NAT. CROAT. | VOL. 20 | No 2 | 397–409 | ZAGREB | December 31, 2011

original scientific paper / izvorni znanstveni rad

NON-MARINE MOLLUSCS (MOLLUSCA: GASTROPODA, BIVALVIA) OF THE ZRMANJA RIVER AND ITS TRIBUTARIES (CROATIA)

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Beran, L.: Non-marine molluscs (Mollusca: Gastropoda, Bivalvia) of the Zrmanja River and its tributaries (Croatia). Nat. Croat., Vol. 20, No. 2., 397–409, 2011, Zagreb.

This paper summarises the results of a malacological survey of the Zrmanja River and its tributaries (Croatia). Although the Zrmanja River is one of the biggest rivers in Croatia belonging to the Adriatic Sea drainage area, its aquatic molluscs are poorly known. Altogether 29 species of aquatic non-marine molluscs (22 gastropods, 7 bivalves) were found in 14 sites in the Zrmanja River and 5 sites in its tributaries in 2009 and 2010. The freshwater part of the Zrmanja River upstream of the Jankovića buk (waterfall) represented by sites No. 4–9 is characterised by the highest diversity. In this part, two very rare and endangered species *Dalmatinella fluviatilis* and endemic *Tanousia zrmanjae* were found only as small populations. In the Krupa River the occurrence of an endemic gastropod *Belgrandiella krupensis* was confirmed.

Key words: Mollusca, *Tanousia zrmanjae*, *Dalmatinella fluviatilis*, *Belgrandiella krupensis*, Zrmanja River, faunistics

Beran, L.: Slatkovodni mekušci (Mollusca: Gastropoda, Bivalvia) rijeke Zrmanje i njenih pritoka (Hrvatska). Nat. Croat., Vol. 20, No. 2., 397–409, 2011, Zagreb.

U radu se donose rezultati malakološkog istraživanja rijeke Zrmanje i njenih pritoka. Iako je Zrmanja jedna od najvećih rijeka jadranskog sliva u Hrvatskoj, njeni vodeni mekušci su slabo poznati. U 2009. i 2010. godini zabilježeno je ukupno 29 vrsta slatkovodnih mekušaca (22 puževa, 7 školjkaša) na 14 lokaliteta na Zrmanji i 5 na njenim pritokama. Slatkovodni dio Zrmanje uzvodno od Jankovića buka (slap) koji predstavljaju lokaliteti br. 4–9 karakterizira najveća raznolikost. U tom dijelu pronađene su male populacije dviju vrlo rijetkih i ugroženih vrsta, *Dalmatinella fluviatilis* i endemska *Tanousia zrmanjae*. U rijeci Krupi potvrđen je endemski puž *Belgrandiella krupensis*.

Ključne riječi: Mollusca, *Tanousia zrmanjae*, *Dalmatinella fluviatilis*, *Belgrandiella krupensis*, rijeka Zrmanja, faunistika

INTRODUCTION

The Zrmanja River is one of the biggest rivers in Croatia belonging to the Adriatic Sea drainage area. The aquatic molluscs of the river are poorly known. Proba-

bly the first data about aquatic molluscs were published in BRUSINA (1866), who mentioned the occurrence of several gastropods e. g. *Theodoxus fluviatilis* (Linnaeus, 1758), *Tanousia zrmanjae* (Brusina, 1866), *Emmericia patula* (Brumati, 1838), *Pyrgula annulata* (Linnaeus, 1767), *Valvata cristata* O. F. Müller, 1774, *Valvata piscinalis* (O. F. Müller, 1774), *Acroloxus lacustris* (Linnaeus, 1758), *Stagnicola fuscus* (C. Pfeiffer, 1821), *Ancylus fluviatilis* O. F. Müller, 1774 or bivalves *Unio mancus* (Lamarck, 1819) and *Pisidium amnicum* (O. F. Müller, 1774). Hydrobioid snails were well studied by P. Radoman who summarised his data in RADOMAN (1983), mentioning the occurrence of several species from this river. *Hydrobia salaria* (Radoman, 1973) and *H. testadura* (Radoman, 1973) are mentioned from the brackish part of the Zrmanja River near Obrovac as well as *Adriohydrobia consociella* (Frauenfeld, 1863). *Dalmatinella fluviatilis* Radoman, 1973, was reported from the Zrmanja River, in its middle, freshwater part as well as *Islamia zermanica* Radoman, 1973. *Orientalina curta* (Küster, 1853) and *Belgrandiella krupensis* Radoman, 1973, are mentioned from a source of the Krupa River while *B. zermanica* Radoman, 1973, was found in the Zrmanja River close to Jankovića buk (waterfall). *Sadleriana fluminensis* (Küster, 1852) was recorded in the freshwater part of the Zrmanja River and also in the Krupa River. *Pyrgula annulata* (Linnaeus, 1767) and finally *Lithoglyphulus tedanicus* Schlickum et Schütt, 1971, were found in the upper (freshwater) course of the Zrmanja River (RADOMAN, 1983). Several species (*Hydrobia salaria*, *H. testadura*, *Islamia zermanica*, *Belgrandiella zermanica*, *B. krupensis*, *Lithoglyphulus tedanicus*) were mentioned only from the Zrmanja or Krupa rivers RADOMAN (1983). SZAROWSKA (2006) published records of *Islamia zermanica* from a spring close to the Zrmanja River. No other data about the occurrence of aquatic molluscs were found, which was the main reason for more detailed research in 2009 and 2010, the results of which are presented in this paper.

MATERIAL AND METHODS

All data used in this study were obtained in summer 2009 and 2010. Only non-marine (freshwater, brackish) molluscs of the Zrmanja River were studied. Altogether 14 sites were studied in the Zrmanja River and 5 sites in the tributaries of this river. The main sampling method for aquatic molluscs is the washing of vegetation or sediments using a metal sieve (a kitchen strainer, diameter 20 cm, mesh size 0.5–1 mm) combined with searches of the surfaces of stones, wood and artificial materials (e.g. plastic bags and bottles). These methods, including diving, were used in this research. Aquatic molluscs were determined according to their shells or dissected and then identified using the differences in their reproductive organs if the identification only based on shells was impossible. Specimens for dissection were killed in hot water and then fixed in 70% ethanol. Selected material of shells and killed specimens in 70% ethanol are deposited in the author's collection.

STUDY AREA

The Zrmanja is a river in southern Lika and northern Dalmatia (Croatia) and was known to the ancient Romans as Tedanius. The spring of the Zrmanja River is

located in southern part of Lika under Poštak – the southern peak of Plješevica mountain, and close to southern end of Mt Velebit. It is characteristic in having a spring located at the bottom of a very steep, almost 200 m high funnel shaped rock called Misije. It flows southward through the narrow and long arable valley that encircles the southern end of Velebit through a 200 m deep canyon, and then turns westwards, reaches Obrovac and after a few kilometers flows into the Adriatic sea in the bay named Novigradsko more. The spring of Zrmanja is 395 m above sea level, and since there are 69 km to the mouth in Novigradsko more, the average fall per kilometer is 5.7 m. Although the river receives most water from the mountain Poštak, there is significant influence by waters which fall into pits on edges of these fields near Gračac, and appear as springs and tributaries which go into the Zrmanja. The average flow of the Zrmanja River in its spring part near Palanka is 5,2 m^3/sec, and in the lower part of the flow near Jankovića buk upstream from Obrovac 40 m^3/sec, which is influenced by the tributary the Krupa and numerous springs. The lower part of the Zrmanja River downstream of Jankovića buk (loc. No. 1–3) is brackish. Except for the short part near Obrovac the whole riverstream is protected in the Zrmanje Canyon Important Landscape (brackish part only) and the rest of the Zrmanja River and also its tributaries are situated in Velebit Nature Park. Despite this, the dam of the reservoir for a hydroelectric power station (HE Velebit) was built in the freshwater part of the Zrmanja River.

The basin of Zrmanja is, according to geological research, built mostly of limestone and dolomite. Waterproof rocks are made of limestone from the geologic era of the Mesozoic, that is, the Triassiac, Jurasic and Cretaceous (220 to 140 million years ago). Waterproof rocks are made of dolomite and limestone plates from the Jurassic, and non-waterproof rocks are clastic, made of sandstone, slate, marl and dolomite. About 40.000 years ago the Zrmanja flowed into the Krka River.

SURVEY OF INVESTIGATED SITES

Data in the list are as follows: site number, geographical co-ordinates (http://www.mapy.cz/), name of the nearest settlement, description of the site, date of investigation. Sites in brackets are situated outside the main stream of the Zrmanja River (tributaries or springs). Sites are ordered upstream from mouth to spring and are depicted in Fig. 1.

1 – 44°12'01''N, 15°40'35''E, Obrovac, the Zrmanja River about 1500 m downstream of the bridge in Obrovac (brackish), 5.7.2010;

2 – 44°11'56''N, 15°41'16''E, Obrovac, the Zrmanja River in Obrovac (brackish), 8.8.2009, 13.8.2009;

3 – 44°12'14''N, 15°41'58''E, Obrovac, the Zrmanja River 2 km to the east of Obrovac (brackish), 13.8.2009;

4 – 44°12'23''N, 15°43'36''E, Zaton-Obrovački, the Zrmanja River near the ruin of the castle St. Obrovac by the destroyed hydroelectric power station (freshwater), 13.8.2009;

5 – 44°12'26''N, 15°44'39''E, Muškovci, the Zrmanja River downstrem of the dam reservoir, 6.7.2010;

(6) – 44°12'05''N, 15°46'02''E, Muškovci, the small tributary of the Zrmanja River about 200 m upstream of the dam reservoir, 6.7.2010;

7 – 44°11'47''N, 15°46'09''E, D. Bilišane (Berberi), the Zrmanja River near waterfalls and bridge in D. Bilišane (Berberi), 9.8.2009, 14.8.2009;

8 – 44°11'38''N, 15°47'35''E, D. Bilišane (Dramotići), the Zrmanja River near D. Bilišane (Dramotiči) upstream of the waterfalls, 3.7.2010, 4.7.2010, 6.7.2010;

9 – 44°11'32''N, 15°48'29''E, D. Bilišane (Dramotići), the Zrmanja River about 800 m downstream of the Visoki buk waterfalls, 14.7.2010;

(10) – 44°11'24''N, 15°53'14''E, Krupa, the Krupa River near the Krupa Monastery, 4.7.2010;

(11) – 44°11'33''N, 15°54'33''E, Krupa, the Krupa River in Krupa near the bridge, 14.7.2010;

(12) – 44°11'33''N, 15°54'34''E, Krupa, a spring by the Krupa River in Krupa near the bridge, 14.7.2010;

13 – 44°09'43''N, 15°51'28''E, Kaštel Žegarski, the Zrmanja River in Kaštel Žegarski, 9.8. 2009, 4.7.2010;

14 – 44°09'04''N, 15°53'12''E, Prndelji, the Zrmanja River 200 m upstream of the bridge in Prndelji, 8.7.2010;

15 – 44°06'28''N, 15°56'23''E, Ervenik, the Zrmanja River in Ervenik near the bridge, 10.8. 2009 (dried), 8.7.2010;

16 – 44°05'31''N, 16°02'01''E, Mokro Polje, the Zrmanja River in Mokro Polje near the bridge, 10.8.2009, 8.7.2010;

17 – 44°08'18''N, 16°04'30''E, Palanka, the Zrmanja River in Palanka, 10.8.2009;

(18) – 44°11'45''N, 16°03'22''E, Zrmanja, a small tributary of the Zrmanja River near a monument in Zrmanja, 8.7.2010;

19 – 44°11'59''N, 16°03'49''E, Zrmanja Vrelo, the Zrmanja River about 2 km from its spring in Zrmanja Vrelo, 8.7.2010.

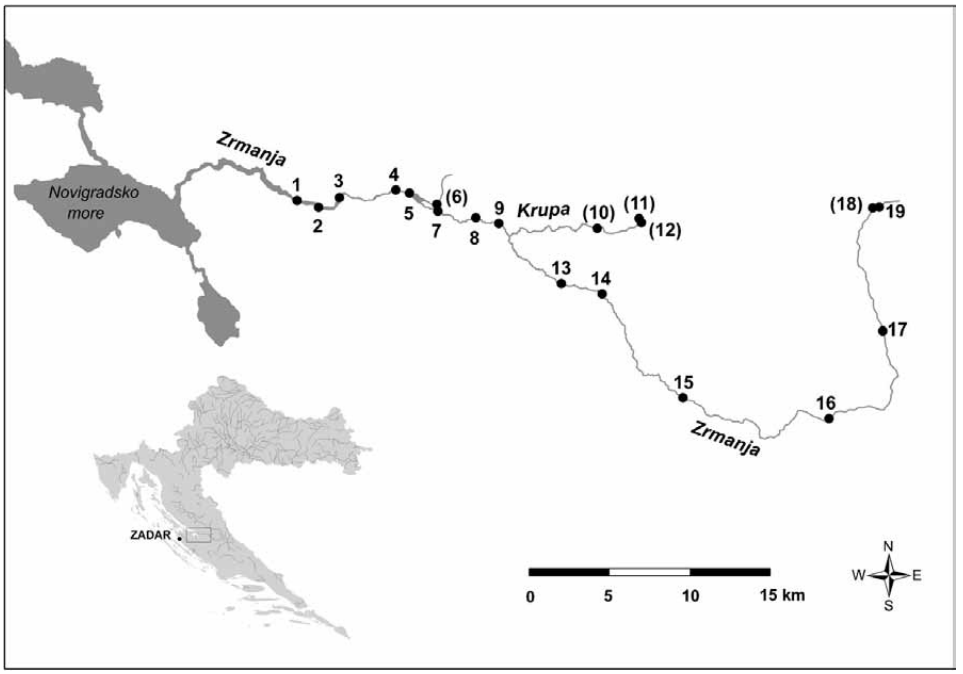

Fig. 1. The map of the sites under study.

RESULTS

This part includes a list of recorded mollusc species, with some notes about distribution in the area under study. Sites with the occurrence of individual species are placed at the end of every single description and are also tabularly mentioned in Tab. 1.

GASTROPODA

Neritaemorphi

Neritopsina

Neritidae

Theodoxus fluviatilis (Linnaeus, 1758) – widespread and dominant mollusc in the brackish part as well as in the lower freshwater part of the Zrmanja River and two tributaries. Sites No. 1–(10) and 13.

Ceanogastropoda

Neotaenioglossa

Bithyniidae

Bithynia tentaculata (Linnaeus, 1758) – common species in the lower freshwater part of the Zrmanja River and one tributary. Sites No. 4–9.

Hydrobiidae

Hydrobia acuta (Draparnaud, 1805) – this species was found in the brackish part of the Zrmanja River in sites No. 1.–3. RADOMAN (1983) mentioned occurrence of two species of genus *Hydrobia* from the brackish part of the Zrmanja River – *Hydrobia salaria* (Radoman, 1973) and *H. testadura* (Radoman, 1973) and reported the Zrmanja River near Obrovac as the type locality of these two species. GIUSTI & PEZZOLI (1984) considered both species to be only synonyms for the widespread *Hydrobia acuta* (Draparnaud, 1805). Specimens found in the Zrmanja River in these sites were dissected and determined as *Hydrobia acuta*. This determination is preliminary due to the existence of cryptic species without anatomical differences among taxa of *Hydrobia* sensu stricto (WILKE *et al.*, 2000) and the absence of genetic data from the population in this river.

Ecrobia ventrosa (Montagu, 1803) – this species was found in numerous population in the brackish part of the Zrmanja River in site No. 1.

Adriohydrobia gagatinella (Küster, 1852) – this species was found in the brackish part of the Zrmanja River where it belongs among the dominant molluscs. RADOMAN (1983) mentioned an occurrence of *Adriohydrobia consociella* (Frauenfeld, 1863) from this part, but WILKE & FALNIOWSKI (2001) confirmed that the genus *Adriohydrobia* comprises only one species *Adriohydrobia gagatinella*, while *A. consociella* and *A. kutschigi* (Küster, 1852) are only junior synonyms. Sites No. 1–3.

Sadleriana fluminensis (Küster, 1852) – at many sites in the freshwater part of the Zrmanja River it is a dominant mollusc, as it is in the Krupa River and the tributary at site No. (6). Sites No. (6)–(11), 13, 14, 16, 17, 19.

Tab.1. List of aquatic molluscs according to localities.

Species/Site No.	1	2	3	4	5	(6)	7	8	9	(10)	(11)	(12)	13	14	15	16	17	(18)	19	Σ
Theodoxus fluviatilis (Linnaeus, 1758)	xxx	xxx	xxx	xxx	xx	xxx	xxx	xxx	xxx	xx			x							11
Bithynia tentaculata (Linnaeus, 1758)				xxx	xxx	xxx	xxx	xxx	xxx											6
Hydrobia acuta (Draparnaud, 1805)	xx	xx	xx																	3
Ecrobia ventrosa (Montagu, 1803)	xxx																			1
Adriohydrobia gagatinella (Küster, 1852)	xxx	xxx	xxx																	3
Sadleriana fluminensis (Küster, 1852)						xxx	xxx	xxx	xxx	xxx	xxx		xxx	xx		xxx	xx		x	11
Belgrandiella krupensis Radoman, 1973								x?		x	xx	xxx								4
Radomaniola curta (Küster, 1853)								x		xxx	xx	xx								4
Dalmatinella fluviatilis Radoman, 1973								x												1
Tanousia zrmanjae (Brusina, 1866)							(x)	x												2
Pyrgula annulata (Linnaeus, 1767)							x	x	x											3
Emmericia patula (Brumati, 1838)						xxx	x	x		x										4
Valvata piscinalis (O. F. Müller, 1774)				xx	xxx		xx	xx												4
Acroloxus lacustris (Linnaeus, 1758)				x	x			x	x											4
Stagnicola fuscus (C. Pfeiffer, 1821)				xx		xx	xx	xx	xx											5
Radix auricularia (Linnaeus, 1758)								xx						x						2
Radix labiata (Rossmäessler, 1835)						xx	x	xxx	xxx				xxx	xxx	xx	xxx	x		xxx	10
Planorbis planorbis (Linnaeus, 1758)													xxx	xxx	x	xx				4
Planorbis carinatus (O. F. Müller, 1774)				xx		xx	xxx	xxx	xxx											5
Gyraulus sp.														xx	x	x				3
Hippeutis complanatus (Linnaeus, 1758)				x	x			x	x											4
Ancylus fluviatilis O. F. Müller, 1774						x	x	x	xxx	x	xxx		x	x		xxx	xxx	xx	x	12
Unio mancus (Lamarck, 1819)				xxx	xxx		xx	xxx	xxx											5
Anodonta anatina (Linnaeus, 1758)				x	xx	x	x	x	x											6
Pisidium amnicum (O. F. Müller, 1774)				xx	xx	x	xx	xxx	xxx	x	xx		xx	xx		x	x			12
Pisidium subtruncatum Malm, 1855				x	xx	xx	x	xxx	xx				xx	x		x				9
Pisidium nitidum Jenyns, 1832				x	x	x		x	x											5
Pisidium personatum Malm, 1855							x	x		x									xx	4
Pisidium casertanum (Poli, 1791)							x	xx	xx	xx	xx		xx	x		x		xxx		9
Number of species	**4**	**3**	**3**	**12**	**10**	**11**	**17**	**24**	**16**	**9**	**6**	**2**	**8**	**9**	**3**	**8**	**4**	**2**	**4**	

x – a few specimens, xx – scattered occurrence, xxx – abundant occurrence, (x) – old shells.

Belgrandiella krupensis Radoman, 1973 – this (probably) endemic species was found in the Krupa River and also in a small spring by this river. Sites (11) and (12). RADOMAN (1983) described from the Zrmanja River also *B. zermanica*. This species was distinguished only on the basis of small conchological differences, and the validity of both species needs more detailed research. Empty shells found at site No. 8 were identical with shells from the Krupa River and in this paper are mentioned as *B. krupensis*.

Radomaniola curta (Küster, 1853) – syn. *Orientalina curta* (Küster, 1853). Numerous populations of this mollusc were found in the Krupa River and a few individuals were also found in the Zrmanja River. Sites No. 8, (10)–(12).

Dalmatinella fluviatilis Radoman, 1973 – a few individuals were found in only one site of the Zrmanja River. This is a rare species, which is known only in the Zrmanja River and in the Neretva River between Kula and Opuzen (RADOMAN, 1983). Site No. 8.

Tanousia zrmanjae (Brusina, 1866) – syn. *Lithoglyphulus tedanicus* Schlickum et Schütt, 1971. A small population of this endemic species was found in only one site in the freshwater part of the Zrmanja River and empty shells were found downstream of this site. Sites No. 8 and 9.

Pyrgula annulata (Linnaeus, 1767) – usually only several specimens of this species were found at three sites in the lower freshwater part of the Zrmanja River. Sites No. 7–9.

Family: Emmericiidae

Emmericia patula (Brumati, 1838) – dominant mollusc in the tributary of the Zrmanja River upstream of the dam reservoir. Only a rare occurrence was recorded at the lower freshwater part of the Zrmanja and Krupa rivers. Sites No. (6)–8, (10).

Heterobranchia

Ectobranchia

Valvatidae

Valvata piscinalis (O. F. Müller, 1774) – scattered occurrence of this mollusc was considered in four sites in lower freshwater part of the Zrmanja River. Sites No. 4, 5, 7 and 8.

Pulmonata

Basommatophora

Hygrophila

Acroloxidae

Acroloxus lacustris (Linnaeus, 1758) – usually a few specimens were found at four sites of the lower freshwater part of the Zrmanja River. Sites No. 4, 5, 8, 9.

Lymnaeidae

Stagnicola fuscus (C. Pfeiffer, 1821) – this mollusc was found only occasionally but is not rare in the lower freshwater part of the Zrmanja River and also in small tributary upstream of the dam reservoir. Sites No. 4–9.

Radix auricularia (Linnaeus, 1758) – rare or scattered occurrence of this common and widespread species was registered in two sites situated in the lower freshwater part of the Zrmanja River. Sites No. 8 and 14.

Radix labiata (Rossmäessler, 1835) – this mollusc occurred in different abundances in all sites in the freshwater part of the Zrmanja River except the first two freshwater sites No. 4 and 5 and was found also in a small tributary upstream of the dam reservoir. Shells of individuals in sites No. (6)–9 were similar to *Radix ampla* (Hartmann, 1821). Sites No. (6)–9, 13–17 and 19.

Planorbidae

Planorbis planorbis (Linnaeus, 1758) – occurrence of this species was recorded in the upper part of the Zrmanja River (upstream of Kaštel Žegarski) and numerous populations were found at two sites. Sites No. 13–16.

Planorbis carinatus (O. F. Müller, 1774) – while previous species occurred in the freshwater part of the Zrmanja River upstream of Kaštel Žegarski *Planorbis carinatus* was found in numerous populations in sites situated downstream. Sites No. 4 and (6)–9.

Gyraulus sp. – occurrence of unidentified species of genus *Gyraulus* was recorded in three sites. Unfortunately all specimens were infected and it was not possible to identified them on the base of reproductive organs. Shells were very close to the shells of *G. parvus* (Say, 1817) or *G. laevis* (Alder, 1838). Sites No. 14–16.

Hippeutis complanatus (Linnaeus, 1758) – rare occurrence of this gastropod was registered in the lower freshwater part of the Zrmanja River. Sites No. 4–5 and 8–9.

Ancylus fluviatilis O. F. Müller, 1774 – in the freshwater part of the Zrmanja River common mollusc especially in flowing parts. Sites No. (6)–(11), 13–14 and 16–19.

BIVALVIA

Palaeoheterodonta

Unionoida

Unionidae

Unio mancus (Lamarck, 1819) – this bivalve was found in the lower freshwater part of the Zrmanja River. In nearly all sites, numerous populations with densities of more than 30 ind./m^2 were found. Sites No. 4–5, 7–9.

Anodonta anatina (Linnaeus, 1758) – compared to the previous bivalve, it was found only occasionally (a few specimens) in the same part of the Zrmanja River and one tributary. Sites No. 4–9.

Heterodonta

Veneroida

Sphaeriidae

Pisidium amnicum (O. F. Müller, 1774) – the most abundant species of the genus *Pisidium* which inhabited many sites in the freshwater part of the Zrmanja River and its tributaries. Sites No. 4–(11), 13–14, 16–17.

Pisidium subtruncatum Malm, 1855 – common and widespread pea mussel which was found also at many sites of the freshwater part of the Zrmanja River and its tributaries. Sites No. 4–9, 13–14, 16.

Pisidium nitidum Jenyns, 1832 – this widespread pea mussel was found only in the lower freshwater part of the Zrmanja River. Sites No. 4–(6), 8–9.

Pisidium personatum Malm, 1855 – occurrence of *P. personatum* was recorded at two sites in the lower freshwater part of the Zrmanja River, Krupa River and in the Zrmanja River in Zrmanja Vrelo. Sites 7–8, (10), 19.

Pisidium casertanum (Poli, 1791) – this widespread species was found in many sites in the freshwater part of the Zrmanja River and also in its tributaries. The more abundant occurrence was considered from a small tributary in Zrmanja. Sites 7–(11), 13–14, 16, (18).

DISCUSSION

Altogether 29 species of aquatic non-marine molluscs (22 gastropods, 7 bivalves) were found in the Zrmanja River and its tributaries. According to the aquatic molluscs found, it is possible to divide the Zrmanja River into four different parts. The first part (sites No. 1–3) from the inflow to the Adriatic Sea to Jankovića buk (waterfall) upstream of Obrovac is brackish. This part is wide and slow-flowing (Fig. 2). Only four non-marine species (*Theodoxus fluviatilis*, *Hydrobia acuta*, *Ecrobia ventrosa*, *Adriohydrobia gagatinella*) in numerous populations were found in this part. The second part (freshwater) of the Zrmanja River upstream of Jankovića buk (waterfall) is represented by sites No. 4–9, including the small tributary (site No. (6)). Slowly flowing parts with pools alternate with fast flowing parts with waterfalls and rips (Fig. 3). This part is characterised by the highest diversity. Molluscan communities are composed of more than 10 species and at site No. 8, 24 species were found. Populations of *Bithynia tentaculata, Dalmatinella fluviatilis, Tanousia zrmanjae, Pyrgula annulata, Valvata piscinalis, Acroloxus lacustris, Stagnicola fuscus, Planorbis carinatus, Hippeutis complanatus, Unio mancus, Anodonta anatina* and *Pisidium nitidum* were only recorded in this part. The third part is the Krupa River (sites No. (10)–(12)). Type of the watercourse is similar to the watercourse in the second part (Fig. 4). This tributary is characterised by the occurrence of *Radomaniola curta* and the endemic *Belgrandiella krupensis*. The fourth part is the Zrmanja River, represented by sites No. 13–19. In this section the Zrmanja River is also similar to second part but the watercourse is not so wide and fast-flowing parts are predominant (Fig. 5 and 6). Species diversity is lower in comparison with the second part. *Sadleriana fluminensis, Radix labiata, Planorbis planorbis* and *Ancylus fluviatilis* are dominant in this part. Gastropods *Planorbis planorbis* and *Gyraulus* sp. occurred only in this part.

All four species found in the brackish part are common and widespread although, except *Theodoxus fluviatilis* and *Ecrobia ventrosa*, they were originally described as endemic to the Zrmanja River (*Hydrobia salaria, H. testadura, Adriohydrobia consociella*) (RADOMAN 1983). In second part, two very rare and endangered species *Dalmatinella fluviatilis* and *Tanousia zrmanjae* were found only in small populations. *Dalmatinella fluviatilis* is also mentioned in RADOMAN (1983) from the Neretva River

Fig. 2. The Zrmanja River in its brackish part near Obrovac (site No. 3). All photos by author.

Fig. 3. The Zrmanja River at site No. 8.

Fig. 4. The Krupa River is the biggest tributary of the Zrmanja River. Site No. (10).

Fig. 5. The Zrmanja River at site No. 14.

Fig. 6. The Zrmanja River at Zrmanja Vrelo (site No. 19).

while *Tanousia zrmanjae* is a gastropod endemic only to the Zrmanja River and due to the scattered occurrence, it is considered to be the most endangered mollusc of this river. Scattered occurrence of this species is mentioned also by Peter Reischütz who found the last living specimen in 2002, and in 2010 found many old and only one fresh shell near the site No. 8 (REISCHÜTZ, pers. comm.). A population of the endemic gastropod *Belgrandiella krupensis* was found in the Krupa River.

In comparison with previous research published in BRUSINA (1866), all species except *Valvata cristata* were found. This relatively common and widespread species could have been overlooked in 2009 and 2010 and misidentification by S. Brusina is also possible. RADOMAN (1983) also mentioned the occurrence of *Belgrandiella zermanica* and *Islamia zermanica*. The first species was not found, but the type locality (Zrmanja River near Jankovića buk), was not searched and validity of this species

needs more detailed research (see text about *Belgrandiella krupensis*). *Islamia zermanica* was not recorded either, but its occurrence from a spring close to the Zrmanja River is mentioned in SZAROWSKA (2006), so the existence of this endemic species was confirmed relatively not long ago. SZAROWSKA (2006) also mentioned the Zrmanja River among destroyed localities of Balkan hydrobiids. The reason is »the river having been dammed in its upper course was apparently changed into a system of stagnant pools (like that at Kaštel Žegarski) interspersed with a dry river bed (like that at Ervenik)«. RÉGNIER *et al.* (2009) probably on the base of SZAROWSKA (2006) even mentioned the gastropods *Belgrandiella zermanica, Dalmatinella fluviatilis, Islamia zermanica, Tanousia zrmanjae* as extinct species. Although the results presented above showed that at least two of the mentioned endangered species (*Dalmatinella fluviatilis, Tanousia zrmanjae*) still occur in the Zrmanja River, the conditions are not favourable, especially because of the existence of the dam reservoir on the Zrmanja River (between sites No. 7 and 5).

CONCLUSIONS

The Zrmanja River is inhabited by valuable and diverse molluscan communities. The most important part is the lower freshwater part between Jankovića buk (waterfall) and Kaštel Žegarski including the Krupa River. This part is the most important for the survival of endemic or very rare species such as *Belgrandiella krupensis, Dalmatinella fluviatilis, Tanousia zrmanjae* and valuable molluscan communities. It is necessary to avoid any other negative human impact (e. g. building dams or weirs, water polution).

More detailed research based especially on the occurrence of endangered and endemic species is needed, in addition to research into some problematic genera, e. g. *Hydrobia* or *Belgrandiella*.

ACKNOWLEDGEMENTS

I would like to thank Michal Horsák for determination or revision of selected species of the genus *Pisidium* collected in 2009 and I am also much obliged to Peter Glöer for help with determination or revision of selected gastropods collected in 2009. I am obliged to Jasna Lajtner for help with permission for this research, which was enabled by the Ministry of Culture of Croatia, and to Zoltán Fehér, Peter Reischütz and Marco Bodon for valuable informations and comments. I also thank two anonymous reviewers for helpful comments.

Received October 22, 2010

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SUMMARY

Non-marine molluscs (Mollusca: Gastropoda, Bivalvia) of the Zrmanja River and its tributaries (Croatia).

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The Zrmanja River is one of the biggest rivers in Croatia belonging to the Adriatic Sea drainage area, the aquatic molluscs of which are poorly known. Except for old records mentioned in BRUSINA (1866) and more than 100 hundred years later records of hydrobioid snails published by RADOMAN (1983) and several other records cited in this paper, no other data about the occurrence of aquatic molluscs were found. This fact was the main reason for more detailed research in 2009 and 2010. Altogether 29 species of aquatic non-marine molluscs (22 gastropods, 7 bivalves) were found in 14 sites of the Zrmanja River and 5 sites of its tributaries in 2009 and 2010. Only four non-marine species (*Theodoxus fluviatilis*, *Hydrobia acuta*, *Ecrobia ventrosa*, *Adriohydrobia gagatinella*) were found in the brackish part. The freshwater part of the Zrmanja River upstream of Jankovića buk (waterfall) represented by sites No. 4–9 is characterised by the highest diversity. Molluscan communities were composed from more than 10 species and in site No. 8 24 species were found. Populations of 12 species were only recorded in this part, including the endangered species *Dalmatinella fluviatilis* and the endemic *Tanousia zrmanjae*, which were found only in small populations. Species diversity of the following part, represented by sites No. 13–19, is lower. Two gastropods *Planorbis planorbis* and *Gyraulus* sp. occurred only in this part. The Krupa River is characterised by the occurrence of *Radomaniola curta* and endemic *Belgrandiella krupensis*.

The Zrmanja River is inhabited by valuable and diverse molluscan communities. The most important part is the lower freshwater part between Jankovića buk (waterfall) and Kaštel Žegarski including the Krupa River. This part is the most important for the survival of endemic or very rare species such as *Belgrandiella krupensis*, *Dalmatinella fluviatilis*, *Tanousia zrmanjae* and valuable molluscan communities. It is necessary to avoid any other negative human impact (e. g. building dams or weirs, water polution).