the wider area of the Deransko wetlands was deduced from the plant communities featured in the hilly areas, in the flooded plains, in the marshes, and in the water areas.

In order to precisely determine the bathymetric chart of Lake Derane and the neighbouring free water bodies, depth measurements were made in 235 points, most of which (205) in the largest and most important water body of the Deransko wetlands in terms of capacity – Lake Derane.

RESULTS AND DISCUSSION

The GIS data analysis is summarised in Table 1. The most recent surface area of the natural, aquatic complex of the Deransko wetlands has been determined at around 1,933.4 ha. This value is the result of planimetric measurements of the surface based on a mean water level of 30 cm in the lakeshore zone during spring season.

The area of the foothills surrounding the depression is covered by thermophilic downy oak-oriental hornbeam woods (*Querco-Carpinetum orientalis*) featuring downy oak (*Quercus pubescens*), oriental hornbeam

Tab. 1: Land cover of the Deransko wetlands by categories.
Tab. 1: Pokrovnost Deranskega mokrišča z različnimi kategorijami.

No.	Category	P (ha)
1	Free water surface	349.60
2	Cane, reed	6.86
3	Cane, sedge, bulrush, reed	249.45
4	White willow, purple willow, manna ash, black poplar	80.63
5	Manna ash, white willow, purple willow	82.74
6	White willow, purple willow, manna ash	3.98
7	Manna ash, white willow	39.22
8	Free water surface, carex	25.27
9	Meadow	36.20
10	Flooded meadow	30.31
11	Free water surface, nenuphar, lotus	670.65
12	Cane, sedge, reed	33.93
13	*Carex*	95.01
14	Free water surface, cane	178.12
15	*Carex*, manna ash, purple willow	48.25
16	Black poplar, alder	3.13

(*Carpinus orientalis*), manna ash, pomegranate, European nettle tree etc. The vegetation of the flooded plains is comprised of white willow (*Salix alba*), purple willow, swamp ash, black poplar (*Populus nigra*), alder, fig tree, poplar tree etc. In the marshes of the Deransko wetland, the prevailing species are cane, sedge, bulrush and reed. The water areas are predominantly covered by the green leaves of nenuphar and lotus.

With regard to the mentioned indicators, it can be stated that the majority of the cover is represented by surfaces displaying a combined type of land cover, primarily water surfaces covered by communities of nenuphar, lotus and cane (around 34.7%), followed by surfaces covered with cane, sedge, bulrush, reed (around 13%) (Fig. 3). It is particularly important to emphasise that free water bodies make for a significant part of the land cover (around 350 ha or 18.1%), which is important in terms of survival of the entire natural-aquatic complex of Lake Derane.

The least represented land cover is that of flooded meadows, which extend over some 67 ha. Nevertheless, they are of great importance to the survival of the entire plant and animal life of the Deransko wetlands. In fact, further degradation and draining, as well as surface decrease of this land cover type in the Deransko wetlands is unacceptable, as it would additionally compromise and endanger the existing ecosystem.

One particular aspect in the interpretation of the mentioned land cover types is their water mass volume potential, especially in spring and summer, when water is of vital importance for eco-biological processes.

Tab. 2: Basic bathymetric indicators for Lake Derane.
Tab. 2: Temeljni batimetrični indikatorji za Deransko jezero.

D (cm)	O (m)	P (m²)	P (%)	D (cm)	O (m)	P (m²)	P (%)
up to 50	18224.98	199777.04	9.81	170-180	3836.41	6343.70	0.31
50-60	17651.47	119042.41	5.85	180-190	3326.24	4247.58	0.21
60-70	16866.30	154622.07	7.60	190-200	3123.72	4545.35	0.22
70-80	15647.65	151291.49	7.43	200-210	3097.56	4611.96	0.23
80-90	16430.55	166879.87	8.20	210-220	3080.00	3980.75	0.20
90-100	14843.44	229154.42	11.26	220-230	2953.49	4828.77	0.24
100-110	13049.04	185997.00	9.14	230-240	2365.12	5144.76	0.25
110-120	10966.49	189005.54	9.28	240-250	1638.59	2270.44	0.11
120-130	9505.70	174254.90	8.56	250-260	1314.40	1143.41	0.06
130-140	8370.86	171570.56	8.43	260-270	1010.55	913.04	0.04
140-150	7481.83	124730.53	6.13	270-280	766.97	353.50	0.02
150-160	6225.21	106644.49	5.24	280-290	751.50	376.35	0.02
160-170	4776.58	23495.33	1.15	290-300	371.21	411.64	0.02
					Total:	**39171.25**	**100.00**

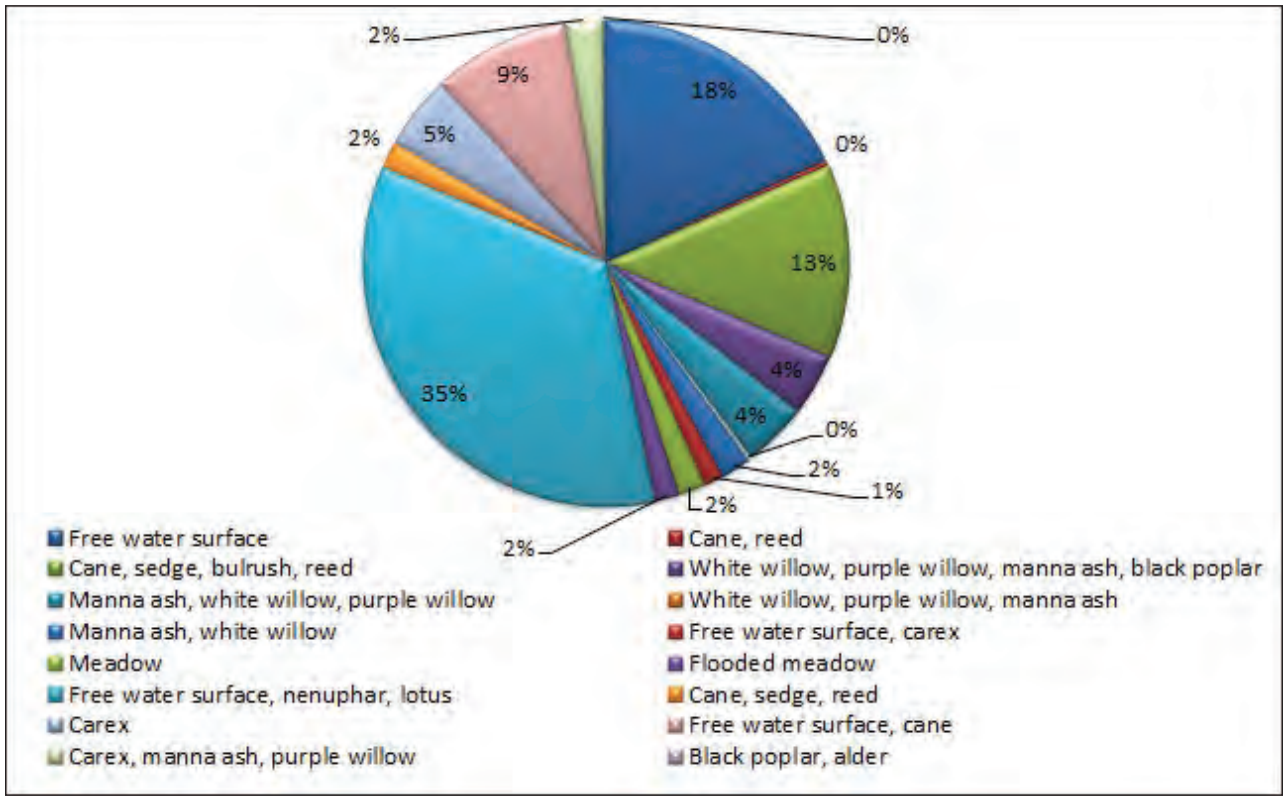

Fig. 3: Land cover of the Deransko wetlands by defined categories.
Sl. 3: Pokrovnost Deranskega mokrišča na podlagi določenih kategorij.

Bathymetric Plan of Derane Lake

The measurement have shown that with respect to the neighbouring marsh vegetation, the Lake Derane basin ends at the 50 cm isobath, with the average depth values in other flooded zones of the Deransko wetlands covered by different types of marsh vegetation varying between 50 and 0 cm (Fig. 4). The surface area of Lake Derane within the mentioned border isobath is 203.56 ha. Other basic bathymetric data concerning Lake Derane (depth of isobath (D), length of bathymetric line (O) and isobath percentage share in the total lake area) are given in Table 2.

It can be concluded from these data that the representation of isobath surfaces is significantly uneven, particularly in the eastern part of the lake, in the area around the Ričina River delta (Fig. 4). The lowest depths are registered in the zone of the lake isle (Krupa River) where, due to the low transportation power of the bottom and lateral lake currents, the most part of the pulled and suspended detritus is being deposited. A few smaller sandbanks (of several tens of m^2) have already formed here, inhabited by typical marsh vegetation – cane and reed, and in some places purple willow.

Similarly, a dozen of smaller sandbanks have formed across the northern borderline of the lake water body, also overgrown with cane and reed. From the mentioned zone towards the central part of the lake basin, the depth values gradually increase, reaching their maximum in the centre. The zones of greater depths (170 to 180 cm) are quite extensive, accounting for around 30% of the total lake basin area. The deepest areas are found in several smaller depressions and across the central part of the lake bed (in karst sinkholes). Further to the north, east, and south of the lake basin, towards the marsh vegetation margin the depth values gradually decrease to around 60 to 70 cm. The easternmost parts of the lake basin, at the crossover towards the Ričina River, are delimited by a 100 cm isobath running along a 50 m wide sand bank. Further away, closer to the area of the Ričina River delta, the depths suddenly increase to 300 cm, reaching the maximum value in the entire Lake Derane basin, as a result of increased erosion in the area of the mouth of the Ričine channel.

According to the depth relations defining the bathymetric chart of Lake Derane, it is possible to determine the water mass capacity of the lake's basin (Tab. 3). In the period of bathymetric measurements, the entire area of the Deransko wetlands registered an increased water inflow which was, in respect of the extent of flooded meadows and vegetation, still within the framework of optimal hydro-ecological conditions; the mean water level, measured at the Boljun-Kuk gauging station (May

Fig. 4: Bathymetric chart of Lake Derane (Map background: Google Earth Imagery, Google 2010).
Sl. 4: Batimetrija Deranskega jezera (ozadje zemljevida: Google Earth Imagery, Google 2010).

2, 2014), was 105 cm and in the range of the seasonal mean water level for Lake Derane.

According to the data calculated, the total capacity of Lake Derane, delimited by a 50 cm isobath at the mentioned water level, is 1,244,595 m^3 or approximately 0.0125 km^3. Isobaths with the greatest surfaces and largest capacity are areas of up to 100 cm of depth. More precisely, the largest amount of water is contained within the first isobath layer at 10 cm of depth (delimited by isobaths of a relative depth between 50 and 60 cm), which holds around 0.002 km^3 of water, followed by the second isobath layer (delimited by isobaths of a relative depth between 40 and 50 cm) with 0.0018 km^3 of water, and so on. Based on this, it can be concluded that the capacities of the lake basin are the lowest at the latter's greatest depths: the 25th isobath layer only holds around 15 m^3, the 24th around 60 m^3, and so on.

It can also be concluded that the zone of the Ričina River delta is also an area of increased capacity, where the values of the entire wet profile reach around 0.0015 km^3.

In addition to the mentioned bathymetric indicators, it is possible to determine other important bathymetric data for a lake water body, which enable a more detailed insight into its hydrological characteristics. Additional results of numerical analyses thus concern the following morphometric characteristics:

- Lake surface area (**F**) 203.56 ha
- Lake length (**L**) 1.97 km
- Lake mean width (**B**) 1.03 km
- Lake maximum width (**Bmax**) 1.515 km
- Bank length (**l**) 18.3 km
- Bank indentedness (**K**) 1.7
- Lake mean depth (**H**) 0.6 m
- Average lakebed gradient (α) 9^o-10^o

CONCLUSIONS

Based on a detailed analysis of the presented bathymetric indicators it can be concluded that Lake Derane is a small basin with polygenic traits originating from

Tab. 3: Volume (V) relations in Lake Derane (in m³).
Tab. 3: Prostorninski odnosi v Deranskem jezeru (v m³).

D (cm)	P (m²)	V (m³)
up to 50	2035636.90	193574.838
50-60	1835859.87	177633.866
60-70	1716817.46	163950.642
70-80	1562195.39	148654.964
80-90	1410903.90	132746.397
90-100	1244024.03	112944.682
100-110	1014869.61	92187.111
110-120	828872.61	73436.984
120-130	639867.07	55273.962
130-140	465612.16	37982.688
140-150	294041.61	23167.634
150-160	169311.07	11598.883
160-170	62666.58	5091.892
170-180	39171.25	3599.940
180-190	32827.55	3070.376
190-200	28579.97	2630.730
200-210	24034.62	2172.864
210-220	19422.66	1743.228
220-230	15441.91	1302.752
230-240	10613.13	804.075
240-250	5468.37	433.315
250-260	3197.93	262.623
260-270	2054.53	159.800
270-280	1141.48	96.473
280-290	787.98	59.981
290-300	411.64	13.721
Total:		**1244594.422**

tectonic activity and karst corrosion. This conclusion is corroborated by the shape of the lake basin – a deep plate – which represents the latter's primary morphological characteristic. The central part of the Lake Derane basin has the greatest area capacity and holds the largest amount of water.

In order to define an environmentally sound discharge, field research was carried out in the area of the greatest depth of water accumulation – Lake Derane. GIS software was employed to draft a model bathymetric chart of 10 cm isobaths. The bathymetric chart of the lake was produced according to the average water level during spring season, when the water levels are optimal for the development of a vibrant life in the Deransko wetlands. The mean water level is related to the measured water level at the Boljun-Kuk water gauge strip, located in the southern lakeshore area. Additional modelling at the level of individual 10-centimetre isobaths enabled the calculation of the volumetric capacity of Lake Derane and the correlated adequate water levels.

By applying these results to the measured water levels at the Boljun-Kuk hydrological station it would be possible to determine the amount of water in Lake Derane required during the growing season to allow for an optimal development of wildlife in the Deransko marshes.

BATIMETRIJA DERANSKEGA JEZERA KOT TEMELJ ZA DOLOČANJE HIDRO-EKOLOŠKEGA OPTIMUMA DERANSKEGA MOKRIŠČA

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POVZETEK

Deransko jezero je največje vodno telo na območju Deranskega mokrišča. Ker je hidrološki režim celotnega območja Deranskega mokrišča odvisen od nihanj vodnega telesa, je bilo potrebno določiti prostorninsko kapaciteto kot temelj za določevanje hidro-ekoloških optimumov v obdobju najintenzivnejših bioloških aktivnosti. Priprava batimetrije Deranskega jezera in povezanih prostih vodnih površin je bila opravljena z batimeričnimi meritvami jezera na predhodno določeni točkovni poti. Geografske koordinate za posamezne batimetrične točke so bile določene predhodno, medtem ko so bile batimetrične meritve opravljene na terenu. Le-te so bile opravljene v maju 2014, v času hidro-ekološkega optimuma, zato dobljeni rezultati kažejo dejanski hidrološki režim. Batimetrija Deranskega jezera je bila narejena z metodo interpolacije.

Ključne besede: Deransko jezero, Deransko mokrišče, nihanja vodne gladine, batimetrične meritve, interpolacija.

REFERENCES

Drešković, N. & R. Mirić (2016): Horizontal air temperature changes as a basis for the regional climate differentiation of Bosnia and Herzegovina. Geographical Review, 37, 51-64.

Drešković, N. & R. Mirić (2014): Climatic regionalization of Bosnia and Herzegovina. Book of papers Third congress of geographers of Bosnia and Herzegovina, Sarajevo, 280.

Hrelja, H. (2007): Inžinjerska hidrologija. Građevinski fakultet, Sarajevo.

Mihailović, D., G. Mimić, N. Drešković & I. Arsenić (2015): Kolmogorov Complexity Based Information Measures Appliedto the Analysis of Different River Flow Regimes. Entropy 2015, 17, 2973-2987.

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OCCURRENCE OF *PARABRACHIELLA INSIDIOSA* (HELLER, 1865) AND *PARABRACHIELLA MERLUCCII* (BASSETT-SMITH, 1896) (COPEPODA; LERNAEOPODIDAE) IN EUROPEAN HAKE IN TURKEY

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ABSTRACT

In this study, Parabrachiella insidiosa *(Heller, 1865) and* Parabrachiella merluccii *(Bassett-Smith, 1896) (Copepoda; Lernaeopodidae) found on gill rakers of European hake,* Merluccius merluccius *(Linnaeus, 1758) (Pisces; Merlucciidae), are reported for the first time from the area of Turkey. Also, some morphological characters of these parasitic copepods are given using photographs and drawings.*

Key words: *Parabrachiella*, european hake, Turkey, parasitic, copepod

SEGNALAZIONE DI *PARABRACHIELLA INSIDIOSA* (HELLER, 1865) E *PARABRACHIELLA MERLUCCII* (BASSETT-SMITH, 1896) (COPEPODA; LERNAEOPODIDAE) NEL MERLUZZO IN TURCHIA

SINTESI

Nello studio viene riportata per la prima volta la presenza di Parabrachiella insidiosa *(Heller, 1865)* e Parabrachiella merluccii *(Bassett-Smith, 1896) (Copepoda; Lernaeopodidae) sulle branchiospine del merluzzo europeo* Merluccius merluccius *(Linnaeus, 1758) (Pisces; Merlucciidae) in Turchia. Gli autori riportano inoltre alcuni caratteri morfologici di questi copepodi parassiti, con l'ausilio di fotografie e disegni.*

Parole chiave: *Parabrachiella*, merluzzo, Turchia, parassiti, copepodi

INTRODUCTION

The European hake (*Merluccius merluccius*) occurs in the Atlantic coasts of Europe and western North Africa; northward up to Norway and Iceland, southward down to Mauritania. It is also found in the Mediterranean Sea and along the southern coast of the Black Sea. The European hake is an economically important species. It is one of the principal target species of trawl fishery in the Mediterranean. *M. merluccius* is an important component of the shelf and upper part of the continental slope fish assemblage in the western Mediterranean Sea (Biagi *et al*., 2002; Busalacchi *et al*., 2010). It is usually found between 70 m and 370 m of depth, but may also occur within a wider depth range, from inshore waters (30 m) to 1000 m (Cohen *et al*., 1990).

Although *P. insidiosa* and *P. merlucci* have been recorded from various localities throughout the world (Thompson & Scott, 1903; Scott & Scott, 1913; Barnard, 1955; Capart, 1959; Kabata, 1963; Kabata, 1979; Kabata, 1992; Kabata & Ho, 1981; Kabata, *1986;* Radujkovic & Raibaut, 1989; Raibaut *et al*., 1998; Benkirane *et al*., 1999; Boualleg *et al*., 2010), there have been no records on these parasitic copepods from Turkey before.

This paper presents the first records of *P. insidiosa* and *P. merluccii* in Turkey.

MATERIAL AND METHODS

One hundred and fifty specimens of *Merluccius merluccius* (Linnaeus, 1758) (Pisces; Merlucciidae) were collected by local gears from Turkey's North Aegean Sea and Bandırma Bay in 2014. The collected parasites were fixed in 70% ethanol. Some of the specimens were cleared in lactic acid before the dissection of their appendages. The photos were taken with a Canon EOS 1100D camera connected to a microscope. Measurements were taken in millimetres (mm), with a micrometric programme (Pro-way). The parasites' scientific names, synonyms and hosts were checked with WoRMS (Eds) (2016), Froese & Pauly (2016). Kabata (1979) was consulted for terminology. *P. insidiosa* (MNHN-IU-2013-18738) and *P. merluccii* **(**MNHN-IU-2013-18737) were deposited in the collections of the Museum National d'Histoire Naturelle (MNHN), Paris, France.

RESULTS

Parabrachiella insidiosa (Heller, 1865) (Copepoda; Siphonostomatoida; Lernaeopodidae)

All parasites were firmly attached to the gill rakers. The prevalence and mean intensity of parasite were 9.33% and 1.35, respectively. The total number of parasites was 19. The body length of *P. insidiosa* varies from 8 to 12 mm (Fig.1). Trunk longer than broader, with 2 pairs of posterior processes. Cephalothorax and second

Fig. 1: *Parabrachiella insidiosa,* ♀ ***(scale bar 2 mm).***
Sl. 1: . *Parabrachiella insidiosa,* ♀ ***(merilo 2 mm).***

maxilla shorter than the trunk. Maxilliped (Fig. 2e) with a robust corpus, myxa bearing single seta. Subchela short, slender with a big spine near mid-length, a spine next to claw base and spinulation on distal part of inner margin, claw well-delimited, with slender tip and pair of teeth near mid-length. Mandible (Fig. 2a) with dental formula P1, S1, P1, S1, P1, S1, B5.

First maxilla exopod (Fig. 2b) from ventral to lateral armed with two subapical setae; endopod with two digitiform papillae, each bearing apical long and short seta. First antenna (Fig. 2c) indistinctly four-segmented, division between first and second segments not always discernible; distal armature with 1 tubercle and 5 visible elements. Second antenna endopod clearly two-segmented (Fig. 2d), distal segment with three spines, two of equal size, the third longer and broader. Exopod larger than endopod. Second maxillae with tips expanded with indistinct 5 lobate processes (more or less separate) (Fig. 2f).

Parabrachiella merluccii (Basset-Smith, 1896) (Copepoda; Siphonostomatoida; Lernaeopodidae)

All parasites were firmly attached to the gill rakers. The prevalence and mean intensity of parasite were

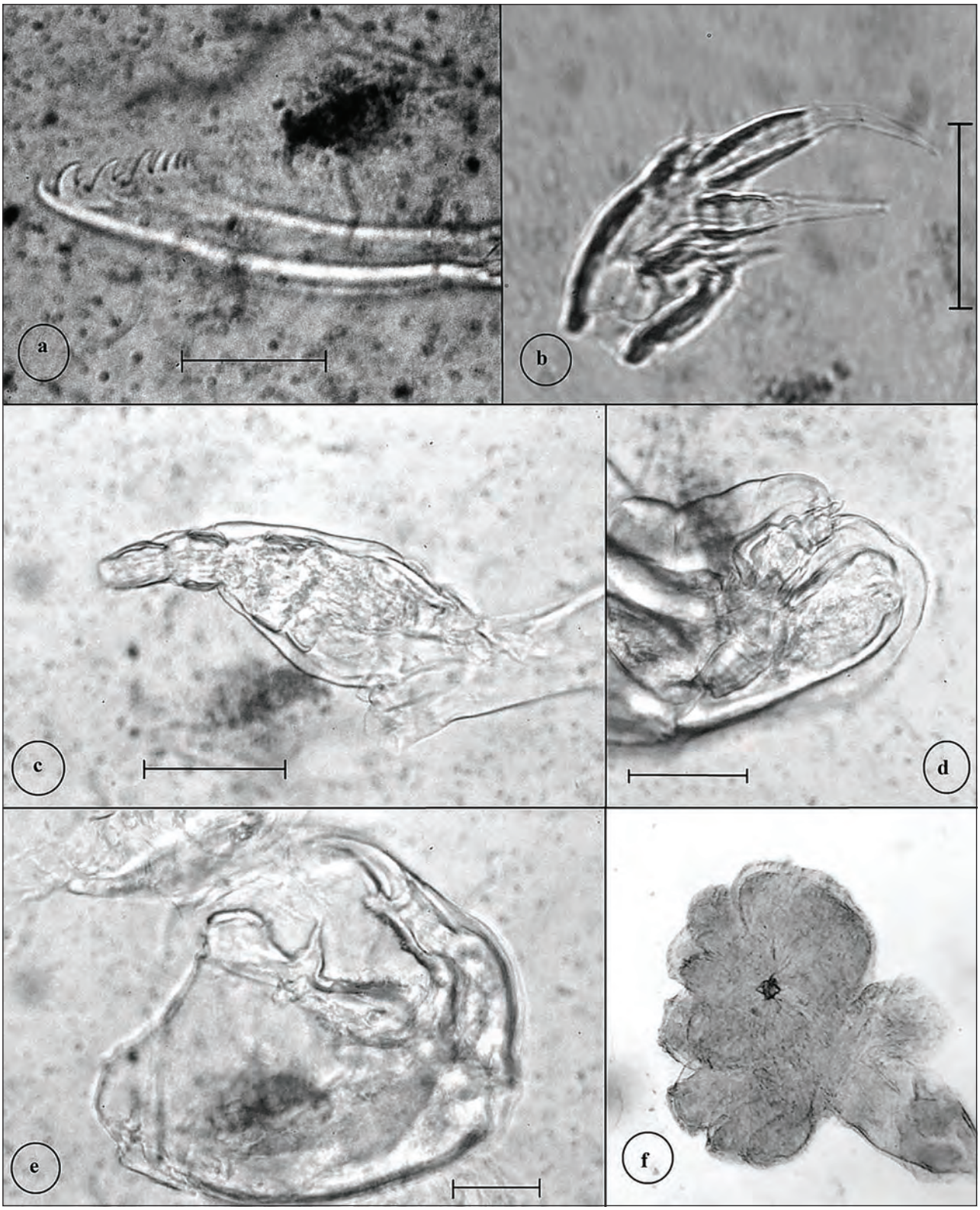

Fig. 2: *Parabrachiella insidiosa (♀):* ***(a) Mandible (0.02 mm); (b) first maxilla (0.02 mm); (c) first antenna (0.05 mm); (d) second antenna (0.04 mm); (e) maxilliped (0.035 mm); (f) bulla****.*
Sl. 2: *Parabrachiella insidiosa (♀):* ***a) spodnja čeljustnica (0,02 mm); (b) prva zgornja čeljustnica (0,02 mm); (c) prva antena (0,05 mm); (d) druga antena (0,04 mm); (e) čeljustna nožica (0,035 mm); (f) bulla.***

Fig. 3: *Parabrachiella merluccii* ♀ ***(scale bar 2 mm).***
Sl. 3: *Parabrachiella merluccii* ♀ ***(merilo 2 mm).***

6.6% and 1, respectively. The total number of parasites was 10.

The body length of *P. merluccii* varies from 4 to 7 mm (Fig. 3). Trunk with 2 pairs of posterior processes. Maxilliped (Fig. 4e, f) with a robust corpus, traces of subdivision near basal end. Myxa with fine small spines and a short seta, barb stout half as long as the claw; near mid-length of inner margin with a secondary tooth, with a pair of teeth on claw some distance above inner margin. Mandible (Fig. 4a) with dental formula P1, S1, P1, S1, P1, S1, B5.

First maxilla (Fig. 4b) long, slender with endopod slightly displaced from ventral to lateral surface, long cylindrical distally with two subequal setae and a short seta, exopod short, narrow with two short setae. First antenna (Fig. 4c) four-segmented with slightly inflated basal part and prominent whip at distal end of second segment, border between first and second indistinct, distal segment with well-developed apical armature comprising one tubercle and 5 setae. Second antenna biramous (Fig. 4d). Exopod more prominent and longer than endopod. Exopod bulbous, covered with robust, conical spinules on rounded tip. Endopod two-segmented, armed apically with a longer and broader seta and two short setae. Spinulation on the anterior-medial side of endopod. Second maxillae with undivided bulla (Fig. 4g).

DISCUSSION

Raibaut *et al.* (1998) reviewed the occurrence of 226 parasitic copepod species distributed over 88 genera and 20 families of fishes of the Mediterranean Sea. The seven parasitic copepods related to the European hake were listed as *Chondracanthus merluccii, Clavella adunca, C. stellata, Lernaeocera lusci*, *Thysanote impudica*, *P. insidiosa* and *P. merluccii* (Kabata, 1992; Tirard *et al.*, 1996; Raibaut *et al.*, 1998; Gaglio *et al.*, 2011).

P. insidiosa is a highly polymorphic species, specific to the genus *Merluccius*. It is reported from the Mediterranean, the North Atlantic Ocean and the Pacific Ocean. *P. insidiosa* has been reported mainly on the Merluccius genus, such as *Merluccius merluccius* (Radujkovic & Raibaut, 1989; Benmansour & Ben Hassine, 1997; Boualleg *et al.*, 2010), *M. australis* (MacKenzie & Longshaw, 1995), *M. gayi peruanus* (Chero *et al.*, 2014), *M. hubbsi* (Etchegoin & Sardella, 1990), *M. capensis* (Krzeptowski, 1980); *M. paradoxus* (Botha, 1986); *M. bilinearis*, *M. productus* (Kabata & Ho, 1981), *M. gayi gayi* (George-Nascimento, 1996), and less frequently on other fish families, including *Chelidonichthys lucerna*, *Trigla lyra* (Raibaut *et al.*, 1998) *and Dicentrarchus labrax* (Brian, 1906). Its morphological variability has caused several scientists to propose new taxa for the parasite of the South African and Argentinian hake species (*M. capensis, M. gayi*). Kabata & Ho (1981) proposed to set the morphology of the posterior extremity as one of the criteria of distinction between the various forms of *P. insidiosa,* the other two being host affiliation and geographical distribution.

P. insidiosa f. insidiosa on *M. merluccius* and other species of this genus from the European and African-Atlantic waters bear well-developed posterior processes, while *P. insidiosa f. lageniformis* (on *M. gayi* from the Atlantic coast of South America) and *P. insidiosa f. pacifica* (on *M. hubbsi* and *M. productus* from the Pacific coasts of South and North America, respectively) are devoid of posterior processes according to the Kabata & Ho (1981) trinominal nomenclature.

The present species were compared with drawings by Kabata (1979) and no major difference was observed. The shape of the trunk was longer than wider, and the morphological features of all the dissected specimens, including structure, size of maxillule exopod and endopod, number of teeth and dental formula of mandible, maxilliped spinulation and location of claw and teeth, size of antenna exopod and endopod, number of segment and seta on antennule, permitted the identification of this copepod as *P. insidiosa*. The second maxillae with 5 lobate processes in our samples are the same as in findings by Kabata (1979) and Barnard (1955).

When the 12 host fish species of the *P. insidiosa* parasite were examined according to family characteristics,

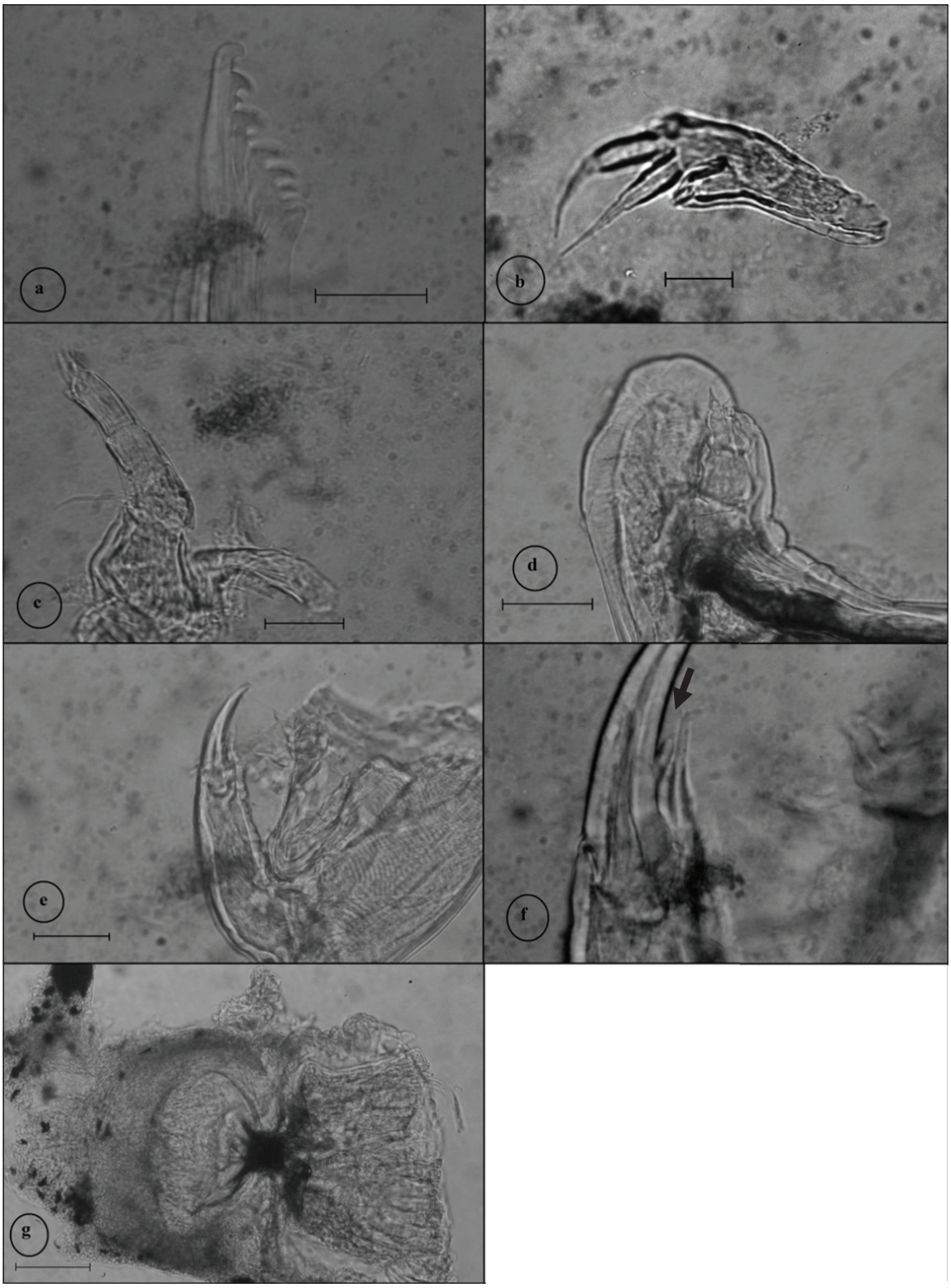

Fig. 4: *Parabrachiella merluccii (♀):* ***(a) Mandible (0.02 mm); (b) first maxilla (0.04 mm); (c) first antenna (0.04 mm); (d) second antenna (0.05 mm); (e) maxilliped (0.035 mm); (f) distal part of maxilliped; (g) bulla (0.8 mm)****.*
Sl. 4: *Parabrachiella merluccii (♀):* ***a) spodnja čeljustnica (0,02 mm); (b) prva zgornja čeljustnica (0,04 mm); (c) prva antena (0,04 mm); (d) druga antena (0,05 mm); (e) čeljustna nožica (0,035 mm); (f) distalni del čeljustne nožice; (g) bulla (0,8 mm)****.*

75% were found to belong to the Merlucciidae, 17% to the Triglidae, 8% to the Moronidae; in terms of habitat 42% of the fish were bathydemersal, 33% demersal, 17% benthopelagic and 8% pelagic-oceanic; as to their feeding habits, all the 12 fish species were denoted in literature as carnivores.

P. merluccii has been reported from the Mediterranean and the North Atlantic Ocean and only on the Merluccius genus, such as *M. merluccius* (Brian, 1906; Scott & Scott, 1913; Delamare Deboutteville, 1950; Papoutsoglou, 1976; Radujkovic & Raibaut, 1989; Benmansour & Ben Hassine, 1998; Benkirane *et al*., 1999; Boualleg *et al*., 2010), *M. polli*, *M. paradoxus* (Nunes-Ruivo, 1956; Capart, 1959), *M. capensis* (Grabda & Soliman, 1975). Kabata (1979) found the Thompson & Scott (1903) record on *Sciaena diacanthus* from the Indian Ocean strange. The morphological characters in the present species are similar to those of Kabata (1963; 1979). For example, the secondary tooth found at near mid-length inner margin of claw, as indicated by the arrow in figure 4f, resembles Kabata's records.

When the 4 host fish species of the *P. merluccii* parasite were examined according to family characteristics, all of them were denoted in literature as belonging to the Merlucciidae family; in terms of habitat, 75% were defined in literature as bathydemersal and 25% as demersal; and according to their feeding habits, all 4 host species were carnivores.

Ten species of the family Lernaeopodidae are reported from marine habitats in Turkey, namely, *Clavellotis fallax*, *C. strumosa*, *C. briani, Clavellisa scombri*, *Clavella alata*, *Lernaeopoda galei*, *T. impudica*, *Parabrachiella bispinosa*, *P. exigua, P. hostilis*. They are reported for the first time from Turkey in this study.

POJAVLJANJE VRST *PARABRACHIELLA INSIDIOSA* (HELLER, 1865) IN *PARABRACHIELLA MERLUCCII* (BASSETT-SMITH, 1896) (COPEPODA; LERNAEOPODIDAE) NA OSLIČIH V TURČIJI

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POVZETEK

Avtorji poročajo o prvem zapisu o dveh vrstah zajedalskih ceponožcev in sicer o Parabrachiella insidiosa *(Heller, 1865) in* Parabrachiella merluccii *(Bassett-Smith, 1896) (Copepoda; Lernaeopodidae), ki so jih našli na škrgah osličev* Merluccius merluccius *(Linnaeus, 1758) (Pisces; Merlucciidae) v Turčiji. Podajajo tudi nekatere morfološke značilnosti teh zajedalskih ceponožcev skupaj z ilustracijami in fotografijami.*

Ključne besede: *Parabrachiella*, oslič, Turčija, zajedalci, raki ceponožci

REFERENCES

Barnard, K.H. (1955): South African parasitic copepoda. Annls. S. Afr. Mus., 41, 223-312.

Benkirane, O. F., F. Coste & A. Raibaut (1999): On the morphological variability of the attachment organ of Lernaeopodidae (Copepoda: Siphonostomatoida). Folia Parasitol., 46, 67-75.

Benmansour, B. & O. K. Ben Hassine (1997): Premiere Mention en Tunisie de Certains Caligidae et Lernaeopodidae (Copepoda) parasites de poissons teleosteens. Ichthyophysiol. Acta, 20, 157-175.

Benmansour, B. & O. K. Ben Hassine (1998): Preliminary analysis of parasitic copepod species richness among coastal fishes of Tunisia. Ital. J. Zool., 65, 341-344.

Biagi, F., P. Sartor, G. Ardizzone, P. Belcari, A. Belluscio & F. Serena (2002): Analysis of demersal assemblages off the Tuscany and Latium coasts (north-western Mediterranean). Sci. Mar., 66, 233-242.

Botha, L. (1986): Major endoparasites of the Cape hakes *Merluccius capensis* and *M. paradoxus*, with brief notes on some conspicuous ectoparasites. S. Afr. J. Marine. Sci., 4, 45-49.

Boualleg, C., M. Seridi, N. Kaquachi, Y. Quiliquini & M. Bensouillah (2010): Les Copépodes parasites des poissons téléostéens du littoral Est-algérien. Bull. Inst. Sci, Rabat, Sci. Vie, 32, 65-72.

Brian, A. (1906): Copepodi parassiti dei Pesci d'Italia. Stab. Tipo-Litografico R. Istituto Sordomuti, Genova, 187 pp.

Busalacchi, B., P. Rinelli, F. De Domenico, A. Profeta, F. Perdichizzi & T. Bottari (2010): Analysis of demersal fish assemblages off the Southern Tyrrhenian Sea (central Mediterranean). Hydrobiologia, 654, 111-124.

Capart, A. (1959): Copépodes parasites. Résult scient. Expéd. océanogr. Belge Eaux côt. Africaines Atlantique Sud. (1948-1949), 3, 55-126.

Chero, J., C. Cruces, J. Iannacone, G. Sáez, L. Alvariño, C. Rodríguez, H. Rodríguez, E. Tuesta, A. Pacheco & N. Huamani (2014): Parasitological indices of the Peruvian Hake *Merluccius gayi peruanus* Ginsburg, 1954 (Perciformes: Merlucciidae) acquired at the fishing terminal of Ventanilla, Callao, Peru. Neotrop. Helminthol., 8, 141-162.

Cohen, D. M., T. Inada, T. Iwamoto & N. Scialabba (1990): Gadiform fishes of the world (Order Gadiformes). An annotated and illustrated Catalogue of Cods, Hakes, Grenadiers and other Gadiform fishes Known to Date. FAO Species catalogue.vol. 10., Synopsis 125, 10-442.

Delamare-Deboutteville, C. (1950): Copepodes parasites des poissons de Banyuls. Vie Milieu, 1, 305-309.

Etchegoin, J. A. & N. H. Sardella (1990): Some ecological aspects of the copepod parasites of the common hake, *Merluccius hubbsi*, from the Argentine-Uruguayan Common fishing zone. Int. J. Parasitol., 20, 1009-1014.

Froese, R. & D. Pauly (2016): FishBase. Available on line at: www.fishbase.org, (Last accessed 11 December 2016).

Gaglio, G, T. Bottari, P., Rinelli, F. Marino, D. Macri & S. Gianetto (2011): Prevalence of *Clavella stellata* (Copepoda: Lernaeopodidae) (Kroyer 1838) in the European hake (*Merluccius merluccius*) (L. 1758), South Tyrrhenian Sea (Central Mediterranean). J. Appl. Ichthyol., 27, 136-138.

George-Nascimento, M. (1996): Populations and assemblages of parasites in hake, *Merluccius gayi*, from the southeastern Pacific Ocean: stock implications. J. Fish Biol., 48, 557-568.

Grabda, J. & I. A. F. M. Soliman (1975): Copepods-Parasites of the Genus *Merluccius* from the Atlantic Ocean and Mediterranean Sea. Acta Ichthyol. Piscat., 5, 31-39.

Kabata, Z. (1963): The Second Antenna in the Taxonomy of Clavellinae (Copepoda, Lernaeopodidae). Crustaceana, 6, 5-14.

Kabata, Z. (1979): Parasitic Copepoda of British Fishes. Ray Society Publications, The Bristish Museum, London, 152, 468 pp.

Kabata, Z. (1986): Redescriptions of and comments on four little-known Lernaeopodidae (Crustacea: Copepoda). Can. J. Zool., 64, 1852-1859.

Kabata, Z. (1992): Copepods parasitic on fishes. Synopses of the British Fauna (Edited by Doris M.Kermack, Barnes, R.S.K., Crothers, J.H.) The Linnean Society of London and the Estuarine and Coastal Sciences Association. Universal Book Services/Dr.W. Backhuys, The Netherlands, 264 pp.

Kabata, Z. & J. S. Ho (1981): The origin and dispersal of hake (genus *Merluccius*: Pisces: Teleostei) as indicated by its copepod parasites. Oceanogr. Mar. Biol. Annu. Rev., 19, 381-404.

Krzeptowski, M. (1980): Occurrence of larval nematode *Anisakis simplex*, larval cestode *Hepatoxylon trichiuri*, and parasitic copepod *Parabrachiella australis* in juvenile *Merluccius capensis* off Namibia. Acta Ichthyol. Piscat., 10, 35-44.

MacKenzie, K. & M. Longshaw (1995): Parasites of the hakes *Merluccius australis* and *M. hubbsi* in the waters around the Falkland Islands, southern Chile, and Argentina, with an assessment of their potential value as biological tags. Can. J. Fish. Aquat. Sci., 52 (1), 213-224.

Nunes-Ruivo, L. (1956): Copepodes parasitas de peixes dos mares de Angola. Anais Junta Invest. Ultramar, 9 (2), 9-45.

Papoutsoglou, S. E. (1976): Metazoan parasites of fishes from Saronicos Gulf, Athens, Greece. Thalassographica, 1(1), 69-91.

Radujkovic, B. & A. Raibaut (1989): Parasites des poissons marins des côtes du Monténégro: Copépodes. Acta Adriat., 28, 237-278.

Raibaut, A., C. Combes & F. Benoit (1998): Analysis of the parasitic copepod species richness among Mediterranean fish. J. Marine Syst., 15, 185-206.

Scott, T. & A. Scott (1913): The British parasitic Copepoda. Ray Society, London, Volumes I and II: 257 pp.

Thompson, I. C. & A. Scott (1903): Report on the Copepoda collected by Professor Herdman, at Ceylon, in 1902. In: Herdman, W.A. (*ed.*). Report to the Government of Ceylon on the Pearl Oyster Fisheries of the Gulf of Manaar, 1, 227-307.

Tirard, C., F. Thomas, A. Raibaut & F. Renaud (1996): The distribution and abundance of Lernaeocera lusci (Copepoda) on hake (*Merluccius merluccius*) and bib (*Trisopterus luscus*) (Teleostei). Int. J. Parasitol., 26, 1387-1392.

WoRMS (Eds) (2016): World Register of Marine Species. Available on line at: http://www.marinespecies.org (Last accessed 11 December 2016).

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PROTEINS, FATTY ACIDS AND NUTRITIONAL VALUE IN THE MUSCLE OF NINE MARINE SPECIES COMMONLY CONSUMED IN TUNISIA (CENTRAL MEDITERRANEAN)

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ABSTRACT

*Protein and fatty acid contents have been determined in nine marine species (*Sepia officinalis, Eledone cirrhosa, E. moschata, Loligo vulgaris, Trachurus trachurus, Scomber scombrus, Sardina pilchardus, Engraulis encrasicolus *and* Parapenaeus longirostris*) commonly consumed in Tunisia. Protein contents ranged from 15.8 % to 20.1 % and the total fatty acids varied between 2.2 % and 9.9 %. The values of the PUFA/SFA ratio were greater than 0.45 except for* S. pilchardus *which has a value of 0.36. The lower value of the ratio of n-3/n-6 was observed in* P. longirostris *(1.7) while the highest (11.7) has been related to L. vulgaris. Most of the species studied had revealed a high content in EPA+DHA, 500 mg / 100 g of muscle, which represent a high nutritional value for the human consumption.*

Keywords: proteins, total fatty acids, EPA+DHA, seafood products

PROTEINE, ACIDI GRASSI E VALORE NUTRIZIONALE NEL MUSCOLO DI NOVE SPECIE MARINE COMUNEMENTE CONSUMATE IN TUNISIA (MEDITERRANEO CENTRALE)

SINTESI

I contenuti di proteine e acidi grassi sono stati determinati in nove specie marine (Sepia officinalis, Eledone cirrhosa, E. moschata, Loligo vulgaris, Trachurus Trachurus, Scomber scombrus, Sardina pilchardus, Engraulis encrasicolus e Parapenaeus longirostris) *comunemente consumate in Tunisia. I contenuti proteici oscillavano tra il 15,8 % e il 20,1 %, mentre quelli degli acidi grassi totali tra il 2,2 % e il 9,9 %. I valori del rapporto PUFA/SFA erano superiori allo 0,45, eccetto che per* S. pilchardus, *con un valore di 0,36. Il valore più basso del rapporto n-3/n-6 è stato osservato in* P. longirostris *(1,7), mentre il più alto (11,7) è stato correlato a* L. vulgaris. *La maggior parte delle specie studiate ha rivelato un alto contenuto di EPA+DHA, 500 mg / 100 g di muscolo, che rappresentano un elevato valore nutrizionale per il consumo umano.*

Parole chiave: proteine, acidi grassi totali, EPA+DHA, prodotti ittici

INTRODUCTION

The nutritional qualities of seafood products such as fish, crustacean and cephalopods are resulting from the richness of their flesh in protein and fatty acids. Although the fish and meat (sheep, cattle, poultry, etc.) have equivalent levels of protein, the content of essential amino-acids of the fish is generally higher than that of the meat (Piclet, 1987; Médale *et al.*, 2003).

Especially fish, both marine and freshwater have beneficial effects on human health because of their lipid contents that are rich in fatty acids of n-3 (Steffens, 1997; Flaten *et al.*, 1997). As such, the fatty acids of marine seafood products are used in the prevention and treatment of arteriosclerosis, thrombosis and hyperglycemia and in the regulation of blood pressure (Barnerjee *et al.*, 1992; Brouwer *et al.*, 2006). To maintain a human health, (Sargent, 1997) recommends to increase the consumption of fish and its products, which are rich in n-3 PUFA and poor in n-6 PUFA series.

The lipid contents and fatty acid profile of the fish are affected by various factors such as temperature, salinity, season, size, age, habitat of the species, the type and abundance food (Ackman, 1989). Research on the n-3 PUFAs have generally focused on eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) obtained by endogenous synthesis from alpha-linolenic acid (ALA), by elongation and desaturation (Garcia-Alonso *et al.*, 2012). It is estimated that 5-10% of ALA intake can be converted to EPA and a rate of 2-5% can be further converted to DHA in healthy adults (Calder & Yaqoob, 2009). EPA is the most important essential fatty acid of n-3 series in the human diet because it is the precursor to the n-3 series eicosanoids (Chen *et al.*, 1995). Therefore, and from a nutritional point of view, it is acclaimed to determine the fat concentration and the relative proportions of various fatty acids in species usually consumed (Soriguer *et al.*, 1997). To fulfill the growing demand for marine seafood products and medical point of view, this study is carried out to analyze the biochemical composition; protein, fat and fatty acids of nine popular species; *Sepia officinalis, Eledone cirrhosa, Eledone moschata, loligo vulgaris,* horse mackerel (*Trachurus trachurus*), *Scomber scombrus, Sardina pilchardus, Engraulis encrasicolus* and pink shrimp (*Parapenaeus longirostris*) commonly consumed in Tunisia. The objective of this study is to provide consumers with information on the potential benefits that they can expect to find in these products.

MATERIALS AND METHODS

Sampling

Studied samples were provided from the production of the northern and eastern marine fishing areas of Tunisia (Fig. 1) carried out during the summer 2013.

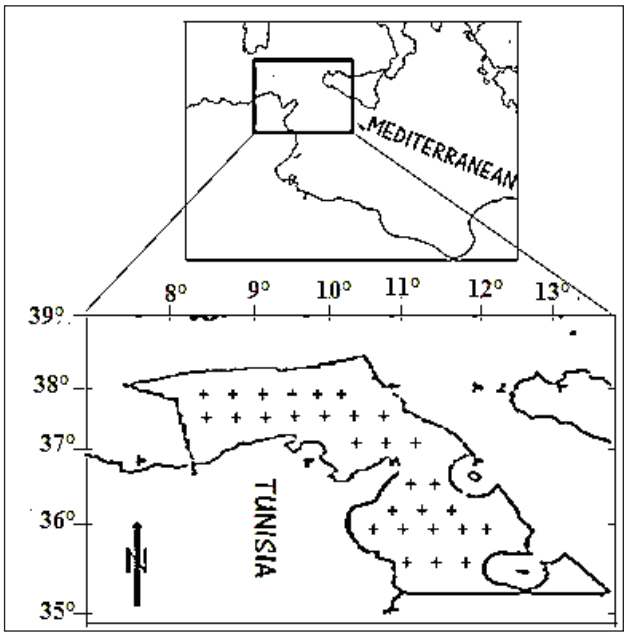

Fig. 1: Map showing the fishing area (+++) of the fish studied.
Sl. 1: Zemljevid ribolovnega območja (+++) obravnavanih vrst.

The collected individuals were kept in glass during the transfer to the laboratory of the University of Sciences of Tunis. Each individual was weighed to the nearest gram (WT). The fish total length (LT) and the mantle of cephalopod (MLT) were measured to the nearest cm. Biometric characteristic species are showing in Table 1.

Protein assay

The determination of the protein content was based on the method of Lowry *et al.* (1951) using as standard a solution of bovine serum albumin. Samples were incubated 10 mn at 50°C, then 20 mn at room temperature. The optical densities were measured at 540 nm.

Total lipid extraction and fatty acid analyses

All samples were fixed in boiling water to completely inactivate enzymatic activity, especially phospholipases (Shewfelt, 1981). The total lipids were extracted from the tissues according to the Folch *et al.* (1957) method, *i.e.*, chloroform-methanol (2:1, v/v). The total lipids fixed in a chloroform-methanol-BHT solution and stored in a freezer at -28°C. The fatty acids were converted to methyl esters according to the method Cecchi *et al.*, 1985).

A gas chromatograph type HP 6890 with a split/splitless injector with electronic pressure control and a flame ionization detector was used for the analysis. A aeparation was performed with a 30 m HP Innowax

capillary column with an internal diameter of 250 µm and a 0.25 µmfilm thickness, the stationary polar phase of the column being polyethylene glycol.

Identification and quantification of fatty acids

The different fatty acids in the nine species were obtained by comparing the retention times of the fatty acids under study and those of a mixture of methyl esters (SUPELCO PUFA-3). The quantification of the fatty acids is based on an internal standard not present in our samples, methyl nonadecanoate or $C_{19:0}$ (Sigma Aldrich, Corporate Headquarters, St Louis, MO).

Statistical analysis

The results represent the mean values of a series of repetitions (n = 6). These results are considered significant if $p < 0.05$. the different values were analyzed according to the Duncan test. The statistical analyses were carried out with the SAS software program version 6.12.

RESULTS AND DISCUSSION

The protein percentage varies between 15.8 % for *S. pilchardus* and 16.8 % in *T. trachurus*. In cephalopods, it varies between 15.6 % in *E. cirrhosa* and 20.1 % in *L. vulgaris* (Tab. 1). Our results corroborate with the range of variation recorded for 540 fish species, which extends from 16 to 22 g / 100 g (Médale, 2008). Table 1 shows the levels of total fatty acids (TFA) expressed in grams per 100 g fresh weight (g / 100 g FW) different species. The lipid concentration in *P. longirostris* was 3 %. Limam *et al*. (2008) found in *Parapenaeus monoceros* and *Penaeus kerathurus*, lipid levels that did not exceed 2 %. Nunes *et al*. (2003) found a value of less than 5 % in *P. longirostris*. According to the classification of Ackman (1989) *P. longirostris* is a moderately species [2-4 %].

In cephalopod species, the lipid analysis showed quantitative variations ranging from 2.2 % (*E. muschata*) to 9.4 % (*S. officinalis*). Özoğül *et al*. (2008) observe in *S. officinalis*, *L. vulgaris* and *E. muschata* respective percentages of 1.29; 1.92 % and 0.68 % lower than those given in Table 2. Our results allow to classify *S. officinalis* as a fat species [> 8 %] and *L. vulgaris*, *E. moschata* and *E. cirrhosa* as a low fat species [2-4 %].

In fish, fat percentages are 9.4 % for *S. pilchardus*, 2.7 % in *S. scombrus*, 9.9 % in *T. trachurus* and 8.2 % in *E. encrasicolus*. Sirot *et al*. (2008) recorded a fat percentages of 5.7 % in *S. pilchardus*, 7 % for *S. scombrus* and 7.5 % for *E. encrasicolus*. Nunes *et al*. (2003) found in *T. trachurus* a percentage ranging from 5 % to 15 %. According Ackman (1989), *S. pilchardus*, *T. trachurus* and *E. encrasicolus* are fatty species [> 8 %] while *S. scombrus* is a poor lipid species [2-4 %].The percentages of saturated fatty acids (SFA), monounsaturated (MUFA) and polyunsaturated (PUFA) are presented in Table 2. In all these species, the lipid profile is SFA > PUFA > MUFA except in *E. cirrhosa* where PUFA> SFA> MUFA while in *E. moschata* SFA ~PUFA> MUFA.

According to Figure 2, there is an inverse relationship between the SFA and PUFA in different species. As shown in figure 2 and table 2, there are two subgroups. On the one hand the subgroup formed by *E. cirrhosa*, *E. moschata*, *S. officinalis* and *S. scombrus* with ratio PUFA / SFA of about 1 and a sub group of *S. pilchardus* with a

Tab. 1: Biometric characteristics, contents of TFA (g / 100 g) and proteins (%) of nine marine species (fish, cephalopods and pink shrimp) (mean ± SE; n=6; p<0.05).
Tab. 1: Biometrične značilnosti, vsebina TFA (g / 100 g) in delež beljakovin (%) pri devetih vrstah morskih organizmov (ribe, glavonožci in kozice) (povprečje ± SE, n = 6; p <0,05).

Species	Total length (cm)	Total weight (g)	Total fatty acids		Proteins %
			(g/100g)	%	
Fish					
S. pilchardus	14.8-18.0	22.4–36.5	9.4±0.4	9.4	15.8
S. scombrus	20.4–22.7	70.7–92.5	2.7±0.5	2.7	15.9
T. trachurus	16.0–22.8	32.7–97.8	9.9±2.4	9.9	16.8
E. encrasicolus	10.5–17.0	10.8–30.5	8.2±1.1	8.2	16.1
Cephalopods					
L. vulgaris	18.0–24.0	26.1–60.8	3.8±0.8	3.8	20.1
S. officinalis	3.5–10.8	61.0–197.0	9.4±0.4	9.4	18.2
E. moschata	25.5–31.5	67.6–89.3	2.2±0.4	2.2	16.2
E. cirrhosa	5.0–8.4	40.9–151.4	2.5±0.2	2.5	15.6
Crustacean					
P. longirostris	16.0–22.8	32.7–97.8	3.0±0.4	3.0	16.3

Tab. 2: Percentages of saturated fatty acids (SFA), monounsaturated (MUFA) and polyunsaturated (PUFA) in nine marine species (fish, cephalopods and pink shrimp).
Tab. 2: Odstotki nasičenih maščobnih kislin (SFA), enkrat nenasičene (MUFA) in večkrat nenasičene maščobne kisline (PUFA) v devetih vrstah morskih organizmov (ribe, glavonožci in kozice).

Species	SFA	MUFA	PUFA	PUFA/SFA
Fish				
S. pilchardus	60.37±3.07^{a}	17.47±2.58^{ab}	22.01±1.98^{c}	0.36
S. scombrus	44.22±0.59^{b}	14.16±0.51^{b}	41.62±0.66^{a}	0.94
T. trachurus	47.67±1.65^{b}	23.98±1.73^{a}	28.56±1.81^{c}	0.59
E. encrasicolus	53.61±0.47^{a}	13.07±0.62^{b}	33.32±0.56^{b}	0.62
Cephalopods				
L. vulgaris	53.46±2.81^{a}	11.33±0.49^{b}	36.37±3.36^{b}	0.68
S. officinalis	45.18±0.78^{b}	12.54±0.39^{b}	42.27±0.89^{a}	0.93
E. moschata	45.57±1.30^{b}	11.31±1.06^{b}	45.08±1.28^{a}	0.98
E. cirrhosa	41.70±1.49^{b}	11.15±0.27^{b}	47.15±1.52^{a}	1.13
Crustacean				
P. longirostris	43.46±1.49^{b}	22.78±1.25^{a}	33.90±0.52^{b}	0.78

ratio of about 0.36. Referring to FAO /WHO (1994), the ratio's PUFA /SFA required for human is 0.45. Excepting *S. pilchardus*, we can state that species studied tended to accumulate PUFAs than SFA.

The percentages of the different families of PUFAs (n-3, n-6) and MUFAs (n-7 and n-9) were calculated for the nine seafood products studied (fish, cephalopods and pink shrimp); the results are displayed in Figure 3. Cephalopods are mainly distinguished by their high n-3 PUFA. Among fish, *T. trachurus* can be considered as a source of n-9 MUFA. While *S. pichardus* is characterized by almost equal concentrations of n-3 PUFA and n-9 MUFA in one hand, on the other hand, by its extreme poverty in n-6 PUFA. It has been shown that MUFA, often referred to as good fats, help reduce blood cholesterol levels and protect against heart disease (Shanmugam *et al.*, 2007).

Considering that the seafood products present a

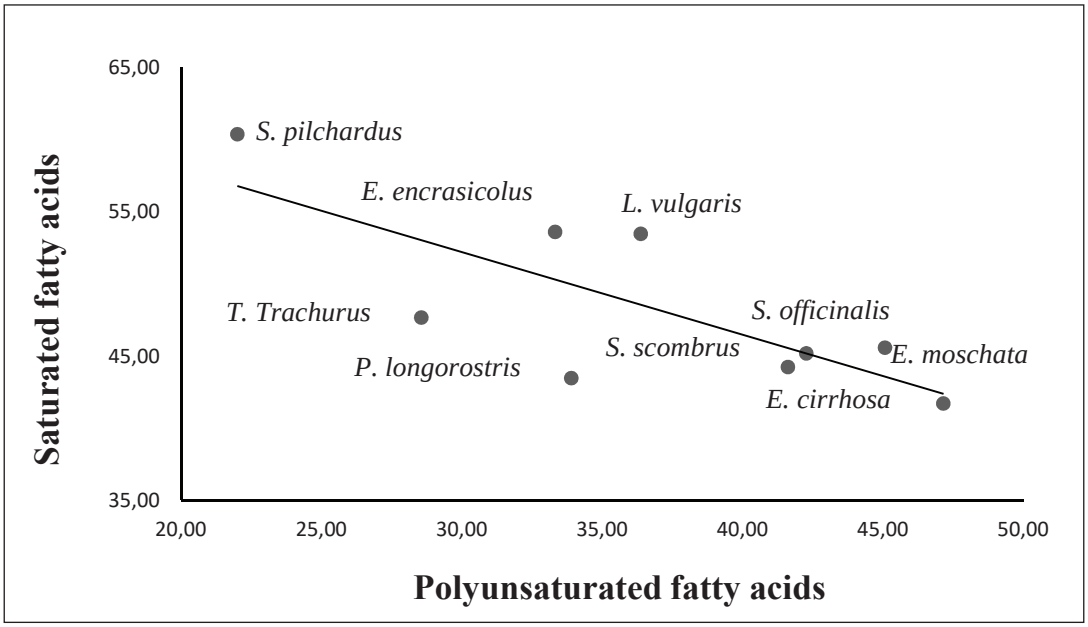

Fig. 2: Relationship between saturated fatty acids (SFA) and polyunsaturated fatty acids (PUFA) (in % TFA) in nine marine fish (fish, cephalopods and pink shrimp).
Sl. 2: Razmerje med nasičenimi maščobnimi kislinami (SFA) in polinenasičenimi maščobnimi kislinami (PUFA) (v % TFA) v devetih vrstah morskih organizmov (ribe, glavonožci in kozice).

Tab. 3: Relative proportions of different fatty acids in nine marine species (fish, cephalopods and pink shrimp).
Tab. 3: Relativni deleži različnih maščobnih kislin v devetih vrstah morskih organizmov (ribe, glavonožci in kozice).

Species	PUFA (g/100g)	n-3 (g/100g)	n-6 (g/100g)	n-3/n-6	EPA+DHA (g/100g)
Fish					
S. pilchardus	2.07	1.74	0.30	5.8	1.27
S. scombrus	1.12	0.89	0.22	4.1	0.80
T. trachurus	2.80	2.25	0.45	5.0	1.85
E. encrasicolus	2.73	2.39	0.33	7.5	1.87
Cephalopods					
L. vulgaris	1.38	1.26	0.11	11.7	1.23
S. officinalis	3.98	3.59	0.33	11.3	2.96
E. moschata	0.99	0.85	0.13	6.3	0.73
E. cirrhosa	1.18	0.99	0.18	5.7	0.91
Crustacean					
P. longirostris	1.02	0.64	0.37	1.7	0.56

relation between the wealth of the fatty acids in omega 3 and their nutritional quality (Mori *et al.*, 1997), the relative proportions of different fatty acid groups were calculated for the nine species studied (Tab. 3).

To compare the quality of fat of different species, it is preferable to use the ratio n-3/n-6 than the ratio PUFA/SFA since the first one takes into account the families of fatty acids of the n-3 and n-6 separately (Sargent *et al.*, 1995). According to Table 3, (n-3/n-6) values ranged from 1.7 to 11.7. A part *P. longirostris*, cephalopod and fish species had a high nutritional value for human consumption (4.1 ≤ n-3 / n-6 ≤ 11.7). Fish and fishery products rich in n-3 fatty acids and low in n-6 fatty acids are considered beneficial for human health (Sargent, 1997). An increase in the n-3/n-6 ratio is essential to help the body use n-3 fatty acids. A low ratio indicates that the enzymes that convert fatty acids to their active forms are likely to be used by n-6 PUFAs (Hossain, 2011). The

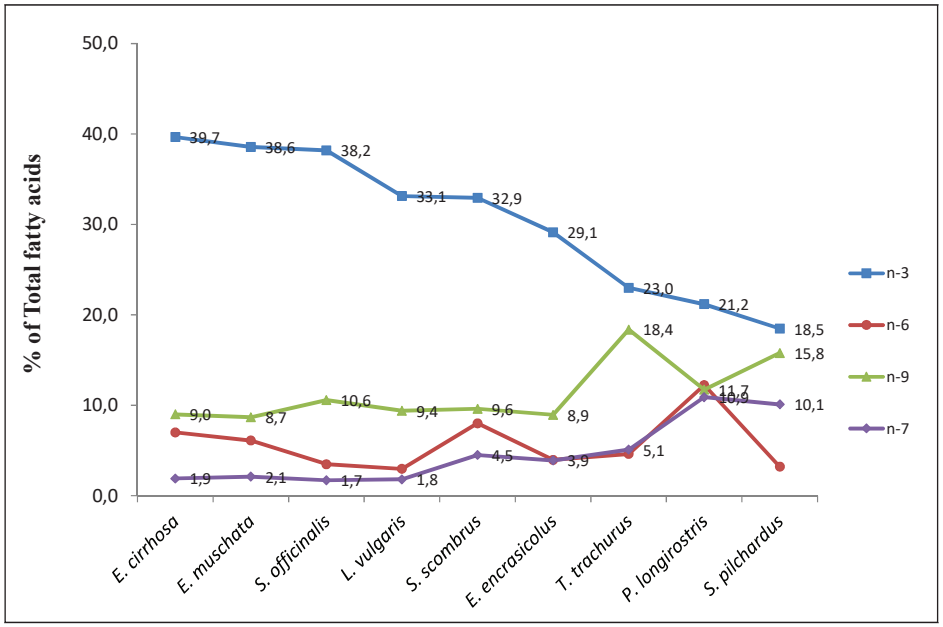

Fig. 3: Percentages of PUFAs (n-3, n-6) and MUFAs (n-7 and n-9) fatty acids per nine marine species (fish, cephalopods and pink shrimp).
Sl. 3: Delež PUFA (n-3, n-6) in MUFAs (n-7 in n-9) maščobnih kislin v vzorcih morskih organizmov (ribe, glavonožci in kozice).

percentage of EPA+DHA is responsible for variations in the n-3/n-6 ratios (Hossain, 2011).

The research has shown that there are significant health benefits of a diet rich in EPA+ DHA. A number of countries including Canada and the United Kingdom, and organizations such as the World Health Organization (WHO) and North Atlantic Treaty Organization have advocated dietary recommendations for n-3 PUFAs. These recommendations are 0.300 to 0.500 mg / day EPA+DHA (Kris-Etherton *et al*., 2003). Based on the results in table 4, these recommendations can easily be met by consuming 100 g fresh seafood product.

CONCLUSIONS

It can be argued that most species had a ratio PUFA / SFA greater than 0.45. The n-3/n-6 ratio is a very conclusive criterion to compare the nutritive value of marine fish fat. Fish or fishery products rich in fatty acids type n-3 and poor in fatty acids type n-6 are considered to be beneficial for human health. The ratio derived from our analysis, varying from 4 (*S. scombrus*) to 11.7 (*L. vulgaris*), is highly beneficial and desirable for human daily intake.

HRANILNA VREDNOST IN VSEBNOST PROTEINOV IN MAŠČOBNIH KISLIN V MIŠIČNINI MORSKIH VRST V TUNIZIJI (OSREDNJE SREDOZEMSKO MORJE)

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POVZETEK

*Določili smo vsebnost beljakovin in maščobnih kislin v devetih vrstah morskih organizmov (*Sepia officinalis, Eledone cirrhosa, E. moschata, Loligo vulgaris, Trachurus trachurus, Scomber scombrus, Sardina pilchardus, Engraulis encrasicolus *in* Parapenaeus longirostris*), ki se uporabljajo v prehrani v Tuniziji. Delež beljakovin je znašal od 15,8 % do 20,1 %, delež celokupne vsebnosti maščobnih kislin pa od 2,2 % do 9,9 %. Vrednosti razmerja PUFA/SFA so bile večje od 0,45 razen pri vrsti* S. pilchardus, pri kateri smo zabeležili vrednost 0,36. Nižja vrednost razmerja n-3/n-6 je bila ugotovljena pri vrsti P. longirostris *(1.7), najvišja pa pri* L. vulgaris *(11.7). Vrednosti EPA+DHA so pri večini obravnavanih vrst znašale nad 500 mg / 100 g mišičnine, zato ti morski organizmi predstavljajo visoko hranilno vrednost za človeško prehrano.*

Ključne besede: beljakovine, skupne maščobne kisline, EPA+DHA, morski proizvodi

REFERENCES

Ackman, R.G. (1989): Marine Biogenic Lipids, Fats and Oils.Vol. 2, CRC Press, Florida, 504 pp.

Barnerjee, I., S. Saha & J. Dutta (1992): Comparison of the effect of dietary fish oils with different n-3 polyunsaturated fatty acid compositions on plasma and liver lipids in rats. Lipids, 27, 425-428.

Brouwer, I.A., A. Geelen & M.B. Katan (2006): n-3 Fatty acids, cardiac arrhythmia and fatal coronary heart disease. Progr. Lipid. Res., 357-367.

Calder, P.C. & P. Yaqoob (2009): Omega-3 polyunsaturated fatty acids and human health outcomes. Biofactors, 35, 3, 266-276.

Cecchi, G., S. Basini & C. Castano (1985): Méthanolyse rapide des huiles en solvant. Revue française des corps gras n°4.

Chen, I.C., F.A. Chapman, C.I. Wei, K.M. Portier & S.F. O'Keefe (1995): Differentiation of cultured and wild sturgeon (*Acipenser oxyrinchus desotoi*) based on fatty acid composition. Journal of Food Science, 60, 3, 631-635.

Flaten, H., A.T. Hostmark, P. Kierulf, E. Lystad, K. Trygg, T. Bjerkedal & A. Osland (1990): Fish-oil concentrate: effects of variables related to cardiovascular disease. Am. J. Clin. Nutr., 52, 300-306.

FAO/WHO (2008): Interim Summary of Conclusions and Dietary Recommendations on Total Fat & Fatty Acids. Expert Consultation on Fats and Fatty Acids in Human Nutrition, November 10-14, 2008, Geneva, 15 pp.

Folch, J., M. Lees & G.A. Sloane-Stanley (1957): A simple method for the isolation and purification of total lipids from animal tissues. J. Biol. Chem., 226, 1, 497-509.

Garcia-Alonso, L., R., Alonso, E. Vidal, A. Amadoz, A. De Maria, P. Minguez, I. Medina & J. Dopazo (2012): Discovering the hidden sub-network component in a ranked list of genes or proteins derived from genomic experiments. Nucleic Acids Res., 40, 20, e158.

Hossain, M.A. (2011): Fish as Source of n-3 Polyunsaturated Fatty Acids (PUFAs), Which One is Better-Farmed or Wild? Advance Journal of Food Science and Technology, 3, 6, 455- 466.

Kris-Etherton, P.M., W.S. Harris & L.J. Appel (2003): Omega-3 fatty acids and cardiovascular disease - New recommendations from the American Heart Association. A.T.V.B., 23, 151-152.

Limam, Z., S. Arafa, S. Sadok, & A. El Abed (2008): Lipids and fatty acids composition in the tissues and by-products of two Tunisian shrimp species from the north and south regions. Nutr Health., 19, 215-220.

Lowry, O.H., N.J. Rosebrough, A.L. Farr & R.J. Randall (1951): Protein measurement with the Folin phenol reagent. J. Biol. Chem., 193, 265-275.

Médale, F. (2008): Le poisson: quels enjeux pour sa consommation? Let. Scien. IFN-n-130, 20 pp.

Médale, F., F. Lefevre & G. Corraze (2003): Qualité nutritionnelle et diététique des poissons. Cah. Nutr. Diet. Cahiers, 38, 37-44.

Mori, T.A., L.J. Beilin, V. Burke, J. Morris & J. Ritchie (1997): Interactions between dietary fat, fish, and fish oils and their effects on platelet function in men at risk of cardiovascular disease. ATVB, 17, 279-286.

Nunes, M.L., N.M. Bandarra & I. Batista (2003): Fish products: Contribution for a healthy food. Electron. J. Environ. Agric. Food Chem., 2, 453-457.

Özoğül, Y., Ö. Düysak, F. Özoğül, A.S. Özkütük & C. Türeli (2008): Seasonal effects in the nutritional quality of the body structural tissue of cephalopods. Food Chem., 108, 847-852.

Piclet, G. (1987): Le poisson aliment. Composition - intérêt nutritionnel. Cahiers de la Nutrition et de la Diététique, 4, 317-336.

Sargent, J.R. (1997): Fish oils and human diet, British Journal of Nutrition, 78, 5-13.

Sargent, J.R. & R.J. Henderson (1986): Lipids. In E.D.S. Corner & S. O'Hara (Eds). Biological chemistry of marine copepods. University Press. Oxford, 59 pp.

Shanmugam, A., Ch. Palpandi, & S. Sambasivam (2007): Some valuable fatty acids exposed from wedge clam *Donax cuneatus* (Linnaeus). Afr. J. Bioch. Res., 1, 2, 014-018.

Shewfelt, R.L. (1981): Fish muscle lipolysis. A review. Journal of Food Biochemistry, 5, 79-100.

Sirot, V., M. Oseredczuk, N. Benmrah-Aouachria, J.L. Volatier & J.C. Leblanc (2008): Lipid and fatty acid composition of fish and seafood consumed in France: Calypso study. J Food Compos. Anal., 21, 8-16.

Soriguer, F., S. Serna, E. Valverde, J. Hernando, A. Martin Reyes, M. Soriguer, A. Pareja, F. Tinahones & I. Esteva (1997): Lipid, protein, and calorie content of different Atlantic and Mediterraneanfish, shellfish, and molluscs commonly eaten in the south of Spain. European Journal of Epidemiology, 13, 451-463.

Steffens, W. (1997): Effects of variation in essential fatty acids in fish feeds on nutritive value of freshwater fish for humans. Aquaculture, 151, 97-119.

OCENE IN POROČILA

RECENSIONI E RELAZIONI

REVIEWS AND REPORTS

Book review: BIOGENIC FORMATIONS IN THE SLOVENIAN SEA
authors: Lovrenc Lipej, Martina Orlando-Bonaca, Borut Mavrič
National Institute of Biology, Marine Biology Station Piran, 2016, 206 pp.
ISBN 978-961-93486-4-2. Printed within the Med-KeyHabitats Project, RAC/SPA Hardback: 20 €
(orders: information@mbss.org)

Marine biologists are increasingly being compelled to discover and expound upon ever more remote and inaccessible habitats, ever more exotic species and their behaviors. The public wants to see faraway coral reefs, open ocean feeding frenzies with tunas, sharks and whales, or read about giant squid and deep-sea "monsters". But let's face it, most marine biologists are paid to make do with what lies directly outside their labs and institutions. Of course, these "front yards" are often exciting enough in their own right. This book and the habitats it describes are a case in point. Even Slovenia, with its ca. 45-km-long coastline, can boast an array of habitats that has kept generations of marine biologists busy over their entire careers.

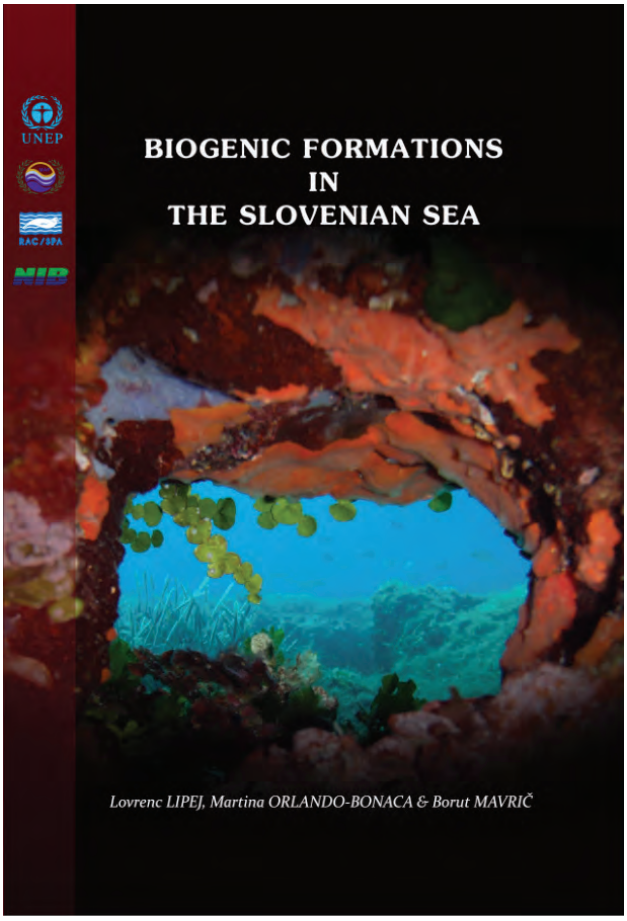
The habitats presented here are "biogenic formations". Although such formations are well known elsewhere (think coral reefs), the northern Adriatic Sea has traditionally been better known for its soft-bottom seafloor. Only fairly recently has sufficient recognition been given to the unique macrofauna on these muddy bottoms and its aggregation into biogenic structures termed bioherms or multi-species clumps.

This book is intriguing because it presents less well known types of biogenic formations such as "trezze" and "tegnue", pre-coralligenous, coralligenous and the stony coral *Cladocora caespitosa* - the closest you'll get to a "coral reef" in the Mediterranean. These are interesting because hard substrata play a major role in evolution and paleoecology. Especially meter-scale biogenic formations associated with cold seeps (called tegnue along the Venetian coast and trezze in the Gulf of Trieste) are increasingly recognized as important for the history of life. The Mediterranean coralligene is nicely developed in several community stages in the northern Adriatic. In its mature stage it consists of sciaphilic communities of coralline red algae, sponges, corals and bryozoans. Depending on the size and diameter of the colonies, these "reefs" serve as a habitat for a wide range of invertebrates, most notably molluscs, polychaetes and crustaceans. Because all these biogenic constructions are also colonized by sessile and cryptic fauna, they are exceptional diversity hotspots. Of special interest in this respect along the Slovenian coasts are two larger formations of dead Mediterranean stony corals that the authors highlight.

The second half of the book is devoted to a field-guide-like presentation, based on color photographs, of the inhabitants of these biogenic formations. This "Biodiversity Overview" includes the flora, the major invertebrate groups and bony fishes. It is admirably introduced by short texts on a range of ecological subtopics such as antipredator strategies (camouflage, mimicry, mutualism) and insights into cryptobenthic habitats and "real" and "false" cryptobentic fauna. This book addresses the general public but is an equally nice compilation for the expert's library. It would have benefited from somewhat more rigorous editing, but this does not detract from the delightful and informative reading experience.

The book is dedicated to two young Slovenian colleagues working at the marine biology station who died in a criminally negligent diving exhibition, underlying that our conquest of the sea remains a perilous adventure despite - or in this case even due to - the newest and most fashionable equipment.

Michael Stachowitsch
Department of Limnology and Bio-Oceanography,
University of Vienna, Vienna, Austria



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:
Krpasta rebrača *Mnemiopsis leidyi* se je poleti leta 2016 pričela pojavljati množično v slovenskem delu Jadrana in Tržaškem zalivu. Za to tujerodno vrsto je znano, da je imela vpliv na upad ribjih populacij v Črnem morju. (Foto: B. Mavrič)
Sl. 1: Polž *Polycera hedgpethi* je tujerodna vrsta morskih polžev zaškrgarjev, ki je bil doslej najden na več lokalitetah v Jadranskem morju. Naseljuje plitve predele in pristanišča, kjer se prehranjuje z mahovnjaki. (Foto: B. Mavrič)
Sl. 2: Na srebrnico (*Clinitrachus argentatus)* naletimo v plitvih vodah ob sredozemski obali. O tej vrsti, ki se rada prikriva v zavetju makroalg, je v Jadranskem morju še vedno zelo malo znanega. (Foto: B. Mavrič)
Sl. 3: Prodišča ob srednjem toku reke Drave (med Ptujem in Ormožem, severovzhodna Slovenija) porašča mozaik različnih vegetacijskih tipov. (Foto: M. Meznarič).
Sl. 4: Skalni glavač (*Gobius cobitis*) na fotografiji se pojavlja v okolju, preraščenem z rdečo algo *Asparagopsis armata* (faza *Falkenbergia rufolanosa*). Ta tujerodna alga je danes ustaljena vrsta v slovenskih obalnih vodah. (Foto: L. Lipej)
Sl. 5: Veleluskasti glavač (*Thorogobius macrolepis*), endemit Sredozemskega morja, je bil do nedavnega opredeljen kot redka vrsta, znana le iz nekaj lokalitet. Novejša spoznanja, ki so jih prispevali potapljači, pa kažejo na to, da je vrsta znatno bolj pogostejša, kot so doslej domnevali. (Foto: B. Mavrič)
Sl. 6: Nižje lege na prodiščih so podvržene pogostejšim motnjam, ki uničijo vegetacijo in ustvarijo nove površine. Neporasla tla najprej kolonizirajo pionirske rastlinske vrste. (Foto: M. Meznarič)

INDEX TO IMAGES ON THE COVER

FRONT COVER:
In the summer 2016, a huge number of Warty comb jellies (*Mnemiopsis leidyi*) were observed in the Slovenian part of the Adriatic Sea and in the Gulf of Trieste. This alien species is known to have caused a dramatic decline of fish population in the Black Sea. (Photo: B. Mavrič)
Fig. 1: The sea slug *Polycera hedgpethi* is an alien opisthobranch species, recently discovered in several parts of the Adriatic Sea. It is generally found in harbours and shallow sites, where it feeds on bryozoans. (Photo: B. Mavrič)
Fig. 2: *Clinitrachus argentatus*, the Cline, is commonly found in shallow waters along Mediterranean coasts. Data on the occurrence of this small fish species in the dense algal belts of the Adriatic Sea are still scarce. (Photo: B. Mavrič)
Fig. 3: Gravel bars alongside the middle Drava River (between Ptuj and Ormož, north-eastern Slovenia) covered by a mosaic of different vegetation types. (Photo: M. Meznarič)
Fig. 4: Giant goby photographed in a background overgrown with the red algae *Asparagopsis armata* (*Falkenbergia rufolanosa* phase). This non-indigenous algal species is considered an established species in the shallow Slovenian coastal waters. (Photo: L. Lipej)
Fig. 5: The Large-scaled goby *Thorogobius macrolepi,* endemic to the Mediterranean Sea, was until recently classified as a rare species, only known from a few localities. New data obtained by scuba divers, however, suggest that the species may be far more common than previously thought. (Photo: B. Mavrič)
Fig. 6: The low-lying areas of gravel bars are more exposed to disturbances resulting in the destruction of vegetation and creation of new surfaces. The bare ground conditions favour *pioneer* plant *species*. (Photo: M. Meznarič)

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