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AQUATIC MOLLUSCAN FAUNA (MOLLUSCA: GASTROPODA, BIVALVIA) OF VRANA LAKE NATURE PARK (CROATIA)

Luboš Beran[1]*, Jasna Lajtner[2]* & Petar Crnčan[3]

[1]Agency for Nature Conservation and Landscape Protection of the Czech Republic, Kokořínsko Protected Landscape Area Administration, Česká 149, CZ–276 01 Mělník, Czech Republic (e-mail: lubos.beran@nature.cz)

[2]Department of Zoology, Division of Biology, Faculty of Science, University of Zagreb, Rooseveltov trg 6, HR-10000 Zagreb, Croatia (e-mail: jasna.lajtner@zg.biol.pmf.hr)

[3]Croatian Natural History Museum, Demetrova 1, HR-10000 Zagreb, Croatia (e-mail: petar.crncan@gmail.com)

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This paper presents the results of a malacological survey of the largest Croatian lake – Vrana Lake and its surroundings in Vrana Lake Nature Park. Altogether 21 species of aquatic non-marine molluscs (15 gastropods, 6 bivalves) have been recorded. Out of all recorded species, only 10 were documented in Vrana Lake, probably due to the higher salinity of water in the lake. A population of the endangered gastropod *Anisus vorticulus* was found in Benča Lake.

Key words: Mollusca, Gastropoda, Bivalvia, *Anisus vorticulus*, Vrana Lake, faunistics

Beran, L., Lajtner, J. & Crnčan, P.: Slatkovodni mekušci (Mollusca: Gastropoda, Bivalvia) Parka prirode Vransko jezero (Hrvatska). Nat. Croat., Vol. 22, No. 1., 15–27, 2013, Zagreb.

U radu su izneseni rezultati malakološkog istraživanja najvećeg hrvatskog jezera - Vranskog jezera, te drugih vodenih staništa na području istoiomenog Parka prirode. Ukupno je zabilježena 21 vrsta slatkovodnih mekušaca (15 vrsta puževa i 6 vrsta školjkaša), od kojih je u samom jezeru pronađeno samo 10 vrsta, što je najvjerojatnije posljedica povišenog saliniteta. U lokvi Benča pronađena je populacija zaštićene i ugrožene vrste puža *Anisus vorticulus*.

Ključne riječi: Mollusca, Gastropoda, Bivalvia, *Anisus vorticulus*, Vransko jezero, faunističko istraživanje

INTRODUCTION

Vrana Lake is a unique wetland situated along the eastern Adriatic coast in Croatia (Fig. 1). Due to its hydrological, ecological, geomorphological and landscape values, it has been under protection since 1999 as a nature park (Katalinić *et al.*, 2008), while in 2013 it was included in the Ramsar List of Wetlands of international importance (www.ramsar.org).

Even though extensive floristic and faunistic research that has been conducted in the park (e.g. Mrakovčić, 2004; Radović *et al.*, 2004; Mihaljević *et al.*, 2005; Treer *et al.*, 2010; Kövér *et al.*, 2012), its aquatic molluscan fauna remains unexplored.

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* These authors contributed equally to this work. Corresponding author: L. Beran

Fig. 1. Vrana Lake Nature Park, February 19, 2011. All photos by I. Lajtner.

The main aim of this research was to provide an inventory of aquatic molluscs, examine their population densities, and establish the occurrence of endangered, as well as non-native molluscs and their possible impacts on native molluscan assemblages.

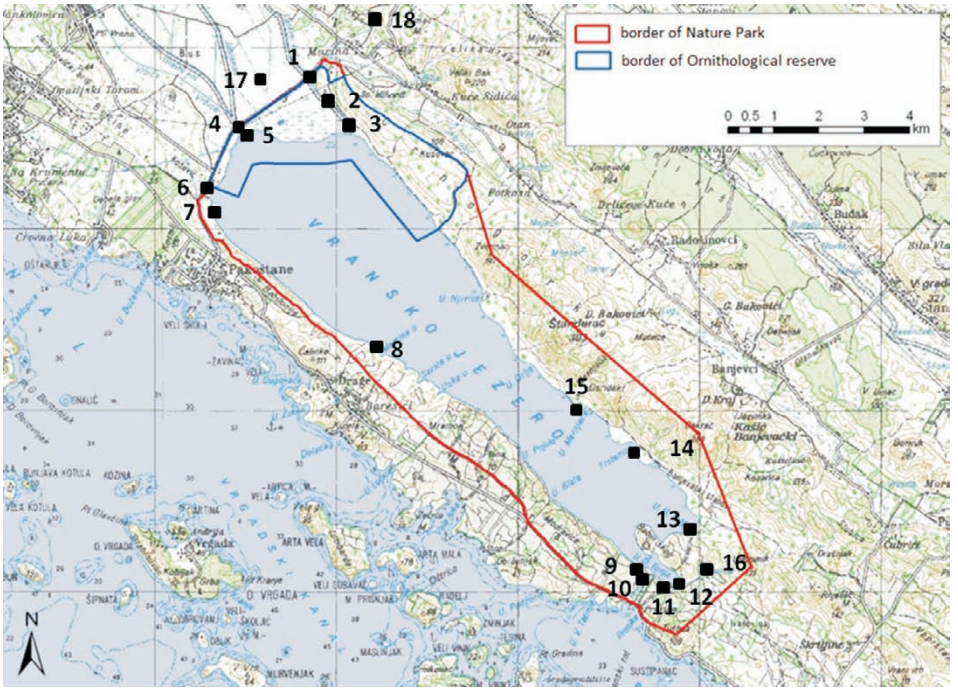

Fig 2. Position of the sampling sites.

MATERIAL AND METHODS

All data used in this study were obtained through a field study conducted from August 2009 to December 2011. Out of 18 examined sites, the majority (16 sites) were located in Vrana Lake Nature Park, while 2 sites were outside of the park (Fig. 2). The main collecting method of aquatic molluscs was sampling by washing vegetation or sediments using a metal sieve (a kitchen strainer, diameter 20 cm, mesh size 0,8 mm) combined with searching surfaces of stones, wood and artificial materials (e.g. plastic bags and bottles) and diving (snorkelling) in shallow parts (ca 3 m deep) of the lake.

Density of recorded mollusc populations was analysed at 10 selected sites in March, May, July, October and December 2011. Samples were collected in triplicate using a 25x25 cm Surber sampler. After processing in the field (removal of wood debris and stones), collected samples were preserved in 70 % ethanol. Density of all recorded molluscs was calculated as an average number of specimens per m^2. At each sampling site we recorded the following water quality parameters using a pH/Oxi 340i probe: water temperature (°C), dissolved oxygen (mg/l), oxygen saturation (%), pH, salinity (‰) and conductivity (mS/cm).

Aquatic molluscs were determined according to their shells or on the basis of differences of their reproductive organs if identification based exclusively on shells was impossible (Glöer, 2002). Specimens for dissection were anaesthetized with menthol (or 5 % ethanol) and killed in hot water and then fixed in 70 % ethanol. Selected material of shells and preserved specimens in 70 % ethanol is deposited in the authors' collections.

STUDY AREA

Vrana Lake is located in the central coastal part of the eastern Adriatic coast, in close proximity to the sea. It is separated from the sea by a narrow limestone ridge over 10 km long. With a surface of 30.2 km^2, an average width of 2.2 km and average length of approximately 13.6 km, Vrana Lake is the largest natural lake in Croatia (Katalinić *et al.*, 2008).

Fig 3. The canal Prosika (Site No. 10), May 20, 2011.

The lake is a cryptodepression with the greatest depth of 3 m under sea level, while the average depth averages around 5 meters. Due to its low average depth, the mechanical activity of waves can mix the entire water column, forming a polymictic lake without stratification. The area is characterized by a typical Mediterranean climate, with a maritime rain regime.

The lake is recharged by waters from several sources within its catchment area, surface waters, but also through non-localized ground waters on the lake brim (Rubinić *et al.*, 2010). The majority of inflows enter the lake through the Main (Kotarka) and the Lateral Canal, which form a part of the extensive soil reclamation system. The aim of the reclamation system was to create agricultural fields from the peripheral parts of the lake (Rubinić *et al.*, 2010). Kotarka collects waters from the main canals, while the Lateral canal collects waters from the north eastern edge of the lake.

In the 18th century, the lake was connected with the sea by the 800 m long Prosika canal, the aim being to reduce the marsh area of the Vrana field and thereby to control the spread of malaria, as well as to enlarge the area of cultivable land. In the meantime, the canal has been widened and deepened several times in order to improve the constructed reclamation system drainage conditions. Currently, the canal is 4 m wide and 5-6 m deep (Rubinić *et al.*, 2010). This canal enables the outflow of the water from the lake into the sea, and the inflow of sea into the lake during drought periods. Even before the construction of the canal, sea water infiltrated into the lake basin through the porous karst ridge dividing the lake from the sea (Katalinić *et al.*, 2012). During a heavy drought in 2008, the inflow of the sea into the lake through Prosika canal and through numerous springs on the lake shore caused intensive lake salinization (Rubinić *et al.*, 2009).

The riparian communities of Vrana Lake are dominated by *Phragmites australis*. These communities have multiple ecological roles ranging from hydrological regulation to accumulation of sediment and nutrients. Moreover, these communities are characterized by high biodiversity (Mrakovčić, 2004). Finally, Vrana Lake is an ornithological hot-spot (Radović *et al.*, 2004), and an especially important feeding area during winter migrations. Due to its importance, a Special Ornithological Reserve was formed in its north-west part in 1983 and has been included to the list of Important Bird Areas in Europe (Katalinić *et al*., 2008).

SURVEY OF INVESTIGATED SITES

A list of the survey sites is provided below. 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, name of the author (LB – L. Beran, JL – J. Lajtner, PC – P. Crnčan). Sites in parentheses are outside of the nature park.

1 – 43°56′55″N, 15°32′09″E, Vrana, a canal (Lateral canal) in the northeastern margin of Vrana Lake Nature Park by the road Pakoštane - Vrana, 6.7.2011, LB;

2 – 43°56′39″N, 15°32′24″E, Vrana, a canal (Lateral canal) in the northeastern margin of Vrana Lake Nature Park about 750 m from the road Pakoštane - Vrana, 6.7.2011, LB; 19.3.2011, 20.5.2011, 19.7.2011, 6.10.2011, 13.12.2011, JL & PC;

3 – 43°56′26″N, 15°32′45″E, Vrana, a canal (Lateral canal) in the northeastern margin of Vrana Lake Nature Park about 1500 m from the road Pakoštane - Vrana, 6.7.2011, LB;

4 – 43°56′21″N, 15°30′58″E, Crkvine, the canal (Main canal) before inflow to Vrana Lake by the bridge of the road, 15.7.2010, LB; 19.3.2011, 20.5.2011, 19.7.2011, 6.10.2011, 13.12.2011, JL & PC;

Fig 4. Jugovir (Site No. 11), May 20, 2011.

5 – 43°56′11″N, 15°31′08″E, Crkvine, the northern bank of Vrana Lake in the inflow of the canal (Main canal), 6.7.2011, LB;

6 – 43°55′39″N, 15°30′37″E, Crkvine, the northwestern bank of Vrana Lake near the camping site, 12.8.2009, LB; 19.3.2011, 20.5.2011, 19.7.2011, 6.10.2011, 13.12.2011, JL & PC;

7 – 43°55′29″N, 15°30′30″E, Crkvine, the northwestern bank of Vrana Lake about 500 m from the camping site, 12.8.2009, LB;

8 – 43°53′44″N, 15°33′08″E, Drage, the western bank of Vrana Lake, 15.7.2010; 19.3.2011, 20.5.2011, 19.7.2011, 6.10.2011, 13.12.2011, JL & PC;

9 – 43°51′02″N, 15°37′40″E, Drage, the southwestern bank of Vrana Lake near the canal Prosika, 11.7.2010, LB; 19.3.2011, 20.5.2011, 19.7.2011, 6.10.2011, 13.12.2011, JL & PC;

10 – 43°50′59″N, 15°37′44″E, Drage, the beginning of the artificial canal Prosika from Vrana Lake, 11.7.2010, LB; (Fig. 3)

11 – 43°50′53″N, 15°38′02″E, Drage, Jugovir, the southwestern bank of Vrana Lake about 500 m south to the information centre, 3.7.2011, LB; 19.3.2011, 20.5.2011, 19.7.2011, 6.10.2011, 13.12.2011, JL & PC; (Fig. 4)

12 – 43°50′55″N, 15°38′13″E, Drage, the southwestern bank of Vrana Lake near the bike track, 3.7.2011, LB;

13 – 43°51′29″N, 15°38′25″E, Drage, the southeastern bank of Vrana Lake, 3.7.2011, LB;

14 – 43°52′22″N, 15°37′30″E, Kašič Banjevački, Punta, the southeastern bank of Vrana Lake, 19.3.2011, 20.5.2011, 19.7.2011, 6.10.2011, 13.12.2011, JL & PC; (Fig. 5)

15 – 43°53′00″N, 15°36′32″E, Kašič Banjevački, Bašinka, the southeastern bank of Vrana Lake, 19.3.2011, 20.5.2011, 19.7.2011, 6.10.2011, 13.12.2011, JL & PC;

16 – 43°51′06″N, 15°38′34″E, Drage, Benča Lake (dry) in Vrana Lake Nature Park, 3.7.2011, LB;

(17) – 43°56′58″N, 15°31′17″E, Jasen, canal north from the road Pakoštane - Vrana, 19.3.2011, 20.5.2011, 19.7.2011, 6.10.2011, 13.12.2011, JL & PC;

(18) – 43°57′35″N, 15°33′17″E, Pećina, the spring and small brook by the cave Pećina, 19.3.2011, 20.5.2011, 19.7.2011, 6.10.2011, 13.12.2011, JL & PC;

Fig. 5. Punta (Site No. 14), October 6, 2011.

RESULTS

During the research, we recorded a salinity of 1.9 to 7.8 ‰ in Vrana Lake (Fig. 6). The highest salinity (37.9 ‰) was recorded in October 2011, at Jugovir site (site No. 11; Fig. 4), in an area with direct underground inflow from the sea. Other parameters measured during the research ranged as follows: water temperature (ºC) 10.1-30.8, pH 6.87-9.29, dissolved oxygen (mg/l) 3.93-10.07, oxygen saturation (%) 51.8-101.5 and conductivity (mS/cm) 0.54-57.2.

Altogether 21 species of aquatic non-marine molluscs (15 gastropods, 6 bivalves) were recorded (Tab. 1), out of which 10 were found in Vrana Lake. The most common species

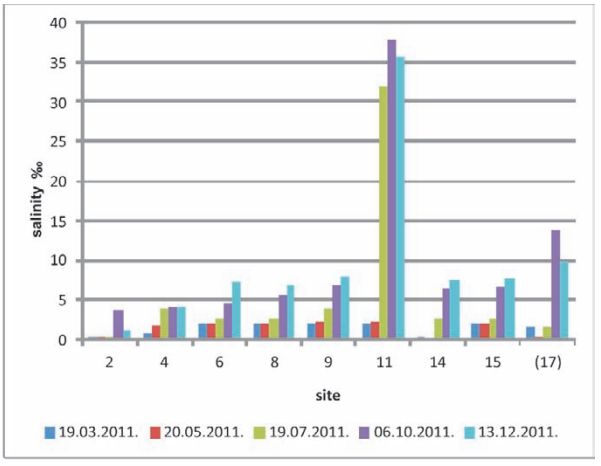

Fig. 6. Salinity values (‰) at selected sites in Vrana Lake Nature Park.

Tab. 1. List of aquatic molluscs according to localities. x – a few specimens, xx – scattered occurrence, xxx – abundant occurrence, (x) – old shells. In the case of different densities during every single visit the highest density is mentioned.

Species/Site No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	(17)	(18)
Theodoxus fluviatilis (Linnaeus, 1758)				x	xxx	xxx	xxx	xxx	xxx	xx	xxx		x	xxx	x			
Viviparus contectus (Millet, 1813)																	(x)	
Bithynia tentaculata (Linnaeus, 1758)		x	x		x	(x)	xx	x	xx		xx	x	x	(x)	(x)	xxx	(x)	
Heleobia stagnorum (Gmelin, 1791)						(x)			(x)		xxx			(x)	(x)			
Paladilhiopsis cf. *solida* Kuščer, 1933		(x)																xx
Islamia cf. *pusilla* (Piersanti, 1952)																		xxx
Valvata cristata O. F. Müller, 1774		(x)		(x)													(x)	xxx
Acroloxus lacustris (Linnaeus, 1758)		xxx	xx	xxx	xxx	x	x	x	(x)		xx	xx		xx	(x)	xxx	(x)	x
Galba truncatula (O. F. Müller, 1774)		(x)				(x)												
Stagnicola fuscus (C. Pfeiffer, 1821)	x	xx	xxx	xxx	xxx	xxx	xx	xxx	xx		xx	xx	xx	xx	xxx	xxx	xx	xx
Radix auricularia (Linnaeus, 1758)		xxx	xx	x	x	xx	x							(x)	(x)			
Anisus vorticulus (Troschel, 1834)				(x)												xxx		
Gyraulus crista (Linnaeus, 1758)				(x)														
Hippeutis complanatus (Linnaeus, 1758)				x	x				(x)							xx		
Ancylus fluviatilis O. F. Müller, 1774		x	xx	x													(x)	
Pisidium milium Held, 1836				(x)														
Pisidium subtruncatum Malm, 1855				(x)													(x)	
Pisidium obtusale (Lamarck, 1818)																x		
Pisidium personatum Malm, 1855		(x)							(x)									
Pisidium casertanum (Poli, 1791)		x															(x)	
Dreissena polymorpha (Pallas, 1771)				(x)		(x)	(x)		(x)		(x)			(x)				
Number of species	1	6(4)	5	6(5)	6	4(3)	5(1)	4	3(4)	1	5(1)	3	3	3(3)	2(4)	6	1(7)	5

recorded were *Theodoxus fluviatilis*, *Bithynia tentaculata*, *Acroloxus lacustris* and *Stagnicola fuscus*, while *Heleobia stagnorum*, *Radix auricularia* and *Hippeutis complanatus* were found only occasionally. A dense population of *H. stagnorum*, a species inhabiting brackish waters, was found only at one site (site No. 11), while at other 4 sites in the lake only empty shells were recorded. Other molluscs such as *Galba truncatula* and *Pisidium personatum* were recorded only as conchs in Vrana Lake. Similarly, in the case of the invasive non-native *Dreissena polymorpha*, only empty shells were recorded despite increased research effort, which included diving (snorkelling) in shallow parts of the lake. Only one species (*Theodoxus fluviatilis*) was recorded at the beginning of the artificial canal (Prosika canal) connecting the lake with Adriatic Sea.

In canals northwest of the lake (Lateral canal, Main canal) the occurrence of 17 species was documented. Among them 8 species were found alive: *Theodoxus fluviatilis*, *Bithynia tentaculata*, *Acroloxus lacustris*, *Stagnicola fuscus*, *Radix auricularia*, *Hippeutis complanatus*, *Ancylus fluviatilis* and *Pisidium casertanum*. *Paladilhiopsis* cf. *solida*, *Valvata cristata*, *Galba truncatula*, *Anisus vorticulus*, *Gyraulus crista*, *Pisidium milium*, *P. personatum*, *P. subtruncatum* and *Dreissena polymorpha* were confirmed as shells only.

The occurrence of numerous populations of threatened planorbid gastropod *Anisus vorticulus* was found in Benča Lake, shallow and temporary lake that is not connected with Vrana Lake. In this small lake *Bithynia tentaculata*, *Acroloxus lacustris*, *Stagnicola fuscus*, *Hippeutis complanatus* and *Pisidium obtusale* occurred together with *A. vorticulus*.

Outside of the nature park in the canal in Jasen (site No. 17) populations of only one species (*Stagnicola fuscus*) were recorded, while other molluscs *Viviparus contectus*, *Ancylus fluviatilis* and *Pisidium subtruncatum* were confirmed as shells only. In the spring and small brook near the cave Pećina (site No. 18) we found numerous living populations of three species (*Islamia* cf. *pusilla*, *Valvata cristata*, *Paladilhiopsis* cf. *solida*).

Variations in density of molluscs at several sites were also studied. The highest density values (ind. m^{-2}) for particular species were as follows: 1,589 ind. m^{-2} for *Theodoxus fluviatilis* (site No. 8, 19.7.2011), 1,488 ind. m^{-2} for *Heleobia stagnorum* (site No. 11, 6.10.2011), 480 ind. m^{-2} for *Islamia* cf. *pusilla* (site No. (18), 6.10.2011), 528 ind. m^{-2} for *Valvata cristata*

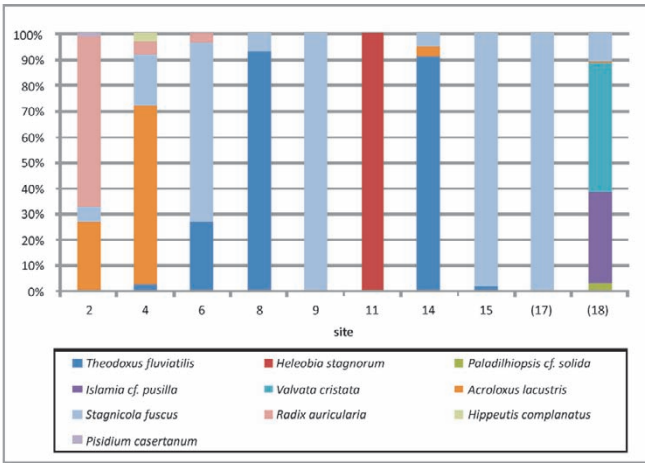

Fig. 7. Relative frequencies of mollusc species at selected sites in Vrana Lake Nature Park.

(site No. (18), 19.7.2011), 459 ind. m^{-2} for *Stagnicola fuscus* (site No. 6, 20.5.2011) and 395 ind. mind. m^{-2} for *Radix auricularia* (site No. 2, 19.7.2011). Densities of other species did not exceed 100 ind. m^{-2}. *Stagnicola fuscus* was recorded in 25 from 50 samples while *Theodoxus fluviatilis* and *Acroloxus lacustris* were found in 16 and 14 samples respectively. Other species were documented from 1 to 7 samples. Mean densities of particular species per site are listed in Tab. 2, while their relative frequencies are given in Fig. 7.

DISCUSSION

Records of only 10 species of non-marine molluscs in the largest Croatian lake, Vrana Lake, and 21 molluscs altogether within its surroundings are surprisingly meagre. Such results might stem from the fact that in comparison with other lakes or rivers in the Adriatic basin, salinity of Vrana Lake is higher and increased salinity probably caused the absence of more diverse molluscan assemblages. Previous research by Rubinić *et al.* (2009) recorded increased salinization of the lake due to anthropogenic influence and climate change. In 2008 the water levels in the lake were for the first time 7 cm lower than the average yearly sea level, allowing the increased inflow of the sea into the lake through Prosika canal (Rubinić *et al.*, 2009). During our investigation in 2011, salinity of Vrana Lake ranged from 1.9 in spring to 7.8 ‰ in autumn, except at site Jugovir (site No. 11) where salinity was higher and ranged from 2 ‰ in spring, to 37.9 ‰ in autumn. This locality receives sea water directly through underground channels. Furthermore, due to high temperatures and the long drought period in 2011, water levels decreased significantly and in the late summer this locality contained sea water only. Increased salinity probably enabled the species *Heleobia stagnorum*, which inhabits brackish waters, to reach high population densities at Jugovir site. Live specimens of this species were only recorded at this site.

At the majority of sites, the gastropods *Stagnicola fuscus*, *Acroloxus lacustris* and *Theodoxus fluviatilis* dominated in numbers and abundance. All three gastropods are typical freshwater species, but they are also tolerant to increased salinity (Glöer, 2002). Another recorded species, *Bithynia tentaculata*, inhabits standing and slow-flowing waters with high detritus abundance. This species is both a grazing and a filter-feeding organism (Tashiro & Colman, 1982), which allows it to reach high densities in eutrophic and antropogenically disturbed waters. Species *Viviparus contectus, Galba truncatula*, *Radix auricularia*, *Hippeutis complanatus* and *Gyraulus crista* are also typical in standing and slow-flowing waters with dense riparian vegetation, which characterized the localities where they were recorded in this research. Recorded species *Ancylus fluviatilis* occurs on and under stones and plant leaves, from small creeks to rivers, also in springs and at lake margins with wave movement (Glöer, 2002). In our investigation we found this species only in canals.

The research conducted in the stream Pećina and its spring in the Pećina cave yielded interesting results. Snails *Valvata cristata*, *Paladilhiopsis* cf. *solida* and *Islamia* cf. *pusilla* were recorded at this locality. *V. cristata* inhabits springs, lakes and streams with dense vegetation, while *P. solida* is an endemic species inhabiting underground watercourses and springs in Croatia and Bosnia and Herzegovina (Bole & Velkovrh, 1986; Glöer, 2002) but according to M. Bodon (pers. comm.) the taxonomic status of specimens found in the Pećina cave have not been confirmed yet so our determination is only preliminary. *I. pusilla*, which also inhabits underground watercourses and springs, was considered as endemic species of Italy (Cianfanelli *et al.*, 2010). Thus, this finding represents the

first record of this species in Croatia and a new species record for molluscan fauna of Croatia but the determination is also preliminary the same as in the case of *Paladilhiopsis* cf. *solida*. Other species recorded in Vrana Lake, Benča Lake and all canals belong to molluscs with extensive distribution range (Holarctic, Palearctic, Euro-Siberian) or are at least common in large part of Europe (Fauna Europaea, 2012).

Only one non-native and invasive mollusc *Dreissena polymorpha* was recorded. Despite detailed research including diving in shallow parts of the lake, only empty shells were found. There are three possible explanations and all are associated with the fact that *D. polymorpha* represents an important source of food for numerous birds and fishes (Molloy *et al.*, 1997). The first explanation is that this species actually does not live there and it was accidentally transported by birds from some other and distant locality. On the other hand, it is possible that *D. polymorpha* live in the deeper part of the lake and due to the methodology applied we did not find live specimens of this species. A third possible reason is that *D. polymorpha* has become established in the lake but bird and fish populations successfully control its abundance. The presence of species which feed on *D. polymorpha* in the lake, such as the common carp (*Cyprinus carpio)* and pumpkinseed sunfish (*Lepomis gibbosus)* (Mrakovčić, 2004; Treer *et al.*, 2010), the Eurasian coot (*Fulica atra),* tufted duck (*Aythya fuligula),* common pochard (*A. ferina)* and common goldeneye *(Bucephala clangula)* (Radović *et al*., 2004), supports the latter assumption. Research by other authors supports the latter hypothesis as well. During the four year research on Rain River, Suter (1982) recorded that birds consume up to 97 % of *D. polymorpha* population in winter months, but the remaining 3 % re-establish the population during other seasons. In Croatia, the distribution of *D. polymorpha* has been limited to the Danube River Basin, that is, the Drava and Sava Rivers and their tributaries (Erben *et al.*, 2000; Lajtner *et al.*, 2004; Paunović *et al.*, 2012). In the Adriatic Sea basin, *D. polymorpha* was recorded in 1878 in the canal which connects Krka River with the sea (Tadić, 1977). However, the presence of this invader in the Krka River has not been established in recent

Tab. 2. Mean density (ind. m-2) of aquatic molluscs at selected sites in 2011.

Species / Site No.	2	4	6	8	9	11	14	15	(17)	(18)
	number of individuals per square metre									
Theodoxus fluviatilis	0	1	40	612	0	0	68	1	0	0
Heleobia stagnorum	0	0	0	0	0	736	0	0	0	0
Paladilhiopsis cf. *solida*	0	0	0	0	0	0	0	0	0	11
Islamia cf. *pusilla*	0	0	0	0	0	0	0	0	0	130
Valvata cristata	0	0	0	0	0	0	0	0	0	186
Acroloxus lacustris	38	26	1	2	0	0	3	0	0	1
Stagnicola fuscus	8	7	102	44	1	0	3	44	6	40
Radix auricularia	96	2	5	0	0	0	0	0	0	0
Hippeutis complanatus	0	1	0	0	0	0	0	0	0	0
Pisidium casertanum	1	0	0	0	0	0	0	0	0	0

research (Marguš, 1998). Thus we can conclude that the record of *D. polymorpha* in Vrana Lake is the only finding of this invasive species in the Mediterranean part of Croatia. However, this finding and the existence and abundance of *D. polymorpha* have yet to be confirmed in future studies. High densities of non-native *D. polymorpha* can change whole ecosystems (Claudi & Mackie, 1993) and are a danger especially for unionid communities (Claudi & Mackie, 1993; Schloesser & Nalepa, 1994. On the other hand, more changes were documented especially in North America in comparison with Europe where *D. polymorpha* is native to the basins of the Black and Caspian Seas (Ricciardi, 2003). Since no unionid species were recorded in Vrana Lake, the potential scattered occurrence of *D. polymorpha* does not represent a serious problem for the protection of aquatic malacofauna of this lake. According to Lajtner & Crnčan (2011), records of empty shells of the unionids *Unio pictorum* and *Sinanodonta woodiana* on the bank of Vrana Lake in 2007 were the consequence of transport of live individuals of this species from continental parts of Croatia as bait for fishing.

The shallow and temporary Benča Lake is not connected with Vrana Lake and is not affected with brackish water. Thus, different molluscan assemblages occur in this lake, including *Anisus vorticulus*. This endangered planorbid species is listed in the EU Habitat Directive. In Croatia, it is a strictly protected species under national legislation (Narodne novine, 99/09). In the basin of the Adriatic Sea this species was recorded for the first time in the Krka National Park (Beran, 2009). Benča Lake is second site where its presence has been recorded in this part of Croatia. Despite the small area, this lake is more important for protection of *A. vorticulus* than the rest of the Nature Park, including Vrana Lake. Empty shells of this species were found also in Main Canal (site No. 4) but the occurrence of living population was not confirmed.

CONCLUSIONS

A study of the aquatic malacofauna of Vrana Lake Nature Park showed that the molluscan assemblages of Vrana Lake consisted only of several widespread species probably due to the higher salinity of this lake. Records of numerous populations of the endangered planorbid gastropod *Anisus vorticulus* in Benča Lake is the most important finding for the conservation of non-marine malacofauna of this nature park. The presence of the invasive species *Dreissena polymorpha* is not currently threatening the ecosystem of Vrana Lake.

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SUMMARY

Slatkovodni mekušci (Mollusca: Gastropoda, Bivalvia) Parka prirode Vransko jezero (Hrvatska)

L. Beran, J. Lajtner, & P. Crnčan

This paper presents the results of a malacological survey of Vrana Lake and its surroundings in Vrana Lake Nature Park. The main aim of this research was to provide an inventory of aquatic molluscs, examine their population densities, and establish the occurrence of endangered as well as non-native molluscs and their possible impacts on native molluscan assemblages. A field study was conducted from August 2009 to December 2011. Out of 18 examined sites, the majority (16 sites) were located in Vrana Lake Nature Park, while 2 sites were outside of the park. Altogether 21 species of aquatic non-marine molluscs (15 gastropods, 6 bivalves) have been recorded. Out of all recorded species, only 10 were documented in Vrana Lake, probably due to the higher salinity of water in the lake. The most common species recorded were *Theodoxus fluviatilis*, *Bithynia tentaculata*, *Acroloxus lacustris* and *Stagnicola fuscus*, while *Heleobia stagnorum*, *Radix auricularia* and *Hippeutis complanatus* were found only occasionally. Only one non-native and invasive mollusc *Dreissena polymorpha* was recorded but despite detailed research only empty shells were found. In canals northwest of the lake (Lateral canal, Main canal) the occurrence of 17 species was documented. Among them, specimens of 8 species were found alive: *T. fluviatilis*, *B. tentaculata*, *A. lacustris*, *S. fuscus*, *R. auricularia*, *H. complanatus*, *Ancylus fluviatilis* and *Pisidium casertanum*. A population of the endangered gastropod *Anisus vorticulus* was found in Benča Lake and together with this species, *B. tentaculata*, *A. lacustris*, *S. fuscus*, *H. complanatus* and *P. obtusale* occurred. Outside of the nature park in the canal in Jasen only populations of *S. fuscus* were recorded. In the spring and small brook near the cave Pećina we found numerous living populations of three species (*Islamia* cf. *pusilla*, *Valvata cristata*, *Paladilhiopsis* cf. *solida*), which were recorded only at this site. During the study three species of gastropods and four species of bivalves, including non-native and invasive *D. polymorpha,* were recorded only by empty shells.