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MARINE FAUNA OF MLJET NATIONAL PARK (ADRIATIC SEA, CROATIA). 7. ECHIURA

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It seems that the only Echiuroid species present in the Mljet National Park is *Bonellia viridis*. This species is known world wide for its peculiar larval development and sexual dimorphism. The forked proboscis females prefer to live in shallow sublittoral crevices in large stones and similar rocky environments. Divers reported *B. viridis* to be a rather common marine invertebrate.

Key words: Echiura, *Bonellia viridis*, Adriatic Sea, National Park Mljet.

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Izgleda da je *Bonellia viridis* jedina vrsta zvjezdana (Echiura) koju nalazimo u Mljetskom Nacionalnom parku. Radi se o životinji poznatoj širom svijeta zbog posebnog razvoja ličinaka i izrazitog spolnog dimorfizma i načina života odraslih jedinki. Velike ženke s račvastim rilom žive ponajviše između kamenja i u pukotinama strmih i okomitih stijena. Prema opažanjima ronilaca na nekim se mjestima u Nacionalnom parku *B. viridis* čak može smatrati čestom vrstom.

Ključne riječi: Echiura, *Bonellia viridis*, Jadransko more, Nacionalni park Mljet.

INTRODUCTION

In the entire Mediterranean Sea, six species of echiurans (*Echiura* Newby, 1940) were recorded (Murina, 1984; van der Land, 2001; Anonymous, 2008; Biseswar, 2009). However, in the Adriatic Sea only two species were identified: *Bonellia viridis* Rolando, 1821, and *Maxmuelleria gigas* (M. Müller, 1852) both belonging to the family *Bonellidae* Baird, 1868.

In the summers of 1995-2002, the student Thais Society for Underwater Research was engaged in studies of benthic communities and biodiversity of marine fauna in the Mljet National Park. The task was done principally on the basis of visual observations by skin and scuba divers. The work resulted in eight bachelor theses, and in numerous professional and scientific papers published elsewhere in Croatia and abroad.

The present contribution is the seventh in the series on the marine fauna of the Mljet National Park. Except for the paper on echinoderms (Zavodnik, 2003) all other contributions appeared in the journal *Natura Croatica* (Kružić, 2002; Logan, 2003; Dell'Angelo & Zavodnik, 2004; Šiletić, 2005; Zavodnik, 2016).

HISTORICAL ACCOUNT

In Adriatic scientific literature echiurids appear only at the beginning of the nineteenth century when big females of a littoral species *Bonellia viridis* attracted the interest of

scientists (Rolando, 1821). Males of this species were found in the Adriatic Sea and were recorded three decades later (Kowalevsky, 1868; Veydovský, 1878). The first critical review of the Adriatic reports was provided by Carus (1885), followed a century ago by Murina (1984), and Zavodnik (1994).

There are many reports of Echiura in Slovenian and Croatian areas, such as the Istrian peninsula (Vatova, 1928; Marcuzzi, 1972; Matjašič *et al*., 1975; Zavodnik & Zavodnik, 1986; Sket *et al*., 2003), the Kvarner archipelago (Zavodnik, 1994, 1998), Rijeka Bay (Zavodnik & Kovačić, 2000), and in Kornati archipelago (Zavodnik D. and Belamarić J., unpublished results).

MATERIALS AND METHODS

The research project into benthic communities and faunal biodiversity in the area of Mljet National Park was carried out by high school students in the summer period. With regard to the main topics of research the work was based on visual observations and the collection of sediments and biological material by snorkeling, and skin and scuba divers equipped with scientific and fishing equipment. The work along transects was previously shown to be successful (Orepić *et al*., 1997; Guidetti *et al*., 2001; Lipej *et al*., 2004).

Sixty five diving sites were explored (Fig. 1), mainly during the day. Occasionally, night dives were organised as well. Two to ten divers were involved in each excursion. Observations on deep rock and sand habitats were carried out exclusively by scuba divers.

In the area of interest, hydrology and planktology were not considered. Benthic research occasionally was documented by environmental photography.

The details of the majority of sites studied were presented in papers by Orepić *et al.* (1997), Kružić (2002), Zavodnik (2003), and Šiletić (2005).

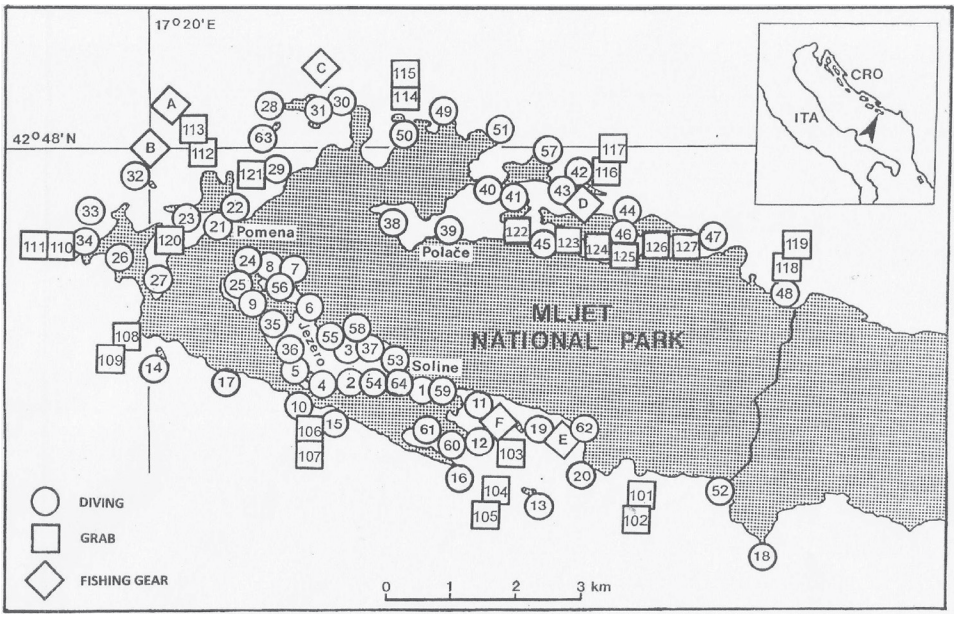

Fig. 1. Research area and surveyed stations.

Fig. 2. A female's divided proboscis in a natural environment. (Photo by P. Kružić; taken at Uvala Srednja, Pomena, at 8 m depth.)

Divers searched in particular for the presence of the forked proboscis of the female *B. viridis* in subtidal gravel and rocky environments (Fig. 2). Observations were perfomed along a 100 metre long rope marked at one meter intervals, and in 4-10 m path width. At steep reefs and entrances to caves, and vertical or even an overhanding bottom contour depth marks only were considered due to technical reasons.

The presence of big *B. viridis* (females only) was recorded from shallow sea 0.1 m at low tide, to a maximum 56 m depth on a vertical rocky wall at Lenga cape – station MLJ-16. At all the studied sites of the research, divers recorded data on rock and boulder morphology and sediments.

To study sediment-dwelling echiurans, numerous grab hauls were done by the research vessel *Vila Velebita* with an improved Van Veen 0.1 m^2 grab type at selected stations (MLJ-101-127). The sediment was sieved through 1 mm^2 mesh. Live animals were extracted and preserved in 60 % alcohol or a neutralized 4 % formol solution.

RESULTS

In the search for echiurans, there were a total of 65 diving sites and 27 grab stations. Divers were usualy engaged in daylight visual observations. No echiurans were found in grab hauls. Similarly, the sediment collected using buckets, and Zahtila hand samplers (Orepić *et al*., 1997) produced no results. Alas, a postal parcel containing few undeterminable worm pieces preserved in alcohol disappeared during transport to Mrs. Galina V.V. Murina, Odessa (Crimea) who had agreed to examine the material.

While extended, the forked proboscis of an about 10 cm large *Bonellia viridis* female can reach about one metre and half in length (Garms & Borm, 1981; present paper). Probosces were noted by divers at our stations MLJ-1, 10, 12, 13, 14, 16, 17, 18, 20, 22, 23, 28, 29, 30, 31, 40, 41, 45, 46, 49, 51, 53, 55 and 59, at 0-45 m depth (Fig. 1, Tab. 1). This species appears to be a typical shade seeking creature, usually inhabiting various rock and similar shelters, and even domestic refuse. Thus *Bonellia* was detected in some glass bottles drawn up in the course of our bottom cleaning actions at stations MLJ-1 and

Tab. 1. Basic facts on the sites where *Bonellia viridis* was found in the Mljet. National Park Exposure abbreviations: Sh – sheltered; Mo – moderately exposed; Ex – exposed to waves.

Station MLJ-n	Site location	Observation depth (m)	Habitat	Geographic orientation	Inclination (°)	Exposition to waves
1	Soline channel	0-3	Under boulders	E	0-10	Sh
10	Amfiteatar	0-2	Rock	S	0-45	Ex
12	Srednji rat (cape)	0-9	Steep rock	S	45	Ex
13	Vanji školj	0-48	Steep cliff	SW	60-90	Ex
14	Štit islet	0-42	Crevices in rocky wall	SW	90	Ex
16	Lenga (cape)	2-56	Crevices in rocky wall	S	90	Ex
17	Zavrti	0-32	Steep rock, overhang	SW	0-120	Ex
18	Rat Tojsti (cape)	0-40	Steep rock	SW	45-90	Ex
20	Hljeb (cape)	0-20	Rock, boulders	SW	0-90	Ex
22	Sikjerica (cape)	0-7	Gravel, rock	SE	0-40	Mo
23	Galijica islet	0-8	Gravel, rock, sand, litter	S	20	Sh
28	Glavat (island)	0-44	Rock, gravel, sand	W	10-70	Mo
29	Debeli rat (cape)	0-47	Gravel, rock, sand	NW	20-90	Mo
30	Rat Glavat (cape)	0-47	Rock, sand	N	40-90	Ex
31	Glavat (island)	3-20	Rock, sand	E	?-90	Mo
40	Rat Lenga (cape SW)	0-16	Rocky wall	SW	90	Ex
41	Tijesno (strait)	0-32	Rock, sand	S	30-90	Sh
45	Tratinica (cove)	0-29	Rock, sand	N	0-80	Sh
46	Kobrava (island)	0-40	Rock, sand	S	45-90	Sh
49	Zazupci (cape)	5-10	Steep holloved wall	N	70-90	Ex
51	Rastupa (cape)	0-45	Steep rock, cliff	NE	45-80	Ex
53	Veli Most (cove)	0-27	Rock, sand, coral reef	E	30-90	Sh
55	Pristanište	0-18	Gravel, rock, sand	S	10-20	Sh
59	Vratosolina	0-2	Gravel, rock	E	20-45	Sh

MLJ-55. Rather few probosces of individual female specimens were seen in daylight (Fig. 2), while during night dives their appearance was characterised by divers as „common". Extended probosces measured from 80-147 cm in length.

BONELLIA VIRIDIS Rolando, 1821

From a systematic point of view the green spoonworm *Bonellia viridis* belongs to the phylum Echiura, class Echiuroidea, order Bonellida, family *Bonellidae*, and the genus *Bonellia* (Murina, 1984; Biseswar, 2009). Previously, echiurids and sipunculids were systematized in a polyphiletic subclass Gephyrea (Quatrefages, 1865; Baird, 1868; Sluiter, 1912; Fischer, 1922), a subclass that is no longer used. It seems that in Adriatic faunistic literature, the term gephyrean was last used by Vatova (1949).

Because of its extreme sexual dimorphysm (Willczynski, 1960) *B. viridis* became known world wide, and it is cited and figures in many University text books, in diving manuals as well as academic literature, such as Heller (1864) and Brusina (1907), Zei & Zháněl (1947), Ercegović (1949), Kaestner (1956), Hyman (1959), Račani team (1963), Riedl (1963, 1970), Štovičcek-Štirn (1963), Gamulin-Brida (1970, 1974), Garms & Borm (1981), Campbell (1982), Zavodnik (1994), Turk (1996, 2011), Zavodnik & Šimunović (1997), Andrić (1999), Ostoić (2000), Hofrichter (2003), Berec *et al*. (2005), Anonymous (2008), and Bakran-Petricioli (2011). The name of this species appeared even in some encyclopaedic sources (Yugoslavian Pomorska enciklopedija: Ercegović, 1954, 1959; Zei, 1955; Sovetskaja encikopedija: Anonymous, 1989; Encyclopaedia Britannica: Pickford, 1966; Fauna Europe: Garms & Borm, 1981; Živalstvo Slovenije: Sket *et al*., 2003; Wikipedia, the free encyclopedia: Anonymous, 2016).

With regard to its geographic distribution the species *B. viridis* was recorded in the eastern Atlantic from Norway and Ireland to the Azores, Canary Islands, Congo, and along the Namaqualano desert coast in Namibia (Murina, 2008). It also was recorded in the Mediterranean and Red Seas, and in the Indian and Pacific Oceans (Wikipedia encyclopaedia, 2016). Its depth distribution is from 0-50 m in the Adriatic Sea, and to about 100 m in the Mediterranean (absent in the Black Sea – Zenkevič, 1963; Anonymous, 1989). Maximum depths noted in other world seas are about 400-2250 m (Murina, 1984; Biseswar, 2009; Wikipedia encyclopaedia, 2016). Consequently, *B. viridis* is a subcosmopolitan species, recorded in tropical and temperate seas (Murina, 1984), most of all in littoral and circumlittoral zones (Pérès & Picard, 1964; present paper). The distribution of *Bonellia* in the Adriatic Sea recently was reviewed by Zavodnik (1994), and along the Italian coast by Anonymous (2008).

In the eastern Adriatic, which is characterised by numerous islands, reefs and coves, nocturnal females occur everywhere in sheltered spaces in unpolluted hard bottom habitats, such as free spaces amongst large gravel and loose stones, below boulders, in genuine rock and cliff crevices (Zimmermann, 1907; Brusina, 1907; Steuer, 1910; Cori, 1928; Ercegović, 1949; Gamulin-Brida, 1974; Zahtila *et al*., 2000; present paper), and in shallow water caves (Riedl, 1966). Much more rarely, it was observed in littoral algal associations and sea grass meadows, or in burrows and shells of dead sessile animals (Cori, 1912, 1928; Bauer, 1928; Schembri & Jaccarini, 1978; Zavodnik & Šimunović, 1997; Bakran-Petricioli (2011); present paper). Surprisingly, *B. viridis* females' presence was noticed within antique amphorae (Picard, 1956). However, in the course of similar research conducted in the northern Adriatic, no *Bonellia* was found (Legac, 1974).

Green spoonworm females feed on organic detritus and small benthic animals killed by venomous mucus that is not dangerous to man (Maretić, 1975). In spite of the large adult female proboscis, in the Adriatic area this species was never fished or consumed by the inhabitants (Faber, 1883; Bakić, 1967; Zavodnik, 1997), even in times of starvation during war conditions (Bakić & Popović, 1983).

As far as is known to the present writer, *B. viridis* is nowhere considered to be an endangered species or protected by law.

DISCUSSION AND CONCLUSIONS

The echiuran worm *Bonellia viridis* is the only species of this genus registered in the Adriatic Sea. Another species of the family Bonellidae is *Maxmuelleria gigas* M. Müller, 1852, which lives in sediments and has been reported from some north Adriatic offsho-

re and channel stations (Vatova, 1928; Murina, 1984; Zavodnik, 1994; Relini, 2008). According to present knowledge, this second species perhaps is endemic in the area studied (Murina, 1984; Sket et *al*., 2003; Anonymous, 2008).

The first critical review of the *B. viridis* distribution in the Adriatic Sea was provided by Carus (1885) who highlighted the collections of biological material from the areas of Lošinj and Cres Islands. In his time the only way of finding *B. viridis* was by the visual observation of seamen, or the occasional catch of specimens. An annotated discussion of knowledge on these matters was presented in a concise review on Adriatic Echiura and Priapulida (Zavodnik, 1994). The general distribution patterns of *B. viridis* in European seas were recently reviewed by Van der Land (2001) and Biseswar (2009).

In the Adriatic territorial waters of Italy, Echiurids were reviewed recently by Bianchi and Castelli (Anonymous, 2008), and in Slovenia by Matjašič & Štirn (1975), and Sket (2003). Apparently, no recent information is available from the coasts of Bosnia and Herzegovina, and Montenegro. From the sea off Albania some records were provided by Schembri & Jaccarini (1978), and Dhora (2009).

New records of the presence of females in Croatian waters from two decennia ago (Zavodnik, 1994) have to be added: Brioni National Park (Veli Brijun Island: Saluga cape, and coves named Dobrika, Javorika, and Verige); Raša Bay (Ubac, Mulac, Tunarica, Prašćarica) (Zavodnik & Zavodnik, 1986); Rijeka Bay: Mošćenićka Draga cove (Zavodnik & Zavodnik, 1994); Kvarnerić: Pag Island and Škrda Islet (Zavodnik *et al*., 2006); Dugi otok Island (Telašćica Bay: Farfarikulac islet); Kornati Archipelago (islets named Balun, Kasela, Lavsa, Levrnaka, Lunga, Mana, Panitula, Rašip, Ravni Žakan), and Kornat Island (Statival cove); Mljet National Park (present paper); Velika Palagruža Island (Veliko žalo, Stara vlaka); Pelješac peninsula (Trpanj); Biševo Island (Modra špilja), and Lastovo Island (Andrić, 1999: Baške stijene; Zavodnik: Skrivena luka) (present paper: Fig. 3; Tab. 2).

The type material of the species was collected from the Sardinian littoral (Rolando, 1828), and in part in the Bay of Trieste, the Lošinj archipelago, and the Vis Island (Schmarda, 1852; Carus, 1885). After the sensational discovery and description of the sexual dimorphism of *B. viridis*, the species' behaviour and habitats were studied. It was confirmed that the females are typical cryptobenthic organisms that live sheltered in

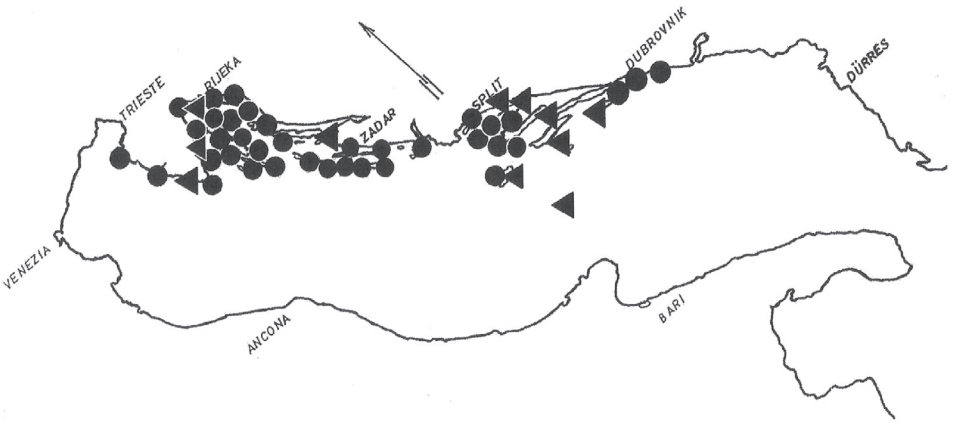

Fig. 3. *Bonellia viridis* recorded in Croatia. New sites not noted in review by Zavodnik (1994) are marked by triangle (Δ).

Tab. 2. New finding spots of *Bonellia viridis* females in Croatia not reviewed previously (Zavodnik, 1994). Habitat abbreviations: Alg – Algae, seaweeds; cor – coralligenous bottom; Cym – *Cymodocea nodosa*; Pos – *Posidonia oceanica*.

Survey areas and sites	Location type	Depth (m) surveyed	Habitats surveyed
VELI BRIJUN	island	0-8	rock (Alg), sand (Cym)
Rt Saluga	cape	1-8	rock (Alg)
Javorika	cove	0-4	rock (Alg), sand (Cym)
Verige	cove	2-5	rock (Alg)
ZALJEV RAŠA	bay	0-23	rock, gravel, sand, mud
Rt Ubac	cape	1-6	rock (Alg)
Rt Mulac	cape	10-20	rock (Alg), gravel
Tunarica	cove	0-10	rock, stones (Alg)
Luka	cove	8-20	stones (Alg), sand
Prašćarica	cape	2-23	rock (Alg)
RIJEČKI ZALJEV	bay	0-62	rock, gravel, sand, mud
Mošćenička Draga	cove	1-5	rock, pebbles
DUGI OTOK	island	1-13	rock (Alg), sand (Cym)
Farfarikulac	islet	2-4	rock (Alg), sand
KORNATSKI OTOCI	archipelago	0-105	rock, cor, sand, mud
Balun	islet	1-3	rock
Kasela	islet	0-12	rock (Alg), cor
Kornati (Stival)	cove	0-13	rock (Alg), gravel,Pos
Lavsa	islet	0-25	rock (Alg), gravel, Pos
Levrnaka	islet	0-12	rock (Alg)
Lunga	islet	2-5	rock (Alg)
Mana	islet	0-65	rock (Alg), (cor)
Mala Panitula	islet	0-12	rock (Alg)
Rašip	islet	0-75	rock (Alg, cor)
Ravni Žakan	islet	13-35	Pos bed
ROGOZNICA	harbour	1-6	rock (Alg)
BIŠEVO	island	0-6	rock (Alg)
Modra špilja	cave	1-5	barren rock
VELIKA PALAGRUŽA	island	0-28	rock, stones, sand
Veliko žalo	beach	0-2	rock, pebbles
Stara Vlaka	cove	1-4	rock, stones
PELJEŠAC	peninsula	0-6	rock, sand
Trpanj	moorings	0-3	mooring wall
MLJET National Park	island beach, islets	0-95 0-56	rock, sand, cor present paper
LASTOVO	island	0-7	rock, sand
Skrivena luka	cove	3-7	rock, sand

tight crevices and spaces below free stones, boulders, and concrete constructions, and in cliffs (Riedl, 1966). In the sea of Mljet National Park, *Bonellia* lives in various sheltered places in benthic communities. It frequently benefits from the empty borings of the date mussel (*Lithophaga lithophaga*) (Steuer, 1910), it occurred in madreporarian coral *Cladocora caespitosa* bioherms (Kružić, 2001, 2002), in shallow water associations of barnacles *Balanus perforatus*, and in some subtidal seaweed settlements (present paper). Unfortunately, due to lack of time in the course of our biocoenological research we have not looked for planktonic larvae and dwarf males of this species (Schmarda, 1852; Veydovský, 1878) living as internal parasites in females.

Consequently, in Croatian shallow waters in the eastern Adriatic rocky bottom *B. viridis* everywhere is a well distributed benthic species, i.e. in the North, Central, and South basins.

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REFERENCES

Note: In references marked by an asterisk (*) drawings or photographs of *Bonellia viridis* are available.

Andrić, M., 1999: Hrvatsko podmorje. Car Herc d.o.o., Zagreb, 274 pp. (*)

Anonymous, Redakcionnaja kollegija, 1989: Biologičeskij enciklopedičeskij slovar', Sovetskaja enciklopedija, Moskva, p. 78. (In Russian).

Anonymous, Redazione, 2008: Pogonophora – Echiura, In: Giulio Relini (Ed.), Checklist della flora e della fauna dei mari italiani (Parte I). Biol. Mar. Mediterr., 374-375.

Anonymous, 2016: *Bonellia viridis*. Wikipedia, the free encyclopedia, 2 pp.

Baird, W.B., 1868: Monograph of the species of worms belonging to the subclass Gephyrea. Proc. Zool. Soc. London, 1868, 76-114.

Bakić, J., 1967: „Divlja" fauna i flora jadranskog područja kao prirodni rezervoar živežnih namirnica. Pomorski zbornik, **5**, 791-830.

Bakić, J., & Popović, M., 1983: Nekonvencionalni izvori u ishrani na otocima i priobalju u toku NOR-a. In: Pomorska medicina III, Mornarički glasnik, Beograd. Pomorska biblioteka, **33**, 49-55.

Bakran-Petricioli, T., 2011: Priručnik za određivanje morskih staništa u Hrvatskoj prema Direktivi o staništima EU. Državni zavod za zaštitu prirode, Zagreb, 184 pp.

Bauer, V., 1928: Über das Tierleben auf den Seegrasswiesen des Mittelmeeres. Z. Jrb. Syst. Ökol. Geogr. Tiere, **56** (1-2), 1-42.

Belamarić, J.: Personal communication.

Belamarić, J. & D. Šerman, 1989: Ekološka studija podmorja Lokruma. Ekološke monografije, **1**, 361-411.

Belamarić, J., D. Zavodnik, E. Zahtila, A. Novosel, N. Orepić, I. Ostoić, T. Radiša, M. Radošević, J.P. Škalamera & J. Vidmar, 1995: Preliminarni rezultati istraživanja makrobentosa uz vanjsku obalu Nacionalnog parka „Mljet". Ekološke monografije, **6**, 545-553.

Berec, L., P.J. Schembri & D.S. Boukal, 2005: Sex determination in *Bonellia viridis* (Echiura: Bonellidae): population dynamics and evolution. Oikos, **108** (3), 473-484.

Biseswar, R., 2009: The geographic distribution of echiurans in the Atlantic Ocean. Zootaxa, **2222**, 17-30.

Brusina, S., 1907: Naravoslovne crtice sa sjevero-istočne obale Jadranskog mora, dio četvrti i posljednji. Rad Jugosl. akad. zn. umjet., **171**: 42-228.

Campbell, A. C., 1982: The Hamlyn guide to the flora and fauna of the Mediterranean Sea. Hamlyn, London, New York, Sydney, Toronto, 320 pp. (*)

Carus, J.V., 1885: Prodromus faunae Mediterraneae, I.E. Schweizerbart Verl. (E. Koch), Stuttgart, 524 pp.

Cimerman, F., & M.R. Langer, 1991: Mediterranean Foraminifera. Slov. Akad. znan. umet., Cl. IV & Znan. raz. Cent. SAZU, Ljubljana. Dela-Opera, **30,** 118 pp. + 93 pl.

Cori, C.I., 1912: Characteristik der Fauna der nördlichen Adria. Verh. VIII. Int. Zool.-Kongr. Graz., 1910, 689-711.

Cori, C. I., 1928: Der Naturfreund am Meeresstrande. Emil Haim & Co., Wien und Leipzig, 174 pp.

Cuénot, L., 1922: Sipunculiéns, Échiuriens, Priapuliens. Faune de France, **4** (14), 18-24. (*)

Cukrov, M., H. Bilandžija, N. Cukrov & B. Jalžić, 2011: Anhialini speleološki objekti na području otoka Mljeta. In: Durbešić P. & Benović A. (Eds), Zbornik radova Simpozija „Dani Branimira Gušića", Nove spoznaje iz prirodoslovlja otoka Mljeta. Ekološke monografije, **9**, 271-278.

Dell'angelo, B. & D. Zavodnik, 2004: Marine fauna of the Mljet National Park (Adriatic Sea, Croatia). 4. Mollusca: Polyplacophora. Nat. Croat., **13** (4), 319-341.

Dhora, D., 2009: Regjistër i specieve të faunës së Shqipërisë. Camaj-Pipa, Shkodër, 208 pp.

Draganović, E., 1980: Litoralne biocenoze Mljetskih jezera i problemi njihove zaštite (Mimeo). Mr. Sc. Thesis, Sveučilište u Zagrebu, 66 pp.

Ercegović, A., 1949: Život u moru. Biologijska oceanografija. JAZU, Zagreb, 412 pp.

Ercegović, A., 1954: Bentos (Bental). Pomorska enciklopedija, Leksikografski zavod FNRJ, Zagreb, **1**, 441-447.

Ercegović, A., 1959: Parazitizam u moru. Pomorska enciklopedija, Leksikografski zavod FNRJ, Zagreb, **6**, 44.

Faber, G.L., 1883: The fisheries of the Adriatic and the fish thereof. Quaritsch, London, 292 pp.

Fischer, W., 1922: Gephyreen des Reichsmuseum zu Stockholm, Ak. Zool., **14** (19), 1-39.

Gamulin-Brida, H., 1970: Nalazi *Bonellia viridis* u Jadranskom moru (Personal communication). Int. Symp. on the biology of the Sipuncula and Echiura, Kotor 18-25.6.1970.

Gamulin-Brida, H., 1974: Biocoenoses benthiques de la Mer Adriatique, Acta Adr., **15** (9), 1-103.

Garms, H. & L. Borm, 1981: Razred Zvjezdani (Echiurida). Fauna Europe. Mladinska knjiga, Ljubljana-Zagreb, 462-463. (*)

Graeffe, E., 1905: Übersicht des Fauna des Golfes von Triest – Vermes, Arb. Zool. Inst. Wien, **15**, 317-332.

Grube, E., 1861: Ein Ausflug nach Triest und Quarnero. Nikolaische Verl., Berlin, 175 pp.

Grube, E., 1864: Die Insel Lussin und ihre Meeresfauna. F. Hirt, Breslau, 113 pp.

Grubelić, I., 1992: Comparative studies of littoral biocenoses of the Kornati Islands. Acta Adriat., **33**, 127-161.

Grubelić, I., 1997: Osnovna obilježja bentoske faune otoka Purara, posebno zaštićenog dijela Nacionalnog parka „Kornati". In: M. Meštrov, P. Durbešić & M. Kerovec (Eds), Kornati. Hrvatsko ekološko društvo etc., Zagreb, Ekološke monografije, **7**, 257-266.

Guidetti, P., S. Busotti & F. Boero, 2001: Fish visual census in shallow meadows of Mediterranean small-sized seagrasses. Rapp. Comm. int. Mer Médit., **36**, 391.

Heller, C., 1864: Horae Dalmatinae. Abh. zool.-bot. Ges.Wien, **14**, 17-64.

Hofrichter, R., 2003: Das Mittelmeer, III. Spektrum Akademischer Verlag, Heildelberg und Berlin, 859 pp.

Hyman, L.H., 1959. The invertebrates. 3. Smaller coelomate groups. Acanthocephala, Aschelminthes, and Entoprocta, and the pseudocoelomate Bilateria. Mc Graw Hill. Comp., New york, 572 pp.

Jaklin, A. & M. Arko-Pijevac, 1997: Benthic biocoenoses of the St. Marko islet (Rijeka Bay). Period. biol., **99**, 219-228.

Kaestner, A., 1956: 8. Stamm: Echiurida. In: Lehrbuch der Speziellen Zoologie. I., **2**, 342-350. (*)

Kowalevsky, V.O, 1868: O planarieobraznom samcy bonelij (in Russian, not seen).

Kružić, P., 2001: Grebenaste tvorbe vrste *Cladocora caespitosa* (L., 1767) (Anthozoa, Scleractinia) u Jadranskom moru. Mr. Sc. Thesis, Sveučilište u Zagrebu, 107 + XXII p.p.

Kružić, P., 2002: Marine fauna of the Mljet National Park (Adriatic Sea, Croatia). 1. Anthozoa. Nat. Croat., **11** (3), 265-292.

Kružić, P.: Personal communication.

Kuščer, I., 1963: Od Svetega Marka do Vele luke. In: I. Kuščer (Ed.), Sprehodi pod morjem, Državna založba Slovenije, Ljubljana, 70-94. (*)

Legac, M., 1974: Prilog poznavanju litoralne flore i faune otoka Raba. Vijesti muzeal. konzerv. Hr., **23** (5-6), 75-87.

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

Logan, A., 2003: Marine fauna of the Mljet National Park (Adriatic Sea, Croatia). 3. Brachiopoda. Nat. Croat., **12** (4), 233-243.

Lorenz, J. R., 1863: Physicalische Verhältnisse und Vertheilung der Organismen im Quarnerischen Golfe. Verl. K. Akad. Wiss., Wien, 379 pp.

Marcuzzi, G., 1972: Le collezione dell'ex Istituto di Biologia marina di Rovigno conservate presso la Stazione Idrobiologica di Chioggia. Atti Mem. Acad. Patavina Sci. Let. ed Arti, Part II: Cl. Sci. Nat., **84**, 169-219.

Maretić, Z., 1975: Životinje otrovnice i otrovne životinje Jadranskog mora. Jugosl. Akad. znan. umjet., Zagreb, 120 pp.

Mathew, J., 1976: The geographic distribution of echiurans in world oceans with special reference to the Indian forms. In: M.E. Rice & M. Todorović (Eds), Proc. Int. Symp. on the Biology of the Sipuncula and Echiura, Kotor, 18-25 June 1970, Naučno delo Press, Beograd, **2**, 127-133.

Matjašič, J., A. Avčin, L. Kubik, J. Štirn, T. Valentinčič & A. Vukovič, 1971: Morska favna in flora Severnega Jadrana. Katalog 1. Portorož, 33 pp. (Mimeo).

Matjašič, J., J. Štirn, A. Avčin, L. Kubik, T. Valentinčić, T. Velkovrh & A. Vukovič, 1975: Flora in favna Severnega Jadrana. I. Slov. Akad. znan. umetn., Razr. IV: Hist. nat., Ljubljana, 3-56.

Murina, G. V., 1984: Sostav i rasprostranenie ehiur Sredizemnogo morja. Tr. Inst. Okeanol., **119**, 82-98. (In Russian).

Murina, G., 2008: Bonellia viridis Rolando, 1821. In: Read, G. & K. Fauchalt (Eds), 2016: World Polychaeta database. World Register of Marine Species, http://www.marinespecies.org/aphia.php?p=taxdetails&id=110363, on 2016-05-28.

Müller, M., 1852: Observationes anatomicae de vermibus quibusdem maritimis. B, 14-22. (not seen).

Newby, W.W., 1940: The embryology of the echiuroid of the worm *Urechis caupo*. Mem. Am. Philos. Soc., **16**, 1-213.

Novosel, M., T. Bakran-Petricioli, A. Požar-Domac, P. Kružić & I. Radić, 2002: The benthos of the northern part of the Velebit Channel (Adriatic Sea, Croatia). Nat. Croat., **11** (4), 387-409.

Orepić, N., J. Vidmar, E. Zahtila & D. Zavodnik, 1997: A marine benthos survey in the lakes of the National park „Mljet" (Adriatic Sea). Period. biol., **99**, 229-245.

Ostoić, I., 2000: Zaronite u Hrvatskoj. Blue Buble Editor, Zagreb, 245 pp. (*)

Pérès, J. M. & J. Picard, 1964: Nouveau manuel de bionomie benthique de la Mer Méditerranée. Recl. Trav. Stn. mar. Endoume, **31** (47), 3-137.

Picard, J., 1956: Les peuplements benthiques des amphores du Grand-Conglu. Résultats scientifiques des campagnes de la „*Calypso*", 2. Ann. Inst. Océanogr., **32**, 155-161.

Pickford, G. E., 1966: Echiurida (Echiuroidea). In: Encyclopaedia Britannica, 7, 898-901.

Popijač, A., 2011: Biocenoza livada posidonije (*Posidonia oceanica* (L.) Delile) u području NP Mljet. Zbornik radova simpozija „Dani Branimira Gušića", Nove spoznaje iz prirodoslovlja otoka Mljeta. Ekološke monografije, **9**, 181-200.

Quatrefages, A. de, 1865: Gephyriens. Histoire naturelle des Annéles marins et d'eau douce. **2**, 608-632.

Račani team, 1963: Sprehodi pod morjem. I. Kuščer (Ed.), Državna založba Slovenije, Ljubljana, 143 pp. (*)

Riedl, R., 1963: Stamm Echiurida (Igelwürmer). In: R. Riedl, Fauna und Flora der Adria. Parey, Hamburg und Berlin, 231-233. (*)

Riedl, R., 1966: Biologie der Meereshöhlen. Parey, Hamburg und Berlin, 636 pp. (*)

Riedl, R., 1970: Stamm Echiurida – Igelwürmer. In: R. Riedl (Ed.), Fauna und Flora der Adria (2. Aufl.), Parey, Hamburg und Berlin, 260-262. (*)

Rolando, I., 1821: Description d'un animal nouveau qui apparient à la classe des Echinodermes. Memorie Reale accad. sci. Torino, **26**, 539-556. (not seen)

Schembri, P. J. & V. Jaccarini, 1978: Some aspects of the ecology of the echiuran worm *Bonellia viridis* and associated infauna. Mar. Biol., **47**, 55-61.

Schmarda, L. K., 1852: Zur Naturgeschichte der Adria. I. *Bonellia viridis*. Denkschr. k. Akad. Wiss., **4** (2), 117-140.

Seneš, J.: Personal communication.

Sket, B., 2003: Zvezdaši – Echiurida. In: B. Sket, M. Gogala & V. Kuštor (Ed.), Živalstvo Slovenije. Tehniška založba Slovenije, Ljubljana, p. 155. (*)

Sket, B., M. Gogala & V. Kuštor (Eds), 2003: Živalstvo Slovenije. Tehniška založba Slovenije, Ljubljana, 664 pp.

Sluiter, C. P., 1912: Gephyriens (Sipunculides et Echiurids) provenant des campagnes de la Princess Alice, 1898-1910. Result. Camp. sci. Prince Albert I., 36, p. 36. (not seen).

Steuer, A. 1910: Biologisches Skizzenbuch für die Adria. Teubner, Lepzig und Berlin, 82 pp. (*)

Stossich, A., 1876: Breve sunto sulle produzioni marine del Golfo di Trieste. Boll. Soc. adr. Sci. nat. Trieste, **2**, 349-371.

Stossich, M., 1882: Prospetto della fauna del Mare Adriatico. Boll. Soc. adr. Sci. nat. Trieste, **7** (1): 97-171.

Šiletić, T., 2005: Marine fauna of Mljet National Park (Adriatic Sea, Croatia). 5. Mollusca: Bivalvia. Nat. Croat., **15** (3), 109-169.

Špan, A., A. Požar-Domac, B. Antolić & J. Belamarić, 1989: Bentos litoralnog područja otoka Lokruma. Ekološke monografije, **1**, 329-360.

Štoviček-Štirn, M., 1991: Moj drugi svet. I. Jadranski svet. In: M. Dolenc (Ed.), Podmorski svet in mi. Prešernova družba, Ljubljana, 143-170.

Turk, T., 1996: Živalski svet Jadranskega morja. Državna založba Slovenije, Ljubljana, 496 pp. (*)

Turk, T., 2011: Pod površinom Mediterana. Školska knjiga, Zagreb, 590 pp. (*)

Van der Land, J., 2001: Echiura. In: M. J. Costello, Ch. Emblow & R. White (Eds), European register of marine species, Mus. natn. Hist. nat. Paris, Patrimoines naturels, **50**: 178.

Vatova, A., 1928: Compendio della flora e fauna del mare Adriatico presso Rovigno. Mem. R. Com. Talass. It., **143**: 1-614.

Vatova, A., 1949: La fauna bentonica dell'Alto e Medio Adriatico. Nova Thalassia, **1** (3), 1-119 + Tab. VII-XXXVII.

Vejdowský, Fr., 1878: Ueber die Eibildung und die Männchen von *Bonellia viridis* Rol. Ztschr. Wiss. Zool., **30**, 487-498 (not seen).

Vidmar, J., T. Žerlić & N. Orepić, 1996: Istraživanje makrobentosa u podmorju otoka Mljeta (1). Priroda, **86** (832), 22-24.

Wikipedia, the free encyclopedia, 2016.

Willczynski, J.Z., 1960: On egg dimorphysm and sex determination in *Bonellia viridis* R. J. Exp. Zool., **143** (1), 61-75.

Zahtila, E., A. Jaklin & D. Zavodnik, 2000: Prilog faunistici Makarskog primorja. In: M. Kerovec & P. Durbešić (Eds), Zbornik kongresa Prirodoslovna istraživanja Biokovskog područja, Makarska 11-16.10.1993. Biokovo, 2. Ekološke Monografije, **5**, 321-326.

Zavodnik, D., 1991: Nekonvencionalni izvori hrane iz mora na tržištu istočnog Jadrana. In: Zbornik radova znanstvenog skupa 'Tisuću godina prvoga spomena ribarstva u Hrvata', Pomena, Zadar, Sali i Split, 10.-18.10.1995., Hrv. Akad. znan. umj., Zagreb, 637-656.

Zavodnik, D., 1994: Distribution and ecology of Echiura and Priapulida on the Adriatic Sea. Period. biol., **96** (4), 459-462. (*)

Zavodnik, D., 1995-2002: Field diaries (unpublished).

Zavodnik, D., 1998: Prilozi morskoj fauni Riječkog zaljeva. 5. Štrcaljci (Sipuncula) i zvjezdani (Echiura). In: M. Arko-Pijevac, M. Kovačić & D. Crnković (Eds), Prirodoslovna istraživanja riječkog područja, Prirodoslovna biblioteka 1, Prirodoslovni muzej Rijeka, 617-622.

Zavodnik, D., 2003: Marine fauna of Mljet National Park (Adriatic Sea, Croatia). 2. Echinodermata. Acta Adriat., **44** (2), 105-160.
Zavodnik, D., 2016: Marine fauna of Mljet National Park (Adriatic Sea, Croatia). 6. Leptocardia. Nat. Croat., **16** (2), 213-221.
Zavodnik, D., A. Jaklin, E. Zahtila & N. Zavodnik, 2002: Životne zajednice morskog dna na području gradske luke Makarska. In: M. Kerovec & P. Durbešić (Eds), Zbornik kongresa Prirodoslovna istraživanja Biokovskog područja, Makarska 11-16.10.1993. Biokovo, 2. Ekološke Monografije, **5**, 303-312.
Zavodnik, D. & M. Kovačić, 2000: Index of marine fauna in Rijeka Bay (Adriatic Sea, Croatia). Nat. Croat., **9** (4), 297-379.
Zavodnik, D. & M. Legac, 2012: Prirodna obilježja Puntarske drage na otoku Krku (otok Krk, Sjeverni Jadran). In: M. Arko-Pijevac & B. Surina (Eds), Prirodoslovna istraživanja Riječkog područja, II., Prirodoslovni muzej Rijeka, Prirodoslovna biblioteka, **10**, 253-267.
Zavodnik, D., M. Legac & T. Gluhak, 2006: An account of the marine fauna of Pag Island (Adriatic Sea, Croatia). Nat. Croat., **15** (3), 65-107.
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** (Suppl. 2), 3-68.
Zavodnik, D. & A. Šimunović, 1997: Beskralješnjaci morskog dna Jadrana. „Svjetlost" D.D., Zavod za udžbenike i nastavna sredstva, Sarajevo, 219 pp. (*)
Zavodnik, D. & N. Zavodnik, 1994: Biološke značajke mora Brseštine. Katedra Čakavskog Sabora, Opatija. Liburnijske teme, **8**, 168-178.
Zavodnik, N. & D. Zavodnik, 1986: Biološka valorizacija zaljeva Raša. III. Pomorski zbornik, **24** (1), 535-554.
Zei, M., 1955: Crvi, morski. Pomorska enciklopedija, Leksikografski zavod FNRJ, Zagreb, **2**, 296-298.
Zei, M. & J. Zhánèl, 1947: Življenje našega Jadrana. Prirodoznanstvena knjižnica, I. Državna založba Slovenije, Ljubljana, 211 pp.
Zenkevič, L. A., 1963: Biologija morej SSSR. Izdatelstvo Akad. Nauk SSSR, Moskva, 740 pp. (in Russian)
Zimmermann, R., 1907: Die Tierwelt der blauen Adria. Ztschr. f. Naturwiss., **78**, 1-82.

SAŽETAK

Morska fauna Nacionalnog parka Mljet (Jadransko more, Hrvatska). 7. Štrcaljci (Echiura)

D. Zavodnik

Prema dosadašnjim saznanjima stablo štrcaljaca (Echiura) u Jadranskom je moru zastupljeno sa samo jednom porodicom (Bonellidae) i dvjema vrstama: *Bonellia viridis* Rolando, 1821, na stjenovitom dnu plitkog priobalnog područja, te *Maxmuelleria gigas* (M. Müller, 1852) koji se zakapa u dubljim područjima pomičnog uglavnom pjeskovitog dna. Zanimljivo je da tipski materijal obje vrste dijelom potječe i s nalazišta u sjevernom dijelu Jadranskog mora (Carus, 1885).

Prilikom istraživanja studentske udruge „Thais" u moru Nacionalnog parka Mljet, ronioci su u dnevnim i noćnim zaronima često naišli na obitavališta zelenog štrcaljca *Bonellia viridis*, ponajviše u procjepima izmedju stijena i kamenja, u bušotinama drugih organizama (na primjer prstaca *Lithophaga lithophaga*) pa čak i u nakupinama brambuljka *Balanus perforatus*.