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Fitobentos in kakovost vode v mrtvicah reke Mure

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Izvleček. Namen naše raziskave je bil ugotoviti vrstno sestavo in pogostost pojavljanja posameznih vrst fitobentosa v izbranih mrtvicah reke Mure ter s pomočjo indikatorskih vrst fitobentosa ugotoviti kakovost vode. Skupno smo v treh mrtvicah reke Mure identificirali 147 taksonov iz petih razredov alg. Po številu identificiranih taksonov so prevladovale kremenaste alge s 117 (80 %) taksoni, sledile so Chlorophyceae z 11 (7 %), cianobakterije z 10 (7 %), Xanthophyceae s sedmimi (5 %) in Euglenophyceae z dvema (1 %) taksonoma. Številčno najbolj zastopana rodova sta bila *Navicula* in *Nitzschia*. V mrtvici Zaton I smo skupno identificirali 37, v mrtvici Zaton II 75 in v mrtvici Mali Bakovci 107 taksonov alg. V izbranih mrtvicah reke Mure smo skupno ugotovili 25 taksonov, ki do sedaj še niso bili znani na območju Slovenije. 19 za Slovenijo novih taksonov pripada razredu kremenastih alg, *Borzia curta* in *Woronichinia robusta* razredu cianobakterij, *Bumilleria klebsiana* in *B. spirotaenia* razredu Xanthophyceae ter *Characium ensiforme* in *Microspora abbreviata* razredu Chlorophycea. V času raziskav je mrtvica Mure Zaton I spadala v II.-III. kakovostni razred, kar pomeni kritično obremenitev vodnega telesa, mrtvici Mure Zaton II in Mali Bakovci pa v II. kakovostni razred, kar pomeni zmerno obremenjeno vodno telo.

Ključne besede: mrtvice, Mura, fitobentos, kakovost vode

Abstract. PHYTOBENTHOS AND WATER QUALITY IN THE MURA RIVER'S OXBOWS – The purpose of our research was to determine species composition and abundance of phytobenthos in the selected Mura River's oxbows, as well as to determine water quality on the basis of indicator phytobenthos species. Altogether, 147 taxa from five algal classes were determined. According to the number of identified taxa, diatoms with 117 (80 %) taxa prevailed, followed by Chlorophyceae with 11 (7 %), Cyanobacteria with 10 (7 %), Xanthophyceae with seven (5 %) and Euglenophyceae with two (1 %) taxa. The most abundant genera were *Navicula* and *Nitzschia*. In the oxbow Zaton I, 37 algal taxa were identified, in the oxbow Zaton II 75, and in the oxbow Mali Bakovci 107. In the selected Mura oxbows, altogether 25 taxa for the first time identified in the territory of Slovenia were determined. 19 taxa new to Slovenia belong to the class of diatoms, *Borzia curta* and *Woronichinia robusta* to the class Cyanobacteria, *Bumilleria klebsiana* and *B. spirotaenia* to the class Xanthophyceae, *Characium ensiforme* and *Microspora abbreviata* to the class Chlorophycea. According to the results of the Saprobic Index, we can classify the Mura oxbows at sampling site Zaton I into II-III quality class, which means a critical load of the water body, and at sampling site Zaton II and Mali Bakovci into II quality class, which means a moderately polluted water body.

Key words: oxbows, Mura River, phytobenthos, water quality

Uvod

Mura je značilna nižinska reka, ki s poplavljanjem in stalnim spreminjanjem struge ustvarja mrtvice. Svet ob Muri je bogat z mrtvicami, poplavnimi logi ter močvirskimi travniki. Skupna značilnost ekosistemov ob Muri je njihovo izredno hitro spreminjanje. Gonilni sili sta sezonski ritem poplav in spreminjanje smeri glavne struge. Ob nastajanju novih strug stari rokavi postopoma izgubijo stik z matico. Rečni nanosi jih zasujejo najprej na zgornji, nato pa še na spodnji strani. Tako nastane rečno jezero ali mrtvica (Jež & Skoberne 1986). Koliko je pravzaprav rečnih jezer oziroma mrtvic, ločenih od reke in stranskih rokavov, lahko le ocenimo. Vsaj 30 jih je, ki nosijo svoja imena in so po njih tudi poznana. Primer je rečno jezero Jula Marof, ki je dobilo ime po rodbini Marof. Mrtvica Orlovšček (tudi Orlovščak) je dobila ime po istoimenskem logu, podobno kot tudi mrtvica Muriša. Precej mrtvic ima tudi madžarska imena, na primer mrtvice Szent Kiraly (Sveti kralj) v Muriši, rečni rokav Vërki Berek (Potok) ali Tóka (Stoječa voda; Voda, ki stoji). Mnoge mrtvice in rokavi nosijo imena kar po bližnjem kraju, na primer Petišovsko jezero po kraju Petišovci; nekaj pa jih je sploh brez imen (Firbas 2002). Beseda zaton pomeni stranske rokave reke Mure; od tod tudi ime mrtvice Zaton. Mrtvico Zaton v kraju Petanjci, ki se ji »življenjska doba« tudi že počasi izteka, tvorijo tri stoječe vode. Znana je po tem, da le tu uspevajo vse predstavnice vodnih lečevk v Sloveniji (Firbas 2002).

Izraz fitobentos se je v preteklosti le redko uporabljal, v Vodni direktivi (Evropski parlament in svet 2000) pa se ta izraz uporablja za pritrjene alge. V preteklosti se je za tovrstne organizme najpogosteje uporabljal izraz perifiton. Po definiciji je perifiton mikrozdružba pritrjenih avtotrofnih in heterotrofnih organizmov na jezerskem ali rečnem dnu ali na drugih potopljenih podlagah. Wetzel (1983) je definiral perifiton kot kompleksno združbo mikrobiontov (alg, bakterij, gliv, živali, anorganskega in organskega detritusa), ki so pritrjeni na podlago. Podlaga je lahko organska ali anorganska, živa ali mrtva. V tej definiciji pod izrazom perifiton niso zajete makroskopske bentoške alge (Stevenson 1996). V nadaljevanju se uporablja izraz fitobentos za pritrjene alge (tudi makroskopske) in cianobakterije.

Z vidika ekologije in onesnaženja okolja je fitobentos že od nekdaj uporaben kazalec prizadetosti ekosistemov. V prisotnosti ali odsotnosti določenih vrst in njihovi količinski zastopanosti se namreč kaže obseg prizadetosti vodnega ekosistema. Od leta 2009 naprej se stanje površinskih (reke, jezera, obalne vode) in podzemnih voda v Sloveniji vrednoti na podlagi ekološkega in kemijskega stanja. Ekološko stanje se vrednoti z biološkimi elementi kakovosti, podpornimi hidromorfološkimi in fizikalno-kemijskimi elementi. Biološki elementi so: vodno rastlinstvo (fitobentos, fitoplankton in makrofiti), bentoški nevretenčarji in ribe. Stanje nekega vodnega telesa je dobro, ko je doseženo dobro kemijsko in zelo dobro ali dobro ekološko stanje.

Namen naše raziskave je bil ugotoviti vrstno sestavo in pogostost pojavljanja posameznih vrst fitobentosa ter s pomočjo indikatorskih vrst fitobentosa ugotoviti kakovost vode v izbranih mrtvicah reke Mure. Ker je bila naša raziskava opravljena pred letom 2009, kakovosti vode nismo vrednotili na podlagi ekološkega stanja, ampak na podlagi saprobnega indeksa po Pantle & Buck (1955), modificiranega po Zelinka & Marvan (1961) po takrat veljavni zakonodaji.

Materiali in metode

Opis vzorčnih mest

Mrtvica Zaton I

Vzorčno mesto leži v kraju Petanjci za mostom čez Muro in njenimi rokavi, ob hiši s hišno številko 96. Mrtvico obdaja pas trstičevja (*Phragmites australis*) in širokolistnega rogoza (*Typha latifolia*) s posameznimi vrbami (*Salix* sp.), na drugi strani mrtvica prehaja v travnik. Vodna površina je popolnoma prerasla z malo vodno lečo (*Lemna minor*). Vzorčno mesto je nezasenčeno, geološka podlaga je silikat. Vzorčili smo na lesu in vodni leči. Koordinate po Gauss–Krügerju: X=5580870, Y=5168070.

Mrtvica Zaton II

Vzorčno mesto leži v kraju Petanjci za mostom čez Muro in njenimi rokavi, v gozdu. Struga je široka približno 4 m in globoka do 0,5 m. Na dnu struge je veliko odpadlega listja in lesnih ostankov (korenin, vej, debel...). Med lesnimi vrstami v okolici vzorčnega mesta prevladujejo veliki jesen (*Fraxinus excelsior*), črni bezeg (*Sambucus nigra*), enovrati glog (*Crataegus monogyna*) in navadna trdoleska (*Euonymus europaea*). Vzorčno mesto je zasenčeno, geološka podlaga je silikat. Vzorčili smo na lesu in odmrlem organskem materialu. Koordinate po Gauss–Krügerju: X=5580690, Y=5168100.

Mrtvica Mali Bakovci

Vzorčno mesto je v bližini naselja Mali Bakovci, v gozdu. Struga je široka približno 7 m in globoka 1 m. Vodna površina je delno prerasla z navadno žabjo lečo (*Spirodela polyrrhiza*) in trstom (*Phragmites australis*). Obrežno vegetacijo na obeh bregovih sestavljajo različne grmovne in drevesne vrste, med katerimi prevladujejo: črna jelša (*Alnus glutinosa*), robinija (*Robinia pseudacacia*), vrbe (*Salix* spp.) in črni bezeg (*Sambucus nigra*). Vzorčno mesto je zasenčeno, geološka podlaga je silikat. Vzorčili smo na lesu, odmrlem rastlinskem materialu, potopljenih in emergentnih makrofitih. Koordinate po Gauss–Krügerju: X=5585970, Y=5163716.

Vzorčenje in laboratorijska analiza fitobentosa

Fitobentos smo vzorčili v različnih letnih časih v letih 2005 in 2006 (Tab. 1). Na posameznem vzorčnem mestu smo nabrali štiri vzorce fitobentosa, skupno smo nabrali 12 vzorcev na 3 vzorčnih mestih. Hkrati smo na vseh vzorčnih mestih merili tudi osnovne fizikalne in kemijske dejavnike: pH, temperaturo, električno prevodnost, vsebnost kisika v vodi in nasičenost vode s kisikom (APHA 1992).

Fitobentos smo vzorčili semikvantitativno, na posameznem vzorčnem mestu so bili vzorci izbrani naključno in so vsebovali alge z različnih naselitvenih površin. Alge smo nabirali tako, da smo postrgali površino prodnikov, kamnov, skal, makrofitov, potopljenega lesa in drugih potopljenih predmetov (steklenic, pločevink, plastenk...) in oželi mahove, potopljene v vodi.

Vzorce smo že na terenu fiksirali s 35-odstotnim formaldehidom v razmerju ena proti devet, tako da je bila končna koncentracija formaldehida v vzorcih približno 4-odstotna.

Tabela 1. Seznam vzorčnih mest z datumi vzorčenja in datumi meritev fizikalnih in kemijskih dejavnikov.
Table 1. Sampling site list with sampling dates and dates of measurements of physical and chemical parameters.

Vzorčno mesto	Datumi vzorčenja
mrtvice reke Mure (Zaton I)	14.5.2005, 16.9.2005, 16.12.2005, 23.3.2006
mrtvice reke Mure (Zaton II)	14.5.2005, 16.9.2005, 16.12.2005, 23.3.2006
mrtvice reke Mure (Mali Bakovci)	14.5.2005, 16.9.2005, 16.12.2005, 23.3.2006

V laboratoriju smo vzorce alg pregledali pod svetlobnim mikroskopom Nikon Eclipse E400 in Nikon Eclipse TE300, opremljenim z digitalno kamero Nikon Digital Camera DXM 1200, Japonska, ter programsko opremo za analizo slike Lucia 4.6, Laboratory Imaging s.r.o., Češka. Da smo lahko določili kremenaste alge do nivoja vrste, smo morali vzorce predhodno primerno obdelati s koncentrirano HNO_3 (Schaumburg *et al*. 2004). Iz očiščenih vzorcev smo pripravili trajne preparate z Naphrax-om (Schaumburg *et al.* 2004). Trajne preparate kremenastih alg smo pregledali pod 1000 × in 1200 × povečavo s pomočjo faznega kontrasta. Druge skupine alg smo pregledali pod 600 ×, 1000 × in 1200 × povečavo, po potrebi smo uporabili fazni kontrast. Posamezne celice alg smo fotografirali, tako smo jih lahko identificirali tudi s pomočjo slike na ekranu (tako vidimo celice močno povečane) in ni bila potrebna takojšnja identifikacija pod mikroskopom. Pri pregledu vzorcev smo ocenili pogostost posameznih taksonov alg na način, kot ga je opisala Grbović (1994) (Tab. 2).

Tabela 2. Lestvica za ocenjevanje pogostosti posameznih taksonov alg (Grbović 1994).
Table 2. Scale for estimation of algal taxa abundance (Grbović 1994).

Ocena pogostosti	Takson, zabeležen v % vidnih polj
1 - posamezno (redko)	1-15
3 - srednje pogosto	>15-60
5 - pogosto (množično)	>60-100

Pri določanju alg smo uporabili sledeče določevalne ključe: Heering (1914), Lazar (1960), Starmach (1966, 1968, 1972, 1974, 1977, 1980), Hindák *et al*. (1978), Krammer & Lange Bertalot (1997a, b, 2004a, b), Hindák (1996), Krammer (2000), Komárek & Anagnostidis (1998, 2005), Hindák (2006), Wołowski & Hindák (2005).

Rezultati

Fizikalni in kemijski dejavniki

Razpon osnovnih fizikalnih in kemijskih dejavnikov na izbranih mrtvicah reke Mure je prikazan v tabeli 3.

Tabela 3. Razpon osnovnih fizikalnih in kemijskih dejavnikov na posameznih vzorčnih mestih v letih 2005 in 2006.
Table 3. Range of physical and chemical parameters of the sampling sites studied in 2005 and 2006.

Vzorčno mesto	pH	T [°C]	χ [µS/cm]	O_2 [mg/L]	Saturacija [%]
Zaton I	6,2-7,0	0,2-22,8	280-507	0,12-8,70	0,9-81,7
Zaton II	6,0-7,2	1,8-15,9	548-732	0,22-4,04	5,2-27,0
Mali Bakovci	7,0-8,8	1,2-14,9	427-514	2,67-11,65	12,5-108,0

Mrtvica Zaton I

V mrtvici Zaton I je bila najvišja pH vrednost (7,0) izmerjena 16.9.2005, najnižja (6,2) pa 23.3.2006. Najvišjo temperaturo (22,8 °C) smo izmerili meseca septembra, najnižjo (0,2 °C) pa decembra. Elektroprevodnost se je gibala med 280 µS/cm (16.12.2005) in 507 µS/cm (23.3.2006). Količina kisika v vodi je bila ves čas meritev pod 10 mg/L (0,12-8,70 mg/L), nasičenost vode s kisikom pa pod 100 % (0,9-81,7 %) (Tab. 3).

Mrtvica Zaton II

V mrtvici Zaton II je bila v času meritev voda kisla do rahlo bazična (6,0-7,2). Najvišjo temperaturo (15,9 °C) smo izmerili 16.9.2005, najnižjo (1,8 °C) pa 16.12.2005. Elektroprevodnost se je gibala med 548 µS/cm (december) in 732 µS/cm (maj). Količina kisika v vodi je bila ves čas meritev nizka. Najmanj kisika (0,22 mg/L) smo izmerili v vodi meseca septembra, ko je bila struga polna razpadajočega organskega materiala. Septembra je bila tudi nasičenost vode s kisikom najnižja (5,2 %) (Tab. 3).

Mrtvica Mali Bakovci

V mrtvici Mali Bakovci je bil v času meritev pH vode bazičen (7,0-8,8). Najvišjo temperaturo (14,9 °C) vode smo izmerili meseca septembra, najnižjo (1,2 °C) pa decembra. Elektroprevodnost se je gibala med 427 µS/cm (maj) in 514 µS/cm (marec). Količina kisika v vodi je bila najvišja (11,65 mg/L) meseca maja in najnižja (2,67 mg/L) septembra. Tudi nasičenost vode s kisikom je bila meseca maja najvišja in meseca septembra najnižja (Tab. 3).

Vrstna sestava in pogostost fitobentosa

Vrstna sestava fitobentosa z razponom saprobnega indeksa je za izbrane mrtvice reke Mure prikazana v tabeli 4. Nekatere vrste kremenastih alg, prvič zabeležene na območju Slovenije, pa so prikazane na sliki 1. Skupno smo identificirali 147 taksonov iz petih razredov alg. Po številu identificiranih taksonov so prevladovale kremenaste alge s 117 (80 %) taksoni, sledile so Chlorophyceae z 11 (7 %), cianobakterije z 10 (7 %), Xanthophyceae s sedmimi (5 %) in Euglenophyceae z dvema (1%) taksonoma. Številčno najbolj zastopana rodova sta bila *Navicula* s 30 in *Nitzschia* s 17 taksoni.

Tabela 4. Vrstna sestava fitobentosa s saprobnimi stopnjami po Pantle & Buck (1955), modificiranimi po Zelinka & Marvan (1961), ter razponom saprobnega indeksa v mrtvicah reke Mure v letih 2005 in 2006. S + so označeni taksoni, ki doslej niso bili zabeleženi na območju Slovenije (Krivograd Klemenčič *et al.* 2009).

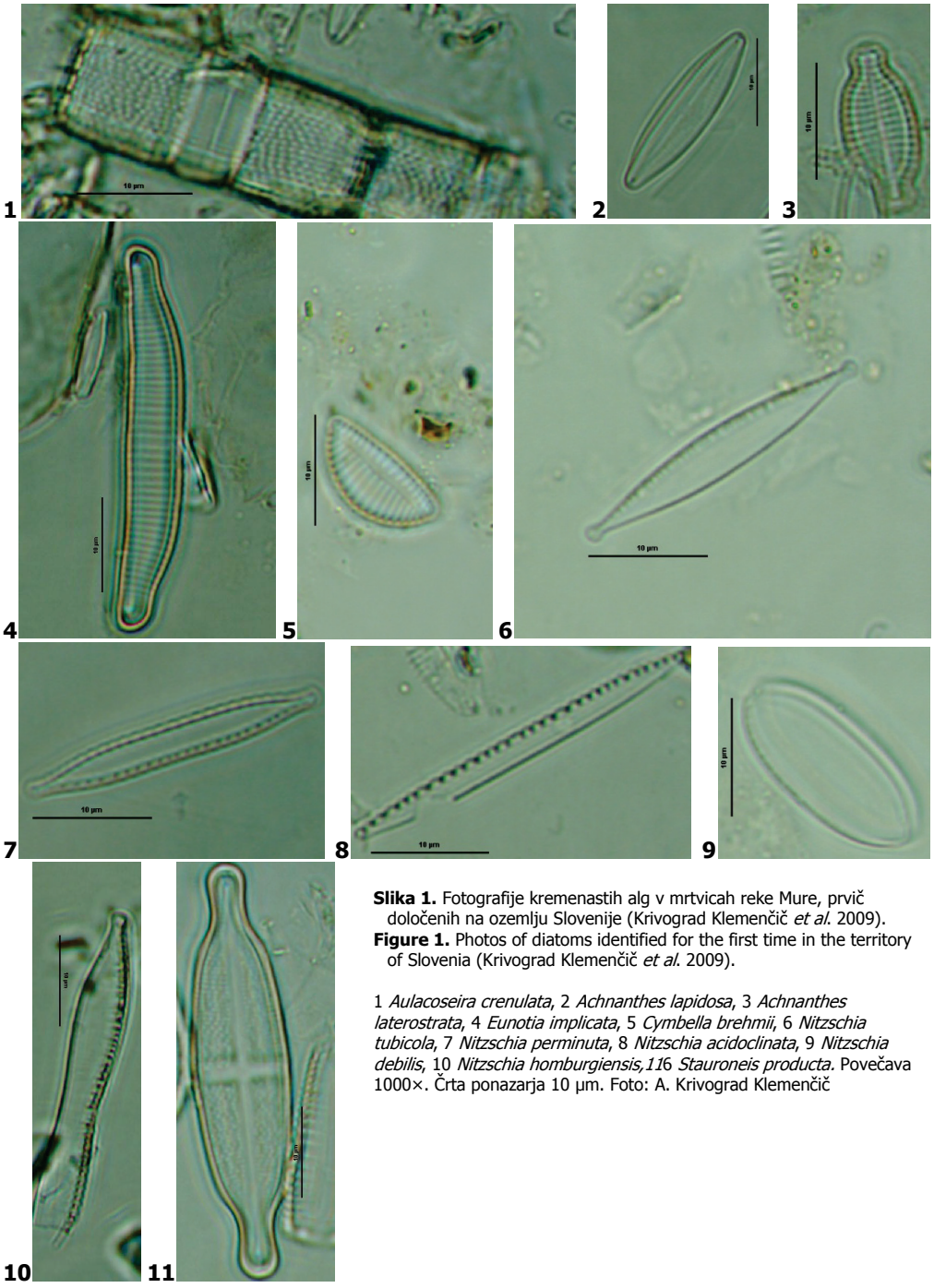
Table 4. Phytobenthos species list with saprobic values after Pantle & Buck (1955), modified after Zelinka & Marvan (1961), and range of saprobic index in the Mura oxbows in 2005 and 2006. + denotes the taxa identified for the first time in the territory of Slovenia (Krivograd Klemenčič *et al.* 2009).

Takson/vzorčno mesto	Sap. st.	Zaton I	Zaton II	Mali Bakovci
PROKARYOTA				
CYANOPHYTA				
CYANOPHYCEAE				
Anabaena spp.	o-a	●		
Aphanothece stagnina (Sprengel) A. Braun	o	●		
+Borzia curta (Lemmermann) Anagnostidis & Komárek		●		
Calothrix spp.	o	●		
Chroococcus minor (Kützing) Nägeli		●		
Heterolebleinia spp.			●	
Leptolyngbya spp.		●		
Nostoc sp.	o-b	●		
Phormidium spp.	o-a	●		●
+Woronichinia robusta (Skuja) Komárek & Hindák		●		
EUKARYOTA				
EUGLENOPHYTA				
EUGLENOPHYCEAE				
Euglena limnophila Lemmermann				●
Phacus pusillus Lemmermann		●		
HETEROKONTOPHYTA				
XANTHOPHYCEAE				
+Bumilleria klebsiana Pascher			●	
+Bumilleria spirotaenia Pascher				●
Heterothrix sp.		●		
Ophiocytium cochleare A. Braun				●
Tribonema affine West				●
Tribonema vulgare Pascher			●	
Vaucheria woroniniana Heering				●
BACILLARIOPHYCEAE				
Achnanthes catenata Bily & Marvan				●
Achnanthes helvetica (Hustedt) Lange-Bertalot				●
Achnanthes hungarica (Grunow) Grunow	b-a	●	●	●

Takson/vzorčno mesto	Sap. st.	Zaton I	Zaton II	Mali Bakovci
Achnanthes laevis Oestrup				●
Achnanthes lanceolata (Brébisson) Grunow	o	●	●	●
+Achnanthes lapidosa Krasske			●	
+Achnanthes laterostrata Hustedt				●
Achnanthes minutissima Kützing	o	●	●	●
Achnanthes oblongella Oestrup			●	
Achnanthes spp.	b	●		
Amphora libyca Ehrenberg			●	●
Amphora montana Krasske		●	●	
Amphora normannii Rabenhorst			●	●
Amphora pediculus (Kützing) Grunow	o-b		●	●
+Aulacoseira crenulata (Ehrenberg) Krammer			●	●
Caloneis bacillum (Grunow) Cleve			●	●
Caloneis silicula (Ehrenberg) Cleve	b			●
Cocconeis pediculus Ehrenberg	b		●	●
Cocconeis placentula Ehrenberg	o		●	●
Cyclotella meneghiniana Kützing	a-b			●
Cymatopleura solea (Brébisson) W. Smith	b			●
Cymbella affinis Kützing	o		●	●
+Cymbella amphicephala var. *hercynica* (Schmidt) Cleve			●	
Cymbella aspera (Ehrenberg) Cleve	o-b			●
+Cymbella brehmii Hustedt			●	
Cymbella minuta Hilse	b			●
Cymbella naviculiformis Auerswald	o			●
Cymbella silesiaca Bleisch	o-b		●	●
Cymbella sinuata Gregory	o-b		●	●
Cymbella subaequalis Grunow				●
Diatoma mesodon (Ehrenberg) Kützing	o		●	●
Diatoma moniliformis Kützing			●	●
Diatoma vulgaris Bory	b		●	●
Didymosphenia geminata (Lyngbye) M. Smith	o			●
Diploneis elliptica (Kützing) Cleve	o		●	
Epithemia adnata (Kützing) Brébisson			●	●
Eunotia bilunaris (Ehrenberg) Mills	o	●	●	●
+Eunotia implicata Nörpel			●	
Eunotia minor (Kützing) Grunow				●
Fragilaria arcus (Ehrenberg) Cleve	o			●
Fragilaria capucina Desmazières	o-b	●	●	●
Fragilaria fasciculata (C. Agardh) Lange-Bertalot				●
Fragilaria ulna (Nitzsch) Lange-Bertalot	b		●	●
Gomphonema acuminatum Ehrenberg	b			●
Gomphonema angustatum (Kützing) Rabenhorst	b	●	●	●
Gomphonema angustum Agardh	o		●	●
Gomphonema clavatum Ehrenberg		●	●	●
Gomphonema gracile Ehrenberg	o	●		

Takson/vzorčno mesto	Sap. st.	Zaton I	Zaton II	Mali Bakovci
Gomphonema olivaceum (Hornemann) Brébisson	o		●	●
Gomphonema parvulum (Kützing) Kützing	o-a	●	●	●
Gyrosigma acuminatum (Kützing) Rabenhorst	b		●	●
Hantzschia amphioxys (Ehrenberg) Grunow	b-a	●	●	●
Melosira varians Agardh	o-b		●	●
Meridion circulare var. *circulare* (Greville) C. A. Agardh	o		●	●
Navicula atomus (Kützing) Grunow	b	●		
Navicula capitata var. *capitata* Ehrenberg				●
Navicula capitatoradiata Germain			●	●
Navicula contenta Grunow			●	
Navicula crucicula (W. Smith) Donkin				●
Navicula cryptocephala Kützing	a		●	●
Navicula cryptotenella Lange-Bertalot	o		●	●
+Navicula disjuncta Hustedt				●
Navicula elginensis var. *elginensis* (Gregory) Ralfs				●
Navicula gregaria Donkin	b-a		●	●
Navicula halophila (Grunow) Cleve	a		●	●
Navicula harderii Hustedt			●	●
+Navicula ignota var. *palustris* (Hustedt) Lund				●
Navicula joubaudii Germain			●	●
Navicula lanceolata (Agardh) Ehrenberg	b		●	●
Navicula menisculus var. *menisculus* Schumann	b		●	
Navicula mutica var. *mutica* Kützing	o		●	
Navicula oblonga (Kützing) Kützing	o-b			●
+Navicula protracta (Grunow) Cleve				●
Navicula pupula var. *pupula* Kützing	b		●	●
Navicula radiosa Kützing	o-b			●
Navicula recens (Lange-Bertalot) Lange-Bertalot				●
Navicula rhynchocephala Kützing	a			●
+Navicula slesvicensis Grunow				●
Navicula spp.	b	●		●
Navicula tripunctata (O. F. Müller) Bory	o-b		●	●
Navicula trivialis Lange-Bertalot			●	●
Navicula veneta Kützing	a		●	●
Navicula viridula var. *rostellata* (Kützing) Cleve	b-a		●	
Nitzschia acicularis (Kützing) W. Smith	a			●
+Nitzschia acidoclinata Lange-Bertalot		●		
Nitzschia constricta (Kützing) Ralfs			●	
+Nitzschia debilis (Arnott) Grunow			●	
Nitzschia dissipata (Kützing) Grunow	o	●	●	●
Nitzschia fonticola Grunow	o		●	●
Nitzschia gracilis Hantzsch	o-b			●
+Nitzschia homburgiensis Lange-Bertalot				●
+Nitzschia intermedia Hantzsch				●
Nitzschia linearis (Agardh) W. Smith	o-b		●	●

Takson/vzorčno mesto	Sap. st.	Zaton I	Zaton II	Mali Bakovci
Nitzschia microcephala Grunow				●
Nitzschia palea (Kützing) W. Smith	b-a	●	●	●
+Nitzschia perminuta (Grunow) M. Peragallo		●		
Nitzschia recta Hantzsch	o-b		●	
Nitzschia sigmoidea (Nitzsch) W. Smith	b-a			●
Nitzschia spp.	b-a		●	●
+Nitzschia tubicola Grunow			●	●
Pinnularia gibba Ehrenberg	o			●
Pinnularia interrupta W. Smith	o-b	●	●	
Pinnularia microstauron (Ehrenberg) Cleve	o			●
Pinnularia subrostrata (A. Cleve) Cleve-Euler				●
Pinnularia viridis (Nitzsch) Ehrenberg	o-b		●	●
Rhoicosphenia abbreviata (C. Agardh) Lange-Bertalot	b		●	●
Stauroneis anceps Ehrenberg	o	●	●	●
Stauroneis kriegerii Patrick			●	●
Stauroneis phoenicenteron (Nitzsch) Ehrenberg	o		●	●
+Stauroneis producta Grunow				●
Stauroneis smithii Grunow	o-b			●
Surirella angusta Kützing	o-b	●	●	●
Surirella brebissonii var. *brebissonii* Krammer & Lange-Bertalot				●
Surirella minuta Brébisson				●
Tabellaria flocculosa (Roth) Kützing	o			●
CHLOROPHYTA				
CHLOROPHYCEAE				
Chaetophora incrassata (Hudson) Hazen			●	
+Characium ensiforme Hermann		●		
+Microspora abbreviata (Rabenhorst) Lagerheim		●	●	●
Microthamnion kuetzingianum Nägeli	b			●
Oedogonium spp.	o-b	●		●
Palmodictyon varium (Nägeli) Lemmermann				●
Pandorina morum (O. F. Müller) Bory	b	●		
Stigeoclonium spp.	b		●	
Stigeoclonium tenue Kützing	a	●		●
Trentepohlia aurea (L.) Martius			●	
Ulothrix variabilis Kützing				●
Saprobni indeks		**2,4-2,5**	**1,9-2,1**	**1,8-1,9**



Slika 1. Fotografije kremenastih alg v mrtvicah reke Mure, prvič določenih na ozemlju Slovenije (Krivograd Klemenčič *et al.* 2009).
Figure 1. Photos of diatoms identified for the first time in the territory of Slovenia (Krivograd Klemenčič *et al.* 2009).

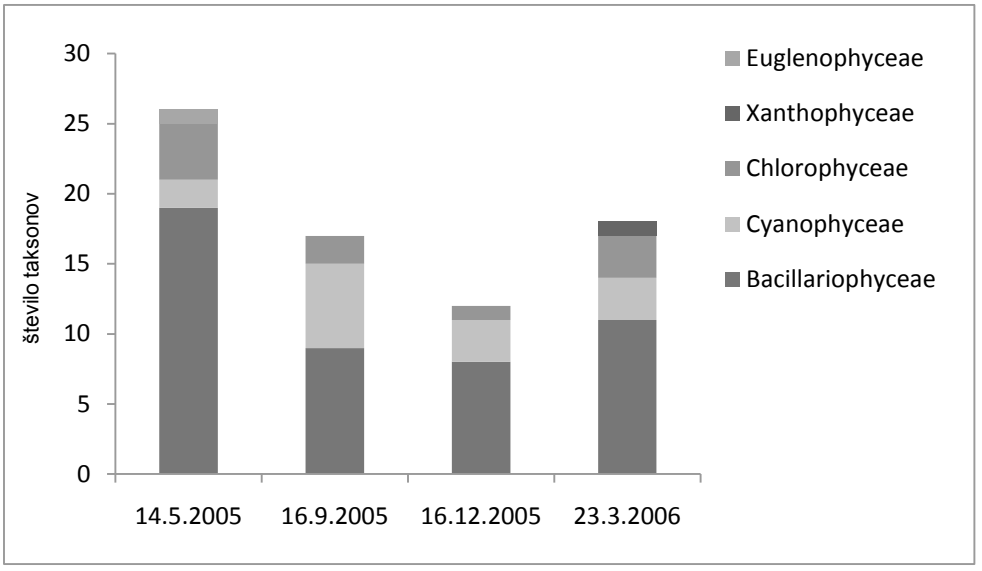
1 *Aulacoseira crenulata*, 2 *Achnanthes lapidosa*, 3 *Achnanthes laterostrata*, 4 *Eunotia implicata*, 5 *Cymbella brehmii*, 6 *Nitzschia tubicola*, 7 *Nitzschia perminuta*, 8 *Nitzschia acidoclinata*, 9 *Nitzschia debilis*, 10 *Nitzschia homburgiensis,11*6 *Stauroneis producta.* Povečava 1000×. Črta ponazarja 10 µm. Foto: A. Krivograd Klemenčič

Mrtvica Zaton I

V mrtvici Zaton I smo identificirali 37 taksonov iz petih razredov alg. Po številu identificiranih taksonov so prevladovale kremenaste alge z 21 (57 %) taksoni, sledile so cianobakterije z devetimi (24 %) in Chlorophyceae s petimi (13 %) taksoni. Iz razredov Euglenophyceae in Xanthophyceae smo identificirali po enega (3 %) predstavnika. Največ taksonov smo določili iz rodov *Achnanthes* (4), *Gomphonema* (4) in *Nitzschia* (4). Množično sta se pojavljali vrsti *Achnanthes hungarica* (16.9.2005; 16.12.2005) in *Stigeoclonium tenue* (14.5.2005). Pogoste so bile še vrste *Leptolyngbya* sp., *Gomphonema clavatum*, *G. parvulum*, *Nitzschia acidoclinata* in *Oedogonium* sp. V vseh štirih vzorcih so bile prisotne vrste *Achnanthes hungarica*, *Gomphonema clavatum*, *G. gracile*, *G. parvulum*, *Nitzschia acidoclinata*, *N. palea*, *N. perminuta* in *Oedogonium* sp.

Med 37 identificiranimi taksoni smo določili šest vrst, ki so prvič najdene na ozemlju Slovenije. Dve za Slovenijo novi vrsti pripadata razredu cianobakterij, dve razredu kremenastih alg in dve razredu Chlorophyceae (Krivograd Klemenčič *et al*. 2009).

Sestava alg po razredih je prikazana na sliki 2. Najvišje število taksonov (26) smo določili v vzorcu, nabranem meseca maja, najnižje (12) pa v vzorcu, vzetem meseca decembra. V vseh štirih vzorcih so po številu identificiranih taksonov prevladovale kremenaste alge z več kot 50 % vseh identificiranih taksonov. V septembrskem, decembrskem in marčevskem vzorcu so kremenastim algam sledile cianobakterije in Chlorophyceae, v majskem vzorcu pa so kremenastim algam sledile Chlorophyceae in šele nato cianobakterije. Predstavnik razreda Xanthophyceae (*Heterothrix* sp.) je bil najden le v vzorcu, nabranem meseca marca, predstavnik razreda Euglenophyceae (*Phacus pusillus*) pa le v vzorcu, nabranem meseca maja.



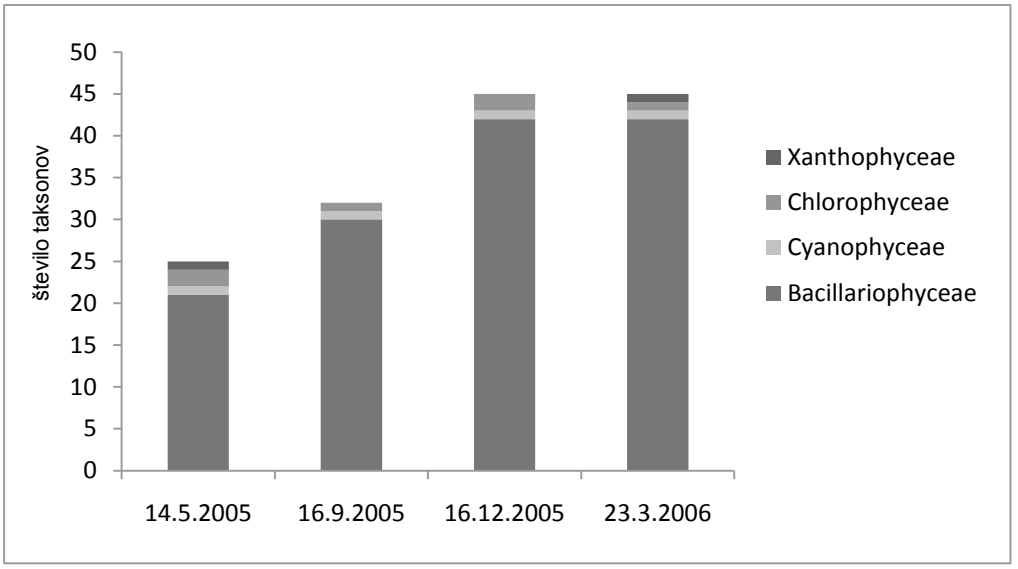
Slika 2. Sestava alg po razredih v mrtvici reke Mure Zaton I v letih 2005 in 2006.
Figure 2. Algal classes in the Mura oxbow Zaton I during 2005 and 2006.

Mrtvica Zaton II

V mrtvici Zaton II smo skupno identificirali 75 taksonov iz štirih razredov alg. Po številu identificiranih taksonov so prevladovale kremenaste alge z 68 (91 %) taksoni, sledile so Chlorophyceae s štirimi (5 %), Xanthophyceae z dvema (3 %) in cianobakterije z enim (1 %) taksonom. Največje število taksonov je pripadalo rodovoma *Navicula* (16) in *Nitzschia* (9). Množično so se pojavljale vrste *Eunotia bilunaris*, *Gomphonema parvulum*, *Nitzschia palea* in *Chaetophora incrassata*, vse v vzorcu, nabranem 14.5.2005. Pogosta je bila še vrsta *Microspora abbreviata*, prav tako v vzorcu, nabranem maja 2005. V vseh štirih vzorcih so bile ugotovljene vrste *Heteroleibleinia* sp., *Achnanthes lanceolata*, *Fragilaria capucina*, *Gomphonema angustatum*, *G. parvulum*, *Navicula joubaudii* in *Nitzschia palea*. 40 % vseh taksonov je bilo najdenih samo v enem vzorcu.

Med 75 identificiranimi taksoni smo določili devet taksonov, ki doslej še niso bili najdeni na območju Slovenije. Sedem za Slovenijo novih taksonov pripada razredu kremenastih alg, eden razredu Xanthophyceae in eden razredu Chlorophyceae (Krivograd Klemenčič *et al*. 2009).

Sestava alg po razredih je prikazana na sliki 3. Najvišje število taksonov (45) smo določili v vzorcih, nabranih meseca decembra in marca, najnižje (25) pa v vzorcu, nabranem meseca maja. V majskem vzorcu so bile štiri vrste alg z relativno abundanco 5 (dominantna). Ob spremembah v ekosistemu lahko pride do zmanjšanja števila vrst alg in kvantitativnega povečanja tistih vrst, ki so bolj prilagojene določenim spremembam v ekosistemu. V vseh štirih vzorcih so po številu določenih taksonov prevladovale kremenaste alge z več kot 84 % vseh določenih taksonov alg.



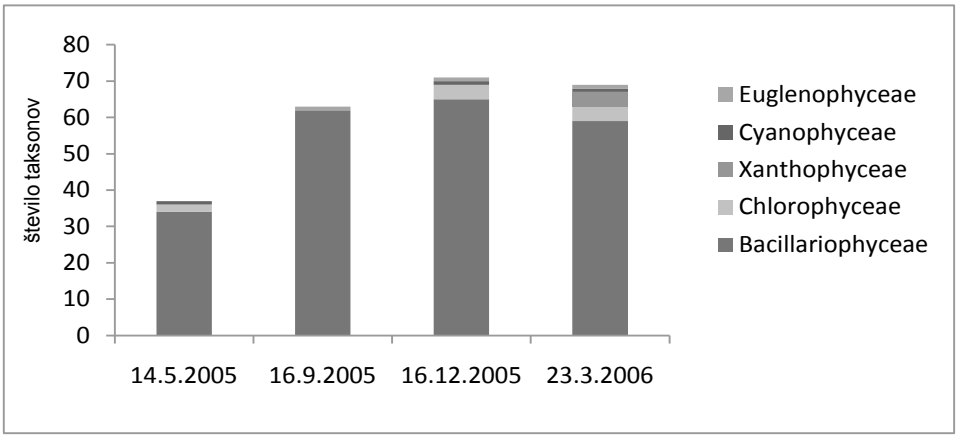
Slika 3. Sestava alg po razredih v mrtvici reke Mure Zaton II v letih 2005 in 2006.
Figure 3. Algal classes in the Mura oxbow Zaton II during 2005 and 2006.

Mrtvica Mali Bakovci

V mrtvici Mali Bakovci smo skupno identificirali 107 taksonov iz petih razredov alg. Po številu identificiranih taksonov so prevladovale kremenaste alge s 95 (88 %) taksoni, sledile so Chlorophyceae s šestimi (6 %) in Xanthophyceae s štirimi (4 %) taksoni. Iz razredov Cyanophyceae in Euglenophyceae smo identificirali po enega (1 %) predstavnika. Številčno najbolj zastopana sta bila rodova *Navicula* s 24 in *Nitzschia* z 12 taksoni. Množično sta se pojavljali vrsti *Achnanthes minutissima* in *Fragilaria ulna*, obe v vzorcu, nabranem 14.5.2005. Pogoste so bile še vrste *Tribonema affine*, *Vaucheria woroniniana*, *Achnanthes lanceolata*, *Cocconeis placentula*, *Eunotia bilunaris*, *Fragilaria capucina*, *Gomphonema angustatum*, *G. angustum*, *G. parvulum*, *Navicula cryptocephala*, *N. disjuncta*, *Microspora abbreviata* in *Stigeoclonium tenue*. V vseh štirih vzorcih so bile vrste *Achnanthes hungarica*, *A. lanceolata*, *A. minutissima*, *Aulacoseira crenulata*, *Cocconeis placentula*, *Diatoma vulgaris*, *Eunotia bilunaris*, *Fragilaria capucina*, *Gomphonema angustum*, *G. parvulum*, *Navicula halophila*, *N. pupula*, *N. radiosa*, *Nitzschia gracilis*, *N. linearis*, *N. palea* in *N.* sp. 31 % taksonov je bilo ugotovljenih samo v enem vzorcu.

Med 107 identificiranimi taksoni smo določili 12 taksonov, ki so novi za Slovenijo. 10 za Slovenijo novih taksonov pripada razredu kremenastih alg, en razredu Xanthophyceae in en razredu Chlorophyceae (Krivograd Klemenčič *et al.* 2009).

Sestava alg po razredih je prikazana na sliki 4. Najvišje število taksonov (71) smo določili v vzorcu, nabranem 16.12.2005, najnižje (37) pa v vzorcu, nabranem 14.5.2005. V majskem vzorcu sta bili masovno zabeleženi vrsti *Achnanthes minutissima* in *Fragilaria ulna*, ki sta bili najbolj prilagojeni obstoječim ekološkim razmeram. V vseh štirih vzorcih so po številu določenih vrst prevladovale kremenaste alge z več kot 85 % vseh določenih taksonov alg. V vseh vzorcih so kremenastim algam sledile Chlorophyceae - z izjemo septembrskega vzorca, ko so manjkale. V septembrskem vzorcu smo poleg kremenastih alg določili le še vrsto *Euglena limnophila*, predstavnico razreda Euglenophyceae. Vrste iz razreda Xanthophyceae so bile najdene le v vzorcu, nabranem 23.3.2006.



Slika 4. Sestava alg po razredih v mrtvici reke Mure Mali Bakovci v letih 2005 in 2006.
Figure 4. Algal classes in the Mura oxbow Mali Bakovci during 2005 and 2006.

Kakovost vode

Glede na vrednosti saprobnega indeksa (2,4-2,5) je spadala mrtvica reke Mure Zaton I v času raziskav v II.-III. kakovostni razred oziroma v beta do alfa mezosaprobno stopnjo, kar pomeni kritično obremenitev vodnega telesa. Glede na vrednosti saprobnega indeksa 1,8-2,1 sta spadali mrtvici reke Mure Zaton II in Mali Bakovci v času raziskav v II. kakovostni razred oziroma v beta mezosaprobno stopnjo, kar pomeni zmerno obremenjeno vodno telo.

Razprava

Razporeditev in vrstna sestava združbe fitobentosa ter relativna pogost posameznih vrst so v veliki meri odvisne od fizikalnih in kemijskih dejavnikov vode, ki se spreminjajo tudi v odvisnosti od geološke podlage (Negro *et al*. 2003). Elektroprevodnost, pH, vsebnost kalcija in karbonatno-bikarbonatni sistem imajo velik vpliv na razvoj in strukturo združbe fitobentosa, še posebej na razvoj ter strukturo združbe kremenastih alg in lepotk (Dell'Uomo & Pellegrini 1993). Prostorske in časovne spremembe fizikalnih in kemijskih dejavnikov vplivajo na pojavljanje in relativno pogostost posameznih vrst alg in s tem vplivajo na specifično sestavo združbe (Rauch *et al*. 2006).

Spremembe v temperaturi vode so na vseh vzorčnih mestih sledile spremembam v temperaturi zraka. Rauch *et al*. (2006) so ugotovili, da je elektroprevodnost poleg pH najpomembnejši okoljski dejavnik, ki vpliva na razporeditev združb alg. Elektroprevodnost v celinskih vodah narašča z naraščanjem slanosti. Na slanost vplivajo tla s sestavo kamnin in njihovo topnostjo, podnebje, temperatura, preperevanje, prah, padavine, izhlapevanje, vetrovi, oddaljenost od morja, rastlinstvo in živalstvo (Rejic 1988). Krammer & Lange-Bertalot (1997a) sta razdelila celinske vode glede na vsebnost elektrolitov na vode, zelo revne z elektroliti (χ < 50 µS/cm), vode, revne z elektroliti (χ = 50-100 µS/cm), vode s srednjo vsebnostjo elektrolitov (χ = 100-500 µS/cm) in vode, bogate z elektroliti (χ > 500 µS/cm). Mrtvici Mure Zaton II in Mali Bakovci sta bogati z elektroliti, vrednosti električne prevodnosti so na teh dveh vzorčnih mestih presegale 500 µS/cm. Iz rezultatov meritev na posameznih vzorčnih mestih je bilo razvidno, da je bila elektroprevodnost pri višjih temperaturah višja. Wetzel & Likens (1991) sta ugotovila, da s povišanjem temperature za eno stopinjo Celzija elektroprevodnost naraste za 2 do 3 %. Razpon pH v celinskih vodah je od 2 do 12, za vode v Sloveniji večinoma med 6 in 8,5 (Rejic 1988). Vrednosti pH pod 7 smo izmerili v mrtvicah Mure Zaton I in II. Bazičen pH (izmerjene vrednosti nad 8) smo izmerili v mrtvici Mure pri Malih Bakovcih, kjer so bila tudi nihanja pH največja (7,0-8,8). Vsebnosti kisika v vodi in nasičenosti vode so bile izredno nizke v mrtvicah Mure Zaton I in II v poletnih in jesenskih mesecih, ko so bile temperature vode visoke in je v vodi potekala intenzivna razgradnja organskega materiala.

Združba alg, identificirana v izbranih mrtvicah reke Mure, je podobna združbam alg v stoječih evtrofnih vodah Slovenije (Vrhovšek *et al*. 2006), le nekatere identificirane vrste se pojavljajo tudi v hitro tekočih slovenskih vodotokih (Peroci *et al*. 2009). V mrtvici Zaton I smo skupno identificirali 37, v mrtvici Zaton II 75 in v mrtvici Mali Bakovci 107 taksonov alg. Na vseh treh vzorčnih mestih so po številu identificiranih taksonov prevladovale kremenaste alge, z najvišjima deležema (več kot 84 %) v mrtvicah Zaton II in Mali Bakovci. Kremenaste alge so po številu taksonov prevladujoče v slovenskih rekah (Krivograd Klemenčič & Vrhovšek 2003, Krivograd Klemenčič *et al*. 2003, Krivograd Klemenčič 2004, Krivograd Klemenčič & Vrhovšek 2004). Kremenastim algam so v mrtvici Zaton I sledile cianobakterije in Chlorophyceae, v mrtvicah Zaton II in Mali Bakovci pa Chlorophyceae in Xanthophyceae. Med kremenastimi algami so bile masovno ugotovljene vrste *Achnanthes hungarica* (Zaton I), *A. minutissima* (Mali Bakovci), *Eunotia bilunaris* (Zaton II), *Fragilaria ulna* (Mali Bakovci), *Gomphonema parvulum* (Zaton II) in *Nitzschia palea* (Zaton II). Naštete vrste kremenastih alg so splošno razširjene v organsko onesnaženih vodah (beta-alfa mezosaprobne vode) (Krammer & Lange-Bertalot 1997a, b, 2004a, b).

Največje število taksonov (9) iz razreda cianobakterij smo identificirali v mrtvici Zaton I, v drugih dveh mrtvicah smo ugotovili le po enega predstavnika tega razreda. Pogost je bil le takson *Leptolyngbya* sp. v mrtvici Zaton I. Največje število taksonov (6) razreda Chlorophyceae smo ugotovili v mrtvici Mali Bakovci. Masovno sta se pojavljali vrsti *Stigeoclonium tenue* (Zaton I) in *Chaetophora incrassata* (Zaton II), pogosti taksoni so bili še *Oedogonium* sp. (Zaton I) in *Microspora abbreviata* (Zaton II, Mali Bakovci).

Predstavniki razreda Xanthophyceae so bili najdeni v vseh treh mrtvicah, z najvišjim številom ugotovljenih taksonov (4) v mrtvici Mali Bakovci. Vrsti *Tribonema affine* in *Vaucheria woroniniana* sta bili pogosti vrsti v mrtvici Mali Bakovci. V mrtvicah Zaton I in Mali Bakovci smo identificirali predstavnici razreda Eglenophyceae: *Phacus pusillus* (Zaton I) in *Euglena limnophila* (Mali Bakovci). *E. limnophila* je značilna predstavnica mrtvih rečnih rokavov (Hindák *et al*. 1978).

V mrtvicah reke Mure smo skupno ugotovili 25 taksonov, ki do sedaj še niso bili znani na območju Slovenije. 19 za Slovenijo novih taksonov pripada razredu kremenastih alg, *Borzia curta* in *Woronichinia robusta* razredu cianobakterij, *Bumilleria klebsiana* in *B. spirotaenia* razredu Xanthophyceae ter *Characium ensiforme* in *Microspora abbreviata* razredu Chlorophycea (Krivograd Klemenčič *et al*. 2009).

Glede na vrednosti saprobnega indeksa (2,4-2,5) je spadala mrtvica reke Mure Zaton I v času raziskav v II.-III. kakovostni razred oziroma v beta do alfa mezosaprobno stopnjo, kar pomeni kritično obremenitev vodnega telesa. Glede na vrednosti saprobnega indeksa 1,8-2,1 sta spadali mrtvici reke Mure Zaton II in Mali Bakovci v času raziskav v II. kakovostni razred oziroma v beta mezosaprobno stopnjo, kar pomeni zmerno obremenjeno vodno telo.

Summary

The main objective of our research was to determine species composition and abundance of phytobenthos in the selected river Mura oxbows as well as to determine the water quality on the basis of indicator phytobenthos species. Algal community identified is similar to the communities of algae in the eutrophic standing waters of Slovenia; only some of the identified species can also be found in Slovenian watercourses with higher velocity. Altogether, 147 taxa from five algal classes were determined. According to the number of identified taxa, diatoms prevailed with 117 (80 %) taxa, followed by Chlorophyceae with 11 (7 %), Cyanobacteria with 10 (7 %), Xanthophyceae with seven (5 %) and Euglenophyceae with two (1 %) taxa. The most abundant genera were *Navicula* with 30 and *Nitzschia* with 17 taxa. In the oxbow Zaton I, 37 algal taxa were identified, in Zaton II 75, and in Mali Bakovci 107. On all sampling sites, diatoms were the prevailing group of algae, with the highest proportion (more than 84 %) in the oxbows Zaton II and Mali Bakovci. In Zaton I, diatoms were followed by Cyanobacteria and Chlorophyceae, while in Zaton II and Mali Bakovci diatoms were followed by Chlorophyceae and Xanthophyceae. *Achnanthes hungarica* (Zaton I), *A. minutissima* (Mali Bakovci), *Eunotia bilunaris* (Zaton II), *Fragilaria ulna* (Mali Bakovci), *Gomphonema parvulum* (Zaton II) and *Nitzschia palea* (Zaton II) were prevalent taxa among diatoms, while *Stigeoclonium tenue* (Zaton I) and *Chaetophora incrassata* (Zaton II) were prevalent among Chlorophyceae. Taxa from other three algal classes were present in somewhat lower numbers. In the selected river Mura oxbows, altogether 25 taxa, identified for the first time in the territory of Slovenia, were determined. 19 taxa new to Slovenia belong to the class of diatoms, *Borzia curta* and *Woronichinia robusta* to the class Cyanobacteria, *Bumilleria klebsiana* and *B. spirotaenia* to the class Xanthophyceae, and *Characium ensiforme* and *Microspora abbreviata* to the class Chlorophycea. According to the results of the Saprobic Index, we can classify the Mura oxbows at the sampling site Zaton I into II-III quality class, which means a critical load of the water body, and at the sampling site Zaton II and Mali Bakovci into II quality class, which means a moderately polluted water body.

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A contribution to the Slovenian spider fauna – I.

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Abstract. Sixteen spider species, new to the Slovenian fauna, have been recorded: *Aphantaulax trifasciata*, *Araneus triguttatus*, *Arctosa cinerea*, *Cnephalocotes obscurus*, *Helophora insignis*, *Heriaeus hirtus*, *Nomisia exornata*, *Nurscia albomaculata*, *Pardosa agricola*, *Pardosa prativaga*, *Pardosa proxima*, *Philodromus longipalpis*, *Runcinia grammica*, *Theridula gonygaster*, *Xysticus ninnii* and *Zora armillata*. Recent records on presumably extinct endemic species *Nesticus idriacus* are also provided, as well as suggestion to its transfer to the IUCN category rare (R).

Key words: new records, spiders, Slovenia, faunistics

Izvleček. PRISPEVEK K FAVNI PAJKOV SLOVENIJE – I. – Prispevek obravnava 16 vrst pajkov, ki doslej v Sloveniji še niso bile najdene, in sicer: *Aphantaulax trifasciata*, *Araneus triguttatus*, *Arctosa cinerea*, *Cnephalocotes obscurus*, *Helophora insignis*, *Heriaeus hirtus*, *Nomisia exornata*, *Nurscia albomaculata*, *Pardosa agricola*, *Pardosa prativaga*, *Pardosa proxima*, *Philodromus longipalpis*, *Runcinia grammica*, *Theridula gonygaster*, *Xysticus ninnii* in *Zora armillata*. Predstavljeni sta tudi novi najdbi vrste *Nesticus idriacus* Roewer, 1931, ki je v Sloveniji veljala za izumrlo, in predlog za njeno premestitev v skupino redkih vrst (R) po klasifikaciji ogroženosti IUCN.

Ključne besede: nove najdbe, pajki, Slovenija, favnistika

Introduction

Initial records on Slovenian spider fauna, contributed by Scopoli (1763), were followed by several sporadic works by various authors during the 19th and early 20th centuries. Nevertheless, the greater part of the arachnological research in Slovenia was contributed by the late Dr Anton Polenec in the second half of the 20th century (reviewed in Kuntner & Šereg 2002). His rich legacy consists of more than 70 publications on the spiders of Slovenia, including the first and so far the only checklist of the Slovenian spider fauna, citing 416 spider records (Nikolić & Polenec 1981). This number has been almost doubled in the ensuing years, mainly by contributions of the next generation of Slovenian arachneologists (e.g. Kuntner & Kostanjšek 2000, Fišer & Kostanjšek 2001, Kuntner & Šereg 2002, Kostanjšek & Miller 2004, Kostanjšek & Fišer 2005, Gregorič & Kuntner 2009), resulting in almost 700 records of spider species in Slovenia to date.

Although the number of recorded spider species has almost doubled in recent two decades, the knowledge of the Slovenian spider fauna is still considered incomplete. Regarding the number of spider species in some countries with similar surface area to Slovenia and more complete knowledge of the spider fauna (e.g. Austria with 984 species, Slovakia 906, Switzerland 945, Czech Republic 841 species (Blick *et al.* 2004) and Hungary with 725 species (Samu & Szinetár 1999)), at least another fifty to hundred spider species are expected to be found in Slovenia.

The prime objective of this new series of contributions to the Slovenian spider fauna is to encourage further and more regular publishing of new and interesting spider records in Slovenia, in order to provide for a much needed comprehensive overview of the Slovenian spider fauna.

Material and methods

The present study includes new records for the Slovenian spider fauna, retrieved during the recent reorganization and survey of the spider collection at the Chair of Zoology in the Department of Biology, Biotechnical Faculty, University of Ljubljana. The collection includes mainly material gathered by students during their practical courses, individual projects and the Students Biology Research Camps (RTŠB), as well as personal collections of the author and his associates at the Chair of Zoology.

Specimens were identified according to various determination keys and published descriptions (Levi 1967, Thaler 1981, Loerbroks 1983, Roberts 1993a, b, 1995, Heimer & Nentwig 1991, Melic 2000, Yoshida 2001, Nentwig *et al.* 2010). The systematics and nomenclature of the determined spiders follow Platnick (2010).

For each species, data on the collected material including description of the collecting site, geographic latitude and longitude in Gauß-Krüger coordinates, altitude in meters above sea level (a. s. l.), as well as data on the material provider (leg.) and determinator (det.) of the species are given, when available. Coordinates and geographic descriptions of the collecting sites follow Atlas okolja of the Slovenian Environment Agency. Descriptions of the collected material are followed by data on distribution of the species in other countries in the region and comments on the finding.

Results and discussion

Aphantaulax trifasciata (O. P.-Cambridge, 1872) - Gnaphosidae

- 2 ♂ - meadow, 1 km W from Osp village; Y=410185, X=48545; 40 m a. s. l.; 20.7.2004; leg.: RTŠB 2004, det. Kostanjšek R.
- 1 ♀ - forest; 50 m NE from Podpeč village near Hrastovlje; Y=415075, X=42735; 440 m a. s. l.; 15.7.2004; leg.: RTŠB 2004, det. Kostanjšek R.

Distribution and comment: the distribution of the species is generally considered Palearctic (Platnick 2010), although the species is absent from Central Europe (Blick *et al*. 2004), Britain and Scandinavia. Its range in Europe extends from Portugal, through Mediterranean countries and the Balkans to Russia (Nentwig *et al*. 2010). Since *A. trifasciata* has been recorded in Serbia (Deltshev *et al*. 2003), as well as in Italy (Stoch 2003) and Croatia (Nikolić & Polenec 1981), the finding of the species in the warm and arid Karst region in south-western Slovenia did not come as a surprise.

Nomisia exornata (C. L. Koch, 1839) - Gnaphosidae

- 1 ♀ - rock wall in Mišja peč 620 m SE of Osp village; Y=411670, X=47669; 100 m a. s. l.; 20.7.2004; leg.: RTŠB 2004; det.: Kostanjšek R.

Distribution and comment: the range of this ant-eating species in Europe is similar to that of *A. trifasciata*, with additional records from Switzerland among Central European countries (Blick *et al*. 2004). Among countries in the region, the species has been recorded from Hungary (Samu & Szinetár 1999), Italy (Stoch 2003), Croatia (Nikolić & Polenec 1981) and Serbia (Deltshev *et al*. 2003). The species inhabits dry and hot environments, which are common in the Kraški rob (Karst Edge) region of Slovenia, where the species has been found.

Araneus triguttatus (Fabricius, 1793) - Araneidae

- 1 ♀ - forest, Osek 1.3 km S from Šempas village; Y=404902, X=87258; 300 m a. s. l; May 1998; leg.: Humar M., det. Gregorič M., Knapič T.

Distribution and comment: the species is Holarctic (Platnick 2010) and widely spread throughout Europe (Blick *et al*. 2004, Nentwig *et al*. 2010). Although the species is rarer than the morphologically similar *A. sturmi* (Roberts *et al*. 1995), the presence of *A. triguttatus* in Slovenia was, in a way, expected.

Arctosa cinerea (Fabricius, 1777) - Lycosidae

- 1 ♀ - gravel bank of Idrijca river, near Reka village; Y=417359, X=108228; 260 m a. s. l.; 28.7.2000; leg.: RTŠB 2000; det.: Kostanjšek R.

Distribution and comment: this fairly large species is spread throughout Europe, including all countries neighbouring Slovenia. The presence of *A. cinerea* in Slovenia has been already assumed (Nikolić & Polenec 1981), yet not confirmed so far. The species is well adapted to water habitats like waterbeds and lake sides, where it can even live submerged in its silk-lined burrows for a considerable amount of time. Due to its presence in the neighbouring countries, the record of *A. cinerea* in Slovenia was certainly expected.

Pardosa agricola (Thorell, 1856) - Lycosidae

- 1 ♂, 5 ♀ - meadow, 50 m S of Hruški vrh Peak in the Karavanke Mountains; Y=424090, X=149050; 1,700 m a. s. l.; 18.7.1999; leg.: Fišer C., Šereg I.; det.: Gregorič M., Knapič T.

Pardosa prativaga (L. Koch, 1870) - Lycosidae

- 1 ♀ - arid meadow, 3.5 km N from Kostanjevica na Krki village; Y=533194, X=81424; 150 m a. s. l.; 26.7.2009; leg.: RTŠB 2009; det.: Kostanjšek R.
- 2 ♂, 1 ♀ - damp meadow, 250 m NW from the main building of Department of Biology on Večna pot in Ljubljana; Y=459208, X=101103; 300 m a. s. l.; 7.5.2003 and 20.5.2003; leg. Gregorič M., det. Kostanjšek R.

Pardosa proxima (C. L. Koch, 1847) - Lycosidae

- 2 ♀ - arid meadow, 150 m NW from the main building of Department of Biology on Večna pot in Ljubljana; Y=459330, X=101087; 300 m a. s. l.; 23.4.2003; leg. & det. Gregorič M.
- 1 ♂ - near pond, Brdo pri Kranju; Y=454290, X=127681; 470 m a. s. l.; 27.6.2004; leg. & det.: Kostanjšek R.
- 1 ♀ - arid meadow, 3.2 km SW from Rečica ob Savinji village; Y= 492108, X=128868; 395 m a. s. l.; 27.7.2007; leg.: RTŠB 2007, det.: Gregorič M.

Distribution and comment: all three above listed species of the genus *Pardosa* are widespread throughout Europe (Blick *et al*. 2004, Nentwig *et al*. 2010), including all countries neighbouring Slovenia (Nikolić & Polenec 1981, Samu & Szinetár 1999, Stoch 2003). Their presence in Slovenia was therefore more or less expected, confirming therefore previous assumptions on the presence of *P. agricola* and subspecies *P. proxima poetica* in Slovenia (Nikolić & Polenec 1981).

Zora armillata Simon, 1878 - Zoridae

- 1 ♀ - forest; Krakovski gozd, 2.2 km N from Kostanjevica na Krki village; Y=533134, X=80111; 150 m a. s. l.; 26.7.2009; leg.: RTŠB 2009, det.: Kostanjšek R.

Distribution and comment: the species is distributed from Europe to Russia (Platnick 2010) and present in most of the countries of Central Europe, where the species is associated with wet habitats and relatively rarely found (Roberts 1995). Among the neighbouring countries, the species has been recorded from Austria (Blick *et al*. 2004), Hungary (Samu & Szinetár 1999) and Italy (Stoch 2003).

Nurscia albomaculata (Lucas, 1846) - Titanoecidae

- 1 ♂, 5♀ - sea shore, Bonifika, Ankaran; Y=401950, X=48580, 0 m a. s. l.; 14.7.2004; leg.: RTŠB 2004; det.: Kostanjšek R.
- 2 ♂, 5♀ - meadow, 150 m S from Cape Ronek Peak near Strunjan; Y=392369, X=44550, 60 m a. s. l.; 17.7.2004; leg.: RTŠB 2004; det.: Kostanjšek R.
- 1 ♂, - meadow, 300 m N from Cape Ronek Peak near Strunjan; Y=392790, X=44345, 60 m a. s. l.; 14.7.2004; leg.: RTŠB 2004; det.: Kostanjšek R.

Distribution and comment: beside the site from Germany (Blick *et al*. 2004), the range of the species in Europe spreads from the Iberian Peninsula to France, Italy (Stoch 2003, Nentwig *et al*. 2010) and the Balkan Peninsula (Nikolić & Polenec 1981, Nentwig *et al*. 2010) and further into Central Asia (Platnick 2010). All three collection sites listed above are located on Slovenian coast in warm, sunny habitats, which are preferred by species according to Nentwig *et al*. (2010).

Philodromus longipalpis Simon, 1870 - Phliodromidae

- 1♀ - forest, northern slope of the Kutošev breg hill, 1 km NW from Šalovci village, Goričko region; Y=597389, X=187700; 270 m a. s. l.; 23.7.1999; leg.: RTŠB 1999, det.: Kostanjšek R.
- 2♀ - forest, 500 m W from Gorje pri Cerknem village; Y=420558, X=112339; 650 m a. s. l.; 27.7.2000; leg.: RTŠB 2000, det.: Kostanjšek R.
- 1♀ - arid meadow and forest edge, S of Stepani, E from Dekani village; Y=411090, X=45500; 140 m a. s. l.; 12.6.2004; leg. Fišer C., det.: Kostanjšek R.
- 1♀ - meadow, 700 m NE from village Modrejce, S of Tolmin; Y=403940, X=114607; 160 m a. s. l.; 22.7.2010; leg.: RTŠB 2010, det.: Kostanjšek R.

Distribution and comment: the species has been recorded in most European countries (Blick *et al*. 2004), including all countries neighbouring Slovenia (Nikolić & Polenec 1981, Samu & Szinetár 1999, Stoch 2003, Nentwig *et al*. 2010), except Austria. Therefore, the species is another in the list of previously expected (Nikolić & Polenec 1981), yet unconfirmed spider species in Slovenia so far.

Theridula gonygaster (Simon, 1873) - Theridiidae

- 1♀ - meadow, 500 m SW from Most na Soči; Y=402925, X=112650, 210 m a. s. l.; 24.7.2010; leg.: Knapič T., det.: Kostanjšek R.
- 1♀ - damp meadow, eastern spring of Lamošček stream, E of Bavconov vrh peak near Šempeter pri Gorici; Y=398268, X=87791; 180 m a. s. l.; 4.8.2010; leg.: Vinko D., det.: Knapič T. Kostanjšek R.

Distribution and comment: although *T. gonygaster* is considered cosmopolitan (Platnick 2010), the confirmed records on its presence in Europe are restricted to the south-western part of Europe. Since species has been recorded only from Corsica (Simon 1873), parts of Italy (Brignoli 1969, Stoch 2003) and relatively recently from Spain (Melic 2000), the species is considered rare. Therefore, the records of *T. gonygaster* on two sites in Slovenia during the same season are probably amongst the most interesting findings in recent year. Despite its relatively small size, with body length of approximately 2 mm, the species has a distinctive habitus with glossy black cephalothorax and dark brown abdomen with several well defined yellow markings. Abdomen is broader than long, with two lateral and posterior tuberculum,

which gives it distinctive rhomboidal appearance (Figure 1a). Beside its distinctive habitus, the species has been determined by the outer morphology of female genitalia (Levi 1967, Melic 2000, Yoshida 2001) (Figure 1b). Since the species is considered rare and restricted to warm climate, two records of *T. gonygaster* in western Slovenia during the same season might be explained by so far unrecorded local geographical or seasonal distribution of the species. Although it is tempting to speculate on climate change and spreading of the species' range towards the north due to global warming, it cannot be excluded that the species has often been simply overlooked due to its size.

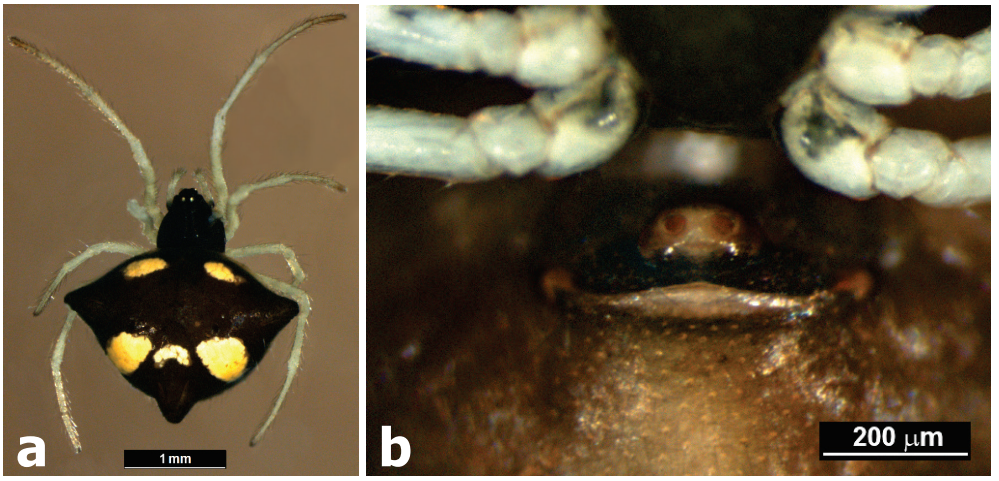

Figure 1. Dorsal view of a female *Theridula gonygaster* (a) and ventral view of its epigine (b).
Slika 1. Samica pajka *Theridula gonygaster* s hrbtne strani (a) in njena epigina z ventralne strani (b).

Cnephalocotes obscurus (Blackwall, 1834) - Linyphiidae

- 1 ♂ - quarry, 240 m SW of Slepšek, W of Mokronog village; Y=50997, X=88839; 280 m a. s. l.; 24.7.2009; leg.: RTŠB 2009, det.: Kostanjšek R.
- 1 ♀ - arid meadow, 560 m E of Mokronog village; Y=512289, X=88900; 250 m a. s. l.; 22.7.2009; leg.: RTŠB 2009, det.: Kostanjšek R.

Distribution and comment: the species is considered Palearctic (Platnick *et al*. 2010) and has been recorded throughout Europe, including Austria (Blick *et al*. 2004) and Italy (Stoch 2003) and Serbia among countries in the region (Deltshev *et al*. 2003). With its body length less than 2 mm, the species might be easily overlooked. However, the distinctive reproductive organs, especially male palpus, enable relatively easy and unambiguous determination of this species. The finding is the first record of the genus in Slovenia.

Helophora insignis (Blackwall, 1841) - Linyphiidae

- 1♀ - entrance of the Bilpa cave, S of Kočevje; Y=497460, X=41084; 250 m a. s. l.; 20.7.2008; leg.: RTŠB 2008, det.: Kostanjšek R.

Distribution and comment: the species is Holarctic, recorded throughout Europe (Nentwig *et al*. 2010), including all countries neighbouring Slovenia, except Croatia (Samu & Szinetár 1999, Stoch 2003, Blick *et al*. 2004). Being the only species of the genus in Europe, the record also yields the first data on the genus in Slovenia.

Runcinia grammica (C. L. Koch, 1837) - Thomisidae

- 1 ♀ - meadow, 150 m S from Cape Ronek Peak near Strunjan; Y=392369, X=44550, 60 m a. s. l.; 14.7.2004; leg.: RTŠB 2004; det.: Kostanjšek R.
- 1 ♀ - meadow E from road, 500 m NEE from Marezige village; Y=407340, X=41300; 280 m a. s. l.; 16.7.2004; leg.: RTŠB 2004, det.: Kostanjšek R.
- 1 ♀ - arid meadow, 400 m S of Šternci, S from Sv. Peter nad Dragonjo village; Y=396655, X=35165; 80 m a. s. l.; 9.6.2004; leg. & det.: Kostanjšek R.
- 1 ♀ - arid meadow and bush, W from road, 500 m N of Kopriva village, N from Sežana; 280 m a. s. l.; 30.3.2004; leg.: Fišer C., det.: Kostanjšek R.
- 1 ♂ - meadow, 50 m E of St. Duh Church at Sveti Peter nad Dragonjo village; Y=397110, X=36300; 210 m a. s. l.; 12.6.2004; leg. & det.: Kostanjšek R.
- 4 ♂ - arid meadow 60 m SE of Sv. Trojica Church at Hrastovlje; Y= 414630, X=41160; 160 m a. s. l.; 11.6.2004; leg.: Fišer C., det.: Kostanjšek R.

Distribution and comment: the species is Palearctic (Platnick 2010), common in South Europe and rather rare in Central Europe (Heimer & Nentwig 1991). It has been recorded from all countries neighbouring Slovenia, except Austria (Nikolić & Polenec 1981, Samu & Szinetár 1999, Stoch 2003, Blick *et al*. 2004). The species is quite common in the Slovenian Karst region and it came as a surprise that beside the students field reports (e.g. Kostanjšek 2005), the species and the genus have not been properly recorded so far.

Heriaeus hirtus (Latreille, 1819) - Thomisidae

- 3 ♂ - meadow, 750 m W from Tinjan village; Y=408515, X=46850; 300 m a. s. l.; 17.7.2004; leg.: RTŠB 2004, det.: Kostanjšek R.
- 1 ♀ - rock wall 500 m S of Dragonja village; Y=395625, X=35080; 60 m a. s. l.; 16.7.2004; leg.: RTŠB 2004, det.: Kostanjšek R.
- 2 ♂, 1 ♀ - arid meadow, 400 m S of Šternci, S from Sv. Peter nad Dragonjo village; Y=396655, X=35165; 80 m a. s. l.; 9.6.2004; leg. & det.: Kostanjšek R.
- 1 ♀ - meadow, 400 m S of Sv. Duh Church in Sv. Peter nad Dragonjo village; Y=397100, X=35825; 200 m a. s. l.; 9.6.2004; leg. & det.: Kostanjšek R.
- 1 ♂ - bush and meadow, 1 km S from St. Duh Church in Sveti Peter nad Dragonjo village; 12.6.2004; leg.: Fišer C., det.: Kostanjšek R.
- 2 ♂ - arid meadow 60 m SE of Sv. Trojica Church in Hrastovlje; Y= 414630, X=41160; 160 m a. s. l.; 11.6.2004; leg.: Fišer C., det.: Kostanjšek R.
- 2 ♀ - arid meadow and forest edge, S of Stepani, E from Dekani village; Y=411090, X=45500; 140 m a. s. l.; 12.6.2004; leg. Fišer C., det.: Kostanjšek R.

Distribution and comment: the species' range spreads throughout Southern Europe, from the Iberian to the Balkan Peninsulas. It has been recorded from all countries neighbouring

Slovenia, except Austria (Nikolić & Polenec 1981, Samu & Szinetár 1999, Stoch 2003, Blick *et al*. 2004). Although the genus can be easily recognized by its distinctive hairy appearance and has been recorded in Slovenia previously (Kuntner 1997, Kuntner & Šereg 2002), the determination at the species level can be challenging due to the similar outer anatomy of genitalia within the genus (Loerbroks 1983). The same as *R. grammica*, *H. hirtus* is commonly found during the summer in warmer and arid habitats of the Karst region, and has therefore been expected in Slovenia.

Xysticus ninnii Thorell, 1872 - Thomisidae

- 5 ♀ - meadow, 1.5 km S from Zagozdec village, SW of Črnomelj; Y=505008, X=41175; 400 m a. s. l.; 20.7.2008; leg.: RTŠB 2008, det.: Kostanjšek R.
- 1 ♀ - meadow; 500 m NE of Kal nad Kanalom village; S of Most na Soči; Y=403336, X=105527; 740 m a. s. l.; 25.7.2010; leg.: RTŠB 2010, det.: Kostanjšek R.
- 1 ♀ - meadow; 440 m NE of Bata village; S of Most na Soči; Y=398311, X=101279; 660 m a. s. l.; 25.7.2010; leg.: RTŠB 2010, det.: Kostanjšek R.

Distribution and comment: the species is distributed throughout Europe (except Britain and Scandinavia (Nentwig *et al*. 2010)), including all countries neighbouring Slovenia (Nikolić & Polenec 1981, Samu & Szinetár 1999, Stoch 2003, Blick *et al*. 2004). Therefore, a record of this Palearctic species in Slovenia has been expected (Nikolić & Polenec 1981).

Nesticus idriacus Roewer, 1931 - Nesticidae

- 1 ♀ - Čendova jama cave (cave cadastre No. 2903), Ponikve S from Kneža village; Y=409420, X=112390; 570 m a. s. l.; 3.6.2009; leg.: Zagmajster M., Trontelj P., Prevorčnik S., Lah L., det. Kostanjšek R.

Distribution and comment: the species is endemic to northeast Italy (Thaler 1981, Stoch 2003), Austria (Thaler 1981, Blick *et al*. 2004) and Slovenia. Due to destruction of its finding site in Ciganska jama near Črni vrh in Trnovski gozd forest (Nikolić & Polenec 1981), the species has been considered extinct according to the IUCN classification in the previous (Polenec 1992) as well as current Red list of endangered species in Slovenia (Pravilnik o uvrstitvi ogroženih rastlinskih in živalskih vrst v rdeči seznam - UL RS 82/4055). Despite its status, a male *N. idriacus* has been recorded from Golerjev ali Jamniški pekel cave in northwestern Slovenia (Kranjc & Novak 1977, Novak 2005), followed by recent record of a female in Čendova jama cave listed above. Since the above mentioned records clearly indicate recent presence of the species in Slovenia, a transfer of *N. idriacus* to the IUCN »rare« (R), the same as other endemic cave spiders in Slovenia, should be made.

Povzetek

Prispevek je prvi v seriji prispevkov o favni pajkov Slovenije, vzpostavljeni z namenom spodbujanja objav novih zanimivih najdb pajkov na območju Slovenije, saj je kljub večjemu številu novih najdb pajkov v zadnjem desetletju poznavanje slovenske aranaeofavne še vedno nepopolno. Prispevek obravnava 16 vrst pajkov, ki do sedaj v Sloveniji še niso bile najdene, in sicer: *Aphantaulax trifasciata* (O. P.-Cambridge, 1872), *Araneus triguttatus* (Fabricius, 1793), *Arctosa cinerea* (Fabricius, 1777), *Cnephalocotes obscurus* (Blackwall, 1834), *Helophora insignis* (Blackwall, 1841), *Heriaeus hirtus* (Latreille, 1819), *Nomisia exornata* (C. L. Koch, 1839), *Nurscia albomaculata* (Lucas, 1846), *Pardosa agricola* (Thorell, 1856), *Pardosa prativaga* (L. Koch, 1870), *Pardosa proxima* (C. L. Koch, 1847), *Philodromus longipalpis* Simon, 1870, *Runcinia grammica* (C. L. Koch, 1837), *Theridula gonygaster* (Simon, 1873), *Xysticus ninnii* Thorell, 1872 in *Zora armillata* Simon, 1878. Predstavljeni sta tudi novi najdbi vrste *Nesticus idriacus* Roewer, 1931, ki je v Sloveniji veljala za izumrlo, in predlog za njeno premestitev v skupino redkih vrst (R) po klasifikaciji ogroženosti IUCN.

Poleg nekaterih redkih vrst, kot na primer *T. gonygaster*, je pojavljanje večine v prispevku predstavljenih vrst v Sloveniji pričakovano. Prav presenetljivo pa je dejstvo, da doslej nismo imeli nobenih objav o vrstah, kakršni sta *H. hirtus* in *R. gramica*, ki sta razmeroma pogosti v jugozahodni Sloveniji, kar pa očitno govori o nezadostni raziskanosti araneofavne v nekaterih predelih Slovenije.

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Emergence and flight routes of the lesser horseshoe bats *Rhinolophus hipposideros* (Bechstein, 1800) from a church at Ljubljansko barje, central Slovenia

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Abstract. The flight routes from roosts to feeding habitats are important for efficient conservation of bats, but in Slovenia they are poorly known. Emergence and flight routes of the lesser horseshoe bats *Rhinolophus hipposideros* from the Church of Sveti Duh at Vnanje Gorice, Ljubljansko barje, were monitored on ten different days in August and September 2009. In the beginning of August, 72 lesser horseshoe bats were counted in the attic; the number decreased to 29 in the beginning of September. Individuals of three other bat species were also found in the attic and belfry: the greater mouse eared bats *Myotis myotis*, serotine bats *Eptesicus serotinus* and a group of alpine long-eared bats *Plecotus macrobullaris*. The lesser horseshoe bats emerged only from a single opening in the attic. The first bat flew out on average 16 minutes after the sunset, while the first bat amongst those that did not return to the roost left on average 20 minutes after sunset. The lesser horseshoe bats flew few metres above the ground into the nearby forest Gulč on the northwestern side of the church. We observed flying bats at nine locations in this forest and at three locations on the forest edge, where they probably foraged. Bats flew along a lit road next to houses, close to a major road they had to cross, and next to a railway southwest from the church. The spatial and temporal distribution of observations indicated the flight towards the mixed forest Plešivica, where a lesser horseshoe bat was observed app. 1.7 km bee-line distance SW from the church at Vnanje Gorice. Considering that bats generally follow linear elements in the landscape, and on the basis of our observations at 21 locations and flight behaviour we envisaged the most likely course of their flight route. These data are important for efficient conservation of the lesser horseshoe bats roosting at Vnanje Gorice and maintenance of important landscape elements in the surrounding landscape.

Keywords: *Rhinolophus hipposideros*, emergence, flight routes, Vnanje Gorice, Ljubljansko barje, Slovenia

Izvleček. IZLETAVANJE IN LETALNE POTI MALIH PODKOVNJAKOV *RHINOLOPUS HIPPOSIDEROS* (BECHSTEIN, 1800) IZ CERKVE NA LJUBLJANSKEM BARJU, OSREDNJA SLOVENIJA – Letalne poti iz zatočišč do prehranjevalnih habitatov so pomembne za učinkovito varstvo netopirjev, a so v Sloveniji večinoma slabo poznane. V okviru naše študije smo deset dni v avgustu in septembru 2009 spremljali izletavanje in letalne poti malih podkovnjakov *Rhinolophus hipposideros* iz cerkve Svetega Duha v Vnanjih Goricah na Ljubljanskem barju. V začetku avgusta je porodniška skupina malih podkovnjakov na podstrešju štela 72 osebkov in se do začetka septembra zmanjšala na 29 osebkov. Na podstrehi in v zvoniku so bili najdeni še navadni netopirji *Myotis myotis*, pozni netopirji *Eptesicus serotinus* in skupina usnjebradih uhatih netopirjev *Plecotus macrobullaris*. Mali podkovnjaki so izletavali le iz ene okrogle line na podstrehi. Prvi netopir je v povprečju izletel 16 minut po sončnem zahodu, medtem ko je prvi izmed tistih, ki se niso vrnili v zatočišče, izletel iz line povprečno 20 minut po sončnem zahodu. Mali podkovnjaki so leteli nekaj metrov nad tlemi v gozd Gulč na severozahodni strani cerkve. Prelete malih podkovnjakov smo zabeležili na devetih lokacijah v gozdu Gulč in na treh lokacijah ob gozdnem robu, kjer so se verjetno prehranjevali. Opazovali smo jih med letom ob osvetljeni cesti blizu hiš, blizu večje ceste, ki so jo morali prečkati, in ob železnici jugozahodno od cerkve. Ob upoštevanju časovne in prostorske razporeditve opažanj kaže na let v smeri mešanega gozda Plešivice, kjer smo zaznali prelet malega podkovnjaka približno 1,7 km jugozahodno od cerkve v Vnanjih Goricah. Na osnovi opažanj na 21 lokacijah in smeri leta ter upoštevajoč ugotovitve, da netopirji v splošnem sledijo linearnim elementom v krajini, smo poskušali ugotoviti najverjetnejšo letalno pot malih podkovnjakov. Ti podatki so pomembni za učinkovito varstvo malih podkovnjakov v Vnanjih Goricah in za ohranitev ključnih elementov v okoliški krajini.

Ključne besede: *Rhinolophus hipposideros*, izletavanje, letalne poti, Vnanje Gorice, Ljubljansko barje, Slovenija

Introduction

The lesser horseshoe bat, *Rhinolophus hipposideros* (Bechstein, 1800), is the smallest species of horseshoe bats (Rhinolophidae) in Europe (Dietz *et al*. 2009). Its distribution range extends across the west Palaearctic to Kashmir, north-west Africa, Ethiopia and Sudan. In Europe, it occurs south of 52° latitude, and also in Ireland and SW England (Schofield 1999, Roer & Schober 2001). In Slovenia, it is the commonest horseshoe bat; records are missing only from parts of the River Mura basin in northeast and the high mountainous areas of the Alps in the northwest of the country (Petrinjak 2009).

During winter, the lesser horseshoe bat roosts mostly in caves and other underground shelters. In summer, only warmer caves in southern Europe harbour nursery colonies, whereas in central and northern regions they roost in attics of buildings (Dietz *et al*. 2009). Such are also the nursery roosts in Slovenia, with an exceptional observation of a colony under a bridge in the warmer south-western part of the country (Petrinjak 2009).

Flight routes are narrow flight corridors that bats regularly use to commute from the roost to foraging grounds. The long-term stability of flight routes (Schaub & Schnitzler 2007) makes them very important for conservation. As many other slow-flying bat species, the lesser horseshoe bats prefer to avoid open and exposed areas in the landscape (Ekman & De Jong 1996, Stone *et al*. 2009); their flight routes are therefore often parallel to linear landscape elements such as hedgerows (Schaub & Schnitzler 2007, Zahn *et al*. 2008). There is much evidence supporting the importance of linear landscape elements as guidelines for bat flight routes; they are suitable for echoacoustic orientation (Verboom *et al*. 1999), serve as foraging habitats and can provide protection against predators and wind (Verboom & Huitema 1997, Verboom & Spoelstra 1999). According to Reiter *et al*. (2008), the vicinity of linear landscape elements to the roost can result in safer emergence.

Foraging habitats and flight routes of the lesser horseshoe bat in Slovenia are poorly known also owing to the relatively difficult detection with bat detector (Petrinjak 2009). Studies from other countries, some of which included radiotelemetry, showed that forests near the roosts are the most important foraging habitats of this species (Schofield 1996, Motte & Libois 2002, Bontadina *et al*. 2002, Zahn *et al*. 2008). The distance between a roost and foraging habitat was mostly up to 2.5 km, and did not exceed 4-6.4 km (Schofield 1996, Holzhaider *et al*. 2002, Motte & Libois 2002, Bontadina *et al*. 2002, Bontadina *et al*. 2006, Zahn & Weiner 2004). Its diet consists mostly of crane flies, moths and neuropterans (McAney & Fairley 1989).

Lesser horseshoe bats are endangered in the greater part of their distribution range, with indications of stabilised or increased numbers only from some parts of Europe (Schofield 1999, Dietz *et al*. 2009). Disturbance at roosts (increasing cave tourism, improper renovation of buildings, i.e. during the nursery periods, by closing the flight openings), effects of pesticides and changes in natural landscape, such as forest fragmentation or the shifting of tree lines, are the major threats to this species (Bontadina *et al*. 2000, Motte & Libois 2002, Petrinjak 2009). The additional threat, light pollution, can negatively affect them at roosts (Decoursey & Decoursey 1964, Shirley *et al*. 2001, Downs *et al*. 2003, Boldogh *et al*. 2007),

and can also change the established flight routes near tree lines and forest roads (Stone *et al*. 2009).

The moor of Ljubljansko barje south of Ljubljana city in central Slovenia is one of the Natura 2000 sites under European Habitats Directive (92/34/EGS, Appendix 2), declared as such also with the aim to protect the lesser horseshoe bats (Official Gazette of the RS, No. 49/04, 110/04, 59/07 and 43/08). Nursery roosts of the species were found in nine churches in the area, several harbouring over 100 bats (Zagmajster 2008, Presetnik *et al*. 2009a, 2009b). In the Church of Sveti Duh at Vnanje Gorice, in the central part of Ljubljansko barje, a nursery of up to 70 lesser horseshoe bats was found (Presetnik *et al.* 2009b, Zagmajster 2008). The church is also inhabited by nurseries of mouse-eared bats *Myotis myotis* and serotine bats *Eptesicus serotinus* (Zagmajster 2008, Presetnik *et al*. 2009a, 2009b). In 2009, some individuals of the alpine long-eared bats *Plecotus macrobullaris* were observed (Presetnik *et al*. 2009b).

In this study, we investigated the emergence behaviour and flight behaviour of the lesser horseshoe bat colony at Vnanje Gorice, which had not been systematically studied before. We expected bats would fly into some of the forest patches in the surroundings of the church that present potential feeding grounds of the species. Our data presented the first information on the colony's flight routes and enabled predictions concerning parts of the flight routes.

Methods

Study area

Ljubljansko barje is a large wetland area (about 150 km^2) south of Ljubljana, with a highly mosaic structure of meadows, agricultural fields, draining ditches, hedgerows and some forest patches. The roost of the lesser horseshoe bats in the church at Vnanje Gorice is situated in the central part of Ljubljansko barje, separated from the potential large forested foraging area in the south (Krim forests) by wetland areas. The village of Vnanje Gorice lies in the central part of Ljubljansko barje, southeast from Ljubljana (Fig. 1). In the centre of the village, the hill Gulč covered with deciduous forests is standing, with the Church of Sveti Duh situated at its top (333 m elevation). The hill is surrounded with buildings, with their highest concentration on the hill's west side and in the area between Gulč and Veliki vrh, and another deciduous forest patch about 600 m east from the church (highest elevation about 373 m). Between the two hills stretches a belt of houses, with trees that form a tree line next to a street in some places. Most streets at Vnanje Gorice are lit with roadside lights during the entire night. The village's major and busiest road is situated west of the church, next to the single track railway, which runs in a straight line south towards Plešivica.

More than 900 m south of Vnanje Gorice the hill Grič (also called Dobčenica), covered with a mixed forest, stands at approx. 342 m a.s.l. About 1 km southwest of Vnanje Gorice stretch a large mixed forest patch Plešivica (390 m elevation) and the villages of Plešivica and Žabnica. The area between Vnanje Gorice, Plešivica and Grič (Fig. 1) is covered by moor meadows, mostly turned into agricultural fields and pastures. This area is crisscrossed by draining ditches, in places overgrown with hedgerows (hazel *Corylus sp.*, willow *Salix sp.*, alder *Alnus sp.*, and ash trees *Fraxinus sp.*).

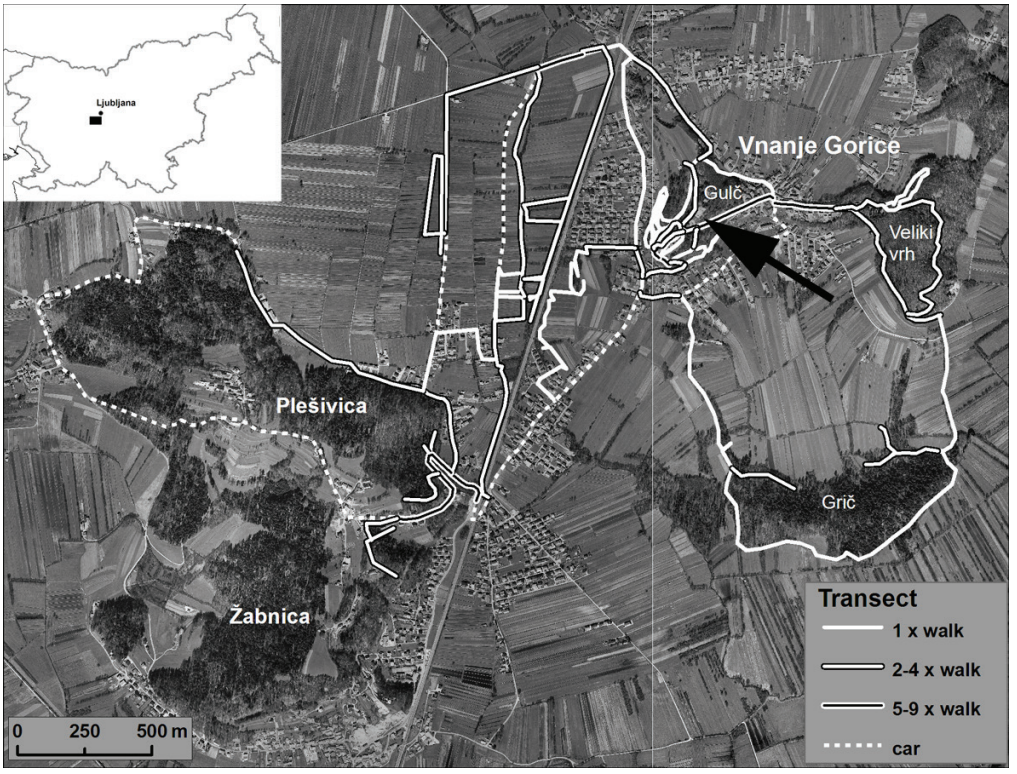

Figure 1. Study area at Ljubljansko barje with marked transects where lesser horseshoe bats were searched for with bat detectors during August and September 2009. Transects were walked on or slowly driven by car, with different numbers of repeats (see the legend). Arrow points to the Church of Sveti Duh at Vnanje Gorice with the lesser horseshoe bat nursery colony.

Slika 1. Preučevano območje na Ljubljanskem barju z označenimi transekti, na katerih smo ugotavljali navzočnost malih podkovnjakov z ultrazvočnim detektorjem avgusta in septembra 2009. Transekte smo prehodili ali prevozili s počasno vožnjo, z različnim številom ponovitev (glej legendo). Puščica označuje cerkev Svetega Duha v Vnanjih Goricah, kjer je nastala porodniška kolonija malih podkovnjakov.

Description of the church

The Church of Sveti Duh at Vnanje Gorice (Gauss Krueger coordinates X: 455126, Y: 95767) is a middle-sized Catholic church with its bell tower connected to the main part of the church. At night, the church is lit from three sides with four pale orange spotlights; with two from the south side (one was off during our study), with one spotlight from the north and one from the northeastern side (Figs. 2, 3). The spotlights were turned on around the time of the sunset (always before the bats started to emerge).

The church attic had openings leading out of it and to the belfry. The opening of 1.5 m x 0.80 m in size was located between the attic and the lower part of the belfry. There was no opening leading to the bells, as the 0.80 m x 0.80 m entrance was closed with a hatch. In the attic, at the southeastern part of the church, there are two round windows measuring 20 cm in diameter. One of the two windows was closed with a wire mesh, while the other was open. We found bat guano at the edge of the opening. There were several smaller openings between the attic's roof tiles (up to few cm in width), all too small for emergence of horseshoe bats. The entrance to the belfry is located at the church's choir and closed with a door. All windows and openings in the lower parts of the belfry are grilled. Some windows in the inner part of the church were open during our study.

Field work

Our study was conducted on ten different days in August and September 2009 (Tab. 1). We used different methods that are described in the following sections.

Table 1. Dates, weather conditions and research methods used during the study of emergence and flight routes of the lesser horseshoe bats of the Church of Sveti Duh at Vnanje Gorice in 2009. Days when emergence of the entire colony was monitored are marked with *. For the descriptions of methods see text.

Tabela 1. Dnevi, vremenske razmere in metode raziskovanja med preučevanjem izletavanja in letalnih poti malih podkovnjakov iz cerkve Svetega Duha v Vnanjih Goricah leta 2009. Dnevi, ko smo opazovali izletavanje cele kolonije, so označeni z *. Metode so podrobno opisane v besedilu.

Day of observation	Date	Weather	Roost survey	Emergence and flight observation	Tracking with ultrasound detector
1	6.8.2009	clear sky	✓		
2*	8.8.2009	clear sky		✓	✓
3*	9.8.2009	clear sky		✓	✓
4	12.8.2009	clear sky		✓	✓
5	13.8.2009	partly clouded with infrequent drizzling		✓	✓
6	28.8. 2009	clear sky	✓	✓	✓
7	30.8.2009	clear sky		✓	✓
8	31.8.2009	clear sky			✓
9*	1.9.2009	clear sky		✓	
10	2.9.2009	clear sky			✓

Roost survey

The attic of the church was examined on two occasions during daytime, when bats were in their roost (Tab. 1). The belfry above the bells was inspected only during our first visit. Bats were identified visually using halogen torches and with bat detector Pettersson D200 (Pettersson Elektronik AB), if they were active. The count of bats was performed with the minimum level of disturbance. We also looked for bat bone remains and droppings.

Emergence behaviour

The start of the evening emergence was monitored during seven evenings, starting 15 minutes before sunset (Tab. 1). On three occasions we observed the emergence of the entire lesser horseshoe bat colony, when we finished observations around 30 minutes after sunset, i.e. at least 15 minutes after the last bat flew out of the roost. On other occasions, the emergence was observed only until the first bat flew out of the roost to the nearby forest, after which we started to look for their flight routes (see next chapter). We recorded the time of the first bat flying out of the opening and the time of the first bat that had left the roost (without returning back). If possible, we determined the flight direction and the location of flight into the forest. We used halogen spotlights, which were not directed towards the flight opening but used only occasionally to track the flying bats. To detect flying bats, we used Pettersson D200 and D240 (Pettersson Elektronik AB) bat detectors in heterodyne mode (Russ 1999) and set on 110 kHz frequency. This is the specific frequency of the echolocation calls of the lesser horseshoe bats (Russo & Jones 2002). Their echolocation calls can be difficult to detect and often allow detection only about 5-6 m away (Motte & Libois 2002).

Flight routes

After recording the location of the flight into the forest, we followed the lesser horseshoe bats using bat detectors (Tab. 1). In six cases, we followed the bats to the forest near the church, until losing track of the echolocation calls. In the following evening one member of our research team began his tracking activities at the place of the last bat observation during the preceding night (as in Motte & Libois 2002). In four nights, we started observations at the places where bats had been heard last during the previous night, but away from the church itself (from 28 Aug onward, see Tab. 1). On days when we started observations at the church (6 days, Tab. 1), we checked the potential presence of lesser horseshoe bats near the church also around midnight of the same night to see whether some bats would be present in its vicinity for potential feeding near the church or returning back into the roost.

Every time we lost track of the flying lesser horseshoe bats, we continued the search for the species in the neighbouring forest patches, at hedgerows. We were looking for bats while walking; only in four cases did we occasionally use the car and make observations through the open window at a speed of 20 km/h. We had set the bat detector to the frequency of 110 kHz, and when the bat was heard, the location was marked with GPS (Garmin). All locations were mapped and analysed using ArcGIS, ver. 9.2 (ESRI).

Results

Bats in the church

On 6 Aug 2009, there were 72 lesser horseshoe bats roosting in the attic. We observed some females with juveniles and thereby confirmed previous reports of a nursery colony in the church (Presetnik et al. 2009b). We also recorded guano and three mummified remains of the lesser horseshoe bats. Some lesser horseshoe bats and one female with juvenile were observed in the belfry, on the ceiling of the room right under the compartment with bells.

The number of lesser horseshoe bats in the attic decreased to 30 on 28 Aug 2009. The count of the bats during their emergence four days after this inspection revealed almost the same number of bats (29 individuals).

During the first visit, we observed three other bat species. One serotine bat was climbing on the wooden trunk under the roof of the attic, and according to the fresh guano it is highly likely that more individuals of the species were present there, but could not be seen. Seven greater mouse-eared bats were in the belfry, in the compartment above the bells only. Social calls suggested that the group, hidden in the cranny, consisted of more bats than we were able to see. Therefore, as far as the greater mouse-eared and serotine bats are concerned, the observed numbers should be considered minimal. In the attic, a group of 12 alpine long-eared bats was observed in a cluster on the wooden trunk close to the roof. During our second visit, when only the attic was checked, a single alpine long-eared bat was recorded, besides lesser horseshoe bats.

Figure 2. Position of the flight opening that lesser horseshoe bats use to emerge from the attic of the Church of Sveti Duh at Vnanje Gorice. Black arrow indicates the round opening, white arrow points to the window in the lower part of the church that remained open during our study. a) View of the southern part of the church, b) Close-up of the flight opening and open window, c) View of the flight opening from the attic. Photo: S. Zidar.

Slika 2. Položaj odprtine, ki so jo mali podkovnjaki uporabljali za izletavanje s podstrehe cerkve Svetega Duha v Vnanjih Goricah. S črno puščico je označena okrogla odprtina, z belo puščico pa okno v cerkev, ki je bilo v času naše raziskave odprto. a) Pogled na južno pročelje cerkve, b) Bližnji pogled na izletalno odprtino in odprto okno c) Pogled na izletalno odprtino s podstrehe. Foto: S. Zidar.

Emergence of lesser horseshoe bats from the roost

Lesser horseshoe bats were using one round opening, situated on the southeastern side of the church, to emerge from the attic (Figs. 2, 3). The opening was located in the shadow, hidden from the light emitted by the spotlights that lit up the church from its eastern side.

The emerging bats did not fly directly from the roost to the nearby forest, but made a few circles in front of the opening and returned to the roost. On seven days, we observed some bats flying to the window at the southeastern part of the church, many of them making a turn under the vault of the window (Fig. 3). This window was in the shadow as well, shaded by the side wall from the spotlights.

Lesser horseshoe bats passed the corner of the church flying low, some of them even less than a metre above the ground (Fig. 3). They flew higher when circling (several times) under the vault of the belfry, just under the ceiling. One bat was seen making even seven turns (on 9 Aug 2009). On their flight away from the belfry, bats flew close to the ground again. They entered the forest northwest from the church, flying over the wall of the cemetery that surrounds the church (Fig. 3).

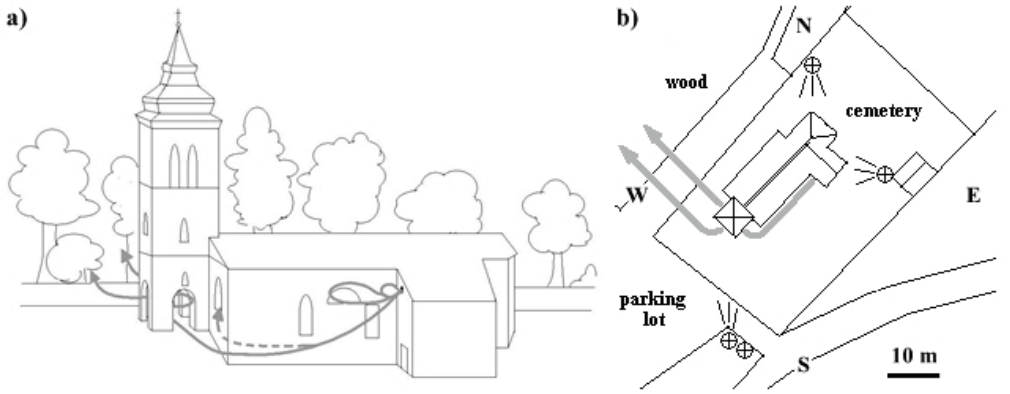

Figure 3. Observed flight routes of the lesser horseshoe bats after emerging from the attic of the Church of Sveti Duh at Vnanje Gorice. Some bats were flying in and out of the church through the open window (hatched line). a) Scheme of the southeastern side of the church with flight routes; b) Top view of the church with marked position of spotlights and direction of lights (bottom southeastern spotlight was not lit during our study).

Slika 3. Opažene letalne poti malih podkovnjakov po izletu iz podstrehe cerkve Svetega Duha v Vnanjih Goricah. S črtkano linijo je označen let nekaj netopirjev, ki so leteli v in iz cerkve skozi odprto okno. a) Shematski prikaz cerkve z jugovzhodne strani z letalnimi potmi; b) Tloris cerkve z označenimi reflektorji in smerjo svetenja (skrajni jugovzhodni reflektor v času raziskave ni bil prižgan).

On the front (southwestern) side of the church, a window was opened every day during our observations, leaving about 40 cm wide opening (Figs. 2b and 3). One lesser horseshoe bat was observed flying out of that window on 9 Aug 2009 after the bats started their emergence from the attic roost. On 1 Sep 2009, a lesser horseshoe bat was seen flying in and out of the same window. Since there is no open connection between the attic and the interior of the church, the bat had to enter the church through this window also on 9 Aug 2009.

On 9 Aug 2009, three lesser horseshoe bats were observed flying towards southeast after emerging. By following one of them, we discovered that it circled above the parking lot next to the church and then continued its flight towards the same forest as other bats.

On 13 Aug 2009, when the weather was cloudy with infrequent drizzles, bats did not exhibit circular flights in front of the church. After emerging, they flew directly under the belfry into the forest.

On average, the first lesser horseshoe bat was observed exiting the roost 16 minutes after the sunset (Fig. 4), with the first bat flying into the forest 20 minutes after the sunset. On 13 Aug 2009, when the weather was cloudy, bats emerged from the roost later than on other days, 26 minutes after the sunset.

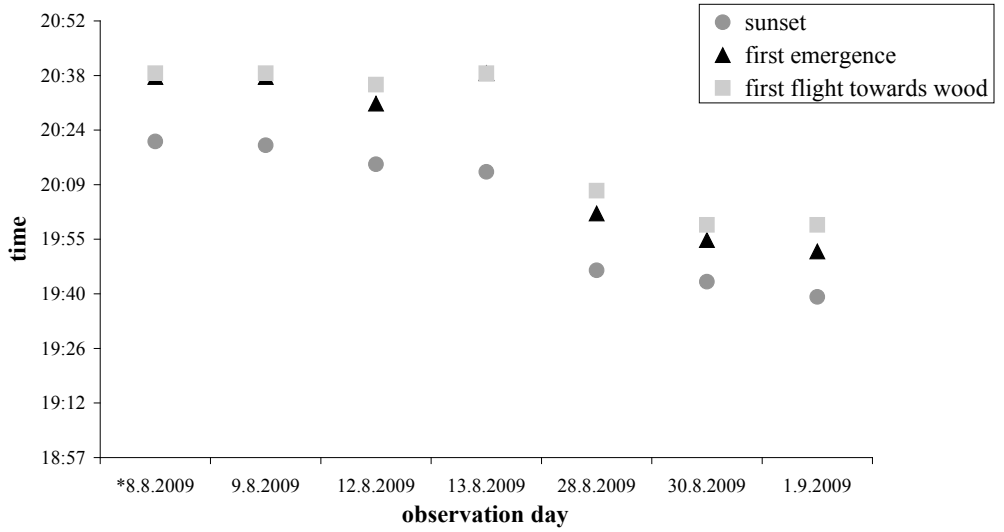

Figure 4. Time of sunset, time of the first lesser horseshoe bat's emergence from the roost (with return shortly afterwards), and time of the first bat leaving the roost and flying into the forest next to the Church of Sveti Duh at Vnanje Gorice, as recorded during the seven days of August and September 2009.

Slika 4. Čas sončnega zahoda (označen s krogom), čas prvega izleta malega podkovnjaka iz zatočišča (trikotnik) in čas prvega izleta malega podkovnjaka proti gozdu ob cerkvi Svetega Duha v Vnanjih Goricah (kvadrat), kot so bili zabeleženi v sedmih dneh avgusta in septembra 2009.

Flight routes of lesser horseshoe bats

After leaving the roost, the bats flew towards the Gulč forest, northwest from the church (points 1-6, 7, 11, 12, Fig. 5, Tab. 2). In six cases, they were recorded at the western and southern edges of the forest. Bats flew out of the forest near the points 8-10 (Fig. 5, Tab. 2), where a small clearing lies in the forest. One evening (13 Aug 2009), the lesser horseshoe bats were also recorded flying along the outer western edge of the forest (points 13-15, Fig. 5, Tab. 2). We had not observed this kind of behaviour during any other night visits of the forest. The longest period from the time that bats first entered the forest to the time we detected them for the last time in the forest was 40 minutes.

We observed lesser horseshoe bats in Plešivica forest on three occasions:

- on 13 Aug 2009 (point 19, Fig. 5, Tab. 2) a bat was detected between the forest and the orchard, near the house at the unlit part of the forest road leading to Plešivica;
- on 30 Aug 2009 (point 20, Fig. 5, Tab. 2) a bat was seen passing the unlit part of the same road 100 m southwest from point 19;
- on 2 Sep 2009 (point 21, Fig. 5, Tab. 2) one bat flew along the unlit edge of the forest next to the road, near the orchard.

To check for the flight routes between Vnanje Gorice and Plešivica, we checked the area between Plešivica and Gulč on four occasions (Fig. 1). The lesser horseshoe bats were observed at three locations:

- on 30 Aug 2009 a bat was flying along the unlit street (point 16, Fig. 5, Tab. 2);
- on 30 Aug 2009 one bat was observed in the meadow near the rail, close to the draining ditch and line of trees t (point 17, Fig. 5, Tab. 2);
- on 31 Aug 2009 a bat was observed above the railway, near a humid meadow and a line of trees (point 18, Fig. 5, Tab. 2).

We did not detect any lesser horseshoe bats in the forest patches of Veliki vrh and Grič during the three evenings they were inspected (on 8 Aug, 9 Aug, and 12 Aug 2009, Figs. 1, 5). We did detect presence of other bat species we are not reporting on in this article.

Figure 5. Locations around the Church of Sveti Duh at Vnanje Gorice (arrow), where lesser horseshoe bats were observed with bat detectors during August and September 2009. The dotted line presents part of the most likely flight route of the lesser horseshoe bats from the church (for detailed explanations see the text). In the rectangle in top left part of the figure is a close-up of the area around the church. See also Tab. 2.

Slika 5. Lokacije v okolici cerkve Svetega Duha v Vnanjih Goricah (puščica), kjer smo avgusta in septembra 2009 z ultrazvočnim detektorjem opazovali male podkovnjake. Črtkana črta ponazarja del najverjetnejše letalne poti malih podkovnjakov iz cerkve (za podrobnejšo razlago glej besedilo. V pravokotniku v zgornjem levem delu slike je prikazano povečano območje v bližnji okolici cerkve. Glej tudi Tab. 2.

Table 2. Locations where lesser horseshoe bats were observed with bat detectors in wider surroundings of the Church of Sveti Duh at Vnanje Gorice in August and September 2009. The Gauss-Krueger coordinates, bee-line distance from the church, the time when a bat was observed and time of sunset are given. See also Fig. 5.
Tabela 2. Točke v širši okolici cerkve Svetega Duha v Vnanjih Goricah, kjer smo avgusta in septembra 2009 z ultrazvočnimi detektorji slišali male podkovnjake. Podane so Gauss-Kruegerjeve koordinate, najkrajša oddaljenost od cerkve, čas, ko je bil netopir opažen, in čas sončnega zahoda. Glej tudi sl. 5.

Point No.	Date	Sunset	Time	Coordinates		Distance from the church [m]
				X	Y	
1	9.8.2009	20:20	20:52	455112	95805	28
2	8.8.2009	20:21	20:57	455106	95799	27
3	9.8.2009	20:20	21:06	455099	95794	29
4	9.8.2009	20:20	20:55	455090	95793	37
5	9.8.2009	20:20	21:04	455099	95783	25
6	9.8.2009	20:20	21:22	455086	95764	41
7	12.8.2009	20:15	21:17	455052	95769	73
8	13.8.2009	20:13	20:42	455004	95702	143
9	13.8.2009	20:13	20:39	454982	95699	163
10	13.8.2009	20:13	20:57	454999	95705	145
11	13.8.2009	20:13	20:43	455011	95716	129
12	12.8.2009	20:15	20:53	455016	95755	111
13	13.8.2009	20:13	20:51	454999	95829	134
14	13.8.2009	20:13	20:48	455008	95838	130
15	13.8.2009	20:13	20:49	455030	95882	139
16	30.8.2009	19:44	20:16	454881	95712	255
17	30.8.2009	19:44	20:40	454613	95499	583
18	31.8.2009	19:42	20:26	454519	95573	639
19	13.8.2009	20:13	22:22	454247	94813	1305
20	30.8.2009	19:44	22:17	454192	94743	1396
21	2.9.2009	19:39	22:05	453969	94540	1694

Based on distribution of 21 localities, where lesser horseshoe bats were detected (Fig. 5, Tab. 2), observations of their flight directions and considering that bats generally follow linear elements in the landscape (Verboom & Huitema 1997, Zahn *et al*. 2008), we envisaged one part of the hypothetical flight route of the lesser horseshoe bats from their roost (Fig. 5). According to our observations, bats needed to cross the well lit and heavily trafficked road west of Vnanje Gorice. Our observation of a lesser horseshoe bat at point 16 (Fig. 5, Tab. 2), flying along the unlit street, supports the prediction that crossing the main road is part of their flight route. Since the calls of the species were detected on both sides of the railway (points 17 and 18, Fig. 5, Tab. 2), we can confirm that the lesser horseshoe bats cross it (Fig. 5).

Discussion

We found four bat species in the Church of Sveti Duh at Vnanje Gorice, whose presence was expected according to the previous studies (Presetnik et al. 2007, 2009a, 2009b, Zagmajster 2008). We found a group of alpine long-eared bats in the church, where a year earlier only single individuals had been found (Presetnik et al. 2009b). We were unable to capture and measure the individuals, but according to the season they were highly likely females with juveniles, which should be taken into account for the conservation purposes of this roost. The closest nursery roost of the alpine long-eared bats was found in the Notranje Gorice church, 2.4 km bee-line distance away (Zagmajster 2008).

We observed typical bat behaviour shown by the first individuals that emerged from the roost, called light sampling (Fure 2006). Bats did not fly directly out of the roost, but rather circled in front of the emergence opening and then returned to the roost, which was repeated several times. Such behaviour was also observed in the lesser horseshoe bats emerging from the winter roosts in north-western Slovenia in spring 2002 (Petrinjak & Jokhadar 2003). During light sampling, bats check the intensity of light, and emerge from the roost at low light intensities to avoid predators (like birds), but not too late to miss the peak of evening insect activity (Rydell et al. 1996, Duverge et al. 2000, Fure 2006). We observed a lesser horseshoe bat flying in and out of the interior of the inner part of the church through the open window. This might be just random behaviour, but it could also be interpreted as searching for new openings leading from the church.

Lesser horseshoe bats were flying less than 5 m above the ground, which is quite characteristic of the species (Russ 1999). They flew through the Gulč forest near the church relatively fast, but it is possible that they also foraged there. On 13 Aug 2009, we detected several bats flying along the outer edge of the Gulč forest on its western side. It may be that on that day bats were foraging so early due to the worse weather compared to our other observation evenings. We were at the same forest edge on four other evenings, but did not observe any lesser horseshoe bats there.

It is very probable that the lesser horseshoe bats observed in the Plešivica area are the ones emerging from the Church of Sveti Duh at Vnanje Gorice. Directions of bats flying from Vnanje Gorice and the timing of our observations support this possibility. On 13 Aug 2009, the last lesser horseshoe bat at Gulč was detected at 20:57 hrs. The species was observed at Plešivica about 1.5 h later. The greatest bee-line distance between the Vnanje Gorice church and the locations where species was detected at Plešivica was 1.7 km from the church. This is within the range of the average lesser horseshoe bat foraging area (Bontadina et al. 2002, Bontadina et al. 2006). It would be possible that individual lesser horseshoe bats roosted in any of the buildings in the Plešivica area, but no such roost has been discovered so far. The next nearest colony is situated in the Church of Sveti Vid at Preserje (Presetnik et al. 2009a), which is 4.6 km bee-line distance away from Plešivica. Presence of the lesser horseshoe bats in the Plešivica area indicates that this could be their feeding habitat, or one of them at the least.

It is possible that lesser horseshoe bats also foraged near linear landscape elements during commuting (Zahn et al. 2008), but no such behaviour was observed. Such foraging behaviour is more often observed for other bat species (Racey & Swift 1985, Verboom & Spoelstra 1999).

Illuminating the roost entries negatively affects emergence of different bat species from their roost (Decoursey & Decoursey 1964, Shirley *et al.* 2001, Downs *et al.* 2003, Boldogh *et al.* 2007, Kozjek *et al.* 2008). According to the recent study by Stone *et al.* (2009), lesser horseshoe bats were affected by street lighting when introduced along their regular flight routes. In our study we have observed that while flying near the church, lesser horseshoe bats always remained in the unlit area, shaded by the side nave. However, bats from Vnanje Gorice have to cross the lit and trafficked road as part of their flight route. This indicates lesser horseshoe bats could perhaps be able to adjust to certain light conditions. Part of their flight route is also the open meadow area between Gulč and the road. However, we assume that they use lines of trees and bushes near the drainage ditches as primary element of their flying routes between the railway and Plešivica, considering the fact that they prefer to fly along linear landscape elements (Schaub & Schnitzler 2007, Zahn *et al.* 2008).

Our observations agree with the finding that recording of lesser horseshoe bats with detectors is hard due to high atmospheric attenuation of their directed high frequency calls, which do not allow detection on long distances (Russ 1999, Russo & Jones 2002). The time of detection of one bat was also limited, since the bat quickly passed the area where it could be detected. Obviously, we did not detect all lesser horseshoe bats present in the monitored areas; however, by detecting some individuals we were able to reconstruct the most probable course of their major flight route. Further research using methods of labelling and tracking specific individuals should provide more information to determine habitat use and flight routes of this colony.

During our research, no lesser horseshoe bats were found in the forests of Veliki vrh and Grič. Neither were the bats of this species observed on car transects with bat detectors conducted near both forest patches on 5 Aug 2009 (Zagmajster 2009). That is surprising, given that both forests are the nearest wooded areas and could be easily accessible without crossing illuminated areas, roads or railways. Motte and Libois suggested (2002) that structure is crucial for forest suitability as a foraging habitat. Maybe the structure of both forest patches is less suitable for the lesser horseshoe bats; however, there seems not to be a great difference in composition of all three forests. Possible reason for preference of the Plešivica forest could also be its size – Plešivica forest is much larger than Veliki vrh and Grič. Another explanation takes into consideration the period when our study was conducted. In the late summer, bats start to migrate from their summer to winter roosts (Dietz *et al.* 2009). It is possible that lesser horseshoe bats fed in closer forest patches in other parts of the season, but were on their migration routes leading toward southern forests at the time of our study. Indeed, bats were gradually leaving the roost during our study, as halving of the number of lesser horseshoe bats in the roost was observed during the 25 days. Whether habitat use differs during the summer and whether lesser horseshoe bats sometimes use the nearby forest areas should be determined by further studies.

Lesser horseshoe bats were flying low above the ground and had to cross a busy road and railway. Thus, bats from Vnanje Gorice could be occasional traffic casualties. Lesser horseshoe bats already have been found victims of the car traffic close to a church with nursery colony at Tomišelj south of Vnanje Gorice (Denac 2003).

For effective conservation of bats in the church, other threats to the bats must also be identified. As already shown, bats use unlit areas of the church during emergence; it is important to leave these parts of the church not illuminated. Furthermore, lesser horseshoe bats used a single exit opening, which is actually a window that used to be closed with the net. This window must remain open to enable bats to enter and exit the roost.

Our observations present the first information on flight routes of the lesser horseshoe bats roosting at Vnanje Gorice. It would be necessary to continue the studies, extending them to the whole season and using additional methods, for example radio-tracking individual bats. Gained data will be important for planning the efficient conservation that includes preservation of the nearby suitable habitats besides roost protection.

Povzetek

Mali podkovnjak *Rhinolophus hipposideros* (Bechstein, 1800) je razširjen po skoraj vsej Sloveniji, kjer prezimuje v podzemnih jamah, porodniške kolonije pa ima večinoma na podstrešjih stavb (Petrinjak 2009). Je ogrožena vrsta, po podatkih iz zadnjih nekaj desetletij pa naj bi se njena številčnost po strmem upadanju stabilizirala ali v nekaterih delih Evrope celo začela povečevati (Schofield 1999, Dietz *et al*. 2009). Poleg svetlobnega onesnaževanja, neustreznih prenov stavb, uporabe pesticidov in jamskega turizma malega podkovnjaka ogroža tudi spreminjanje gozdne krajine (Bontadina *et al*. 2000, Motte & Libois 2002, Petrinjak 2009). V Sloveniji so prehranjevalni habitati malih podkovnjakov slabo poznani, tudi zaradi razmeroma težkega zaznavanja te vrste z ultrazvočnimi detektorji (Petrinjak 2009). Kot druge počasi leteče vrste netopirjev se tudi mali podkovnjaki na svojih letalnih poteh izogibajo odprtim predelom (Ekman & De Jong 1996, Stone *et al*. 2009). Letalne poti so redno uporabljeni letalni koridorji od zatočišč do prehranjevalnih habitatov, ki zaradi mnogih ugodnosti za netopirje pogosto potekajo ob linearnih elementih krajine, kot so žive meje in linije dreves (Verboom & Huitema 1997, Verboom & Spoelstra 1999, Verboom *et al*. 1999). Zaradi stalnosti letalnih poti (Schaub & Scnitzler 2007) pa so te tudi pomemben del učinkovitega varstva netopirjev.

V naši raziskavi smo spremljali kolonijo malih podkovnjakov iz cerkve Svetega Duha v Vnanjih Goricah na Ljubljanskem barju deset dni v avgustu in septembru 2009. S pregledom podstrehe in zvonika smo popisali netopirje v začetku avgusta in ponovno v začetku septembra (ko dela nad zvonovi nismo pregledali). Male podkovnjake smo opazovali med izletavanjem, spremljali smer letenja ter jim sledili z ultrazvočnimi detektorji, dokler nismo izgubili signala. Iz lokacij, kjer smo jih zaznali, smo sklepali na potek letalne poti iz zatočišča in potencialne prehranjevalne habitate.

Mali podkovnjaki imajo porodniško skupino na podstrehi cerkve Svetega Duha, ki je v času pregleda podstrehe 6.8.2009 štela 72 osebkov. V cerkvi v Vnanjih Goricah so bile opažene še tri druge vrste netopirjev, ki so bile na podlagi preteklih raziskav pričakovane: navadni netopir *Myotis myotis*, pozni netopir *Eptesicus serotinus* in usnjebradi uhati netopir *Plecotus macrobullaris* (Presetnik *et al*. 2009a, 2009b). Prvič smo našli večjo skupino usnjebradih uhatih netopirjev. Pri pregledu podstrešja konec avgusta smo našli le 30 malih podkovnjakov in enega usnjebradega uhatega netopirja.

Edina nezamrežena in primerna odprtina za izlet malih podkovnjakov iz podstrešja je okroglo okno premera približno 20 cm na jugozahodni strani cerkve. Prvi netopir je iz te line izletel približno 16 minut po sončnem zahodu. Zatem smo opazili značilno vedenje s kroženjem pred lino in vračanjem v zatočišče za domnevno preverjanje jakosti svetlobe. Prvi netopir je v povprečju izletel iz zatočišča (tako da se ni več vrnil vanj) 20 minut po sončnem zahodu. Netopirji so tik ob cerkvi leteli nizko, do 4 metre visoko, namenjeni naravnost v gozd Gulč na severozahodni strani cerkve. Čeprav se verjetno mali podkovnjaki pri letu skozi ta gozd tudi prehranjujejo, pa so ga vsakič zapustili v razmeroma kratkem času. Male podkovnjake smo zaznali na 9 lokacijah v gozdu in na 6 lokacijah ob robu gozda. Pri iskanju letalnih poti smo jih zaznali tudi ob prometni in osvetljeni cesti ter železniški progi, ki vodi proti Plešivici jugozahodno od cerkve. Na osnovi zabeleženih lokacij in upoštevajoč ugotovitve, da netopirji v splošnem sledijo linearnim elementom v krajini, smo ugotavljali najverjetnejšo letalno pot malih podkovnjakov. Ti se namreč na letalnih poteh izogibajo odprti krajini in osvetljenim predelom (Stone *et al*. 2009), primerni elementi za njihove letalne poti so linije dreves in grmovja, ki rastejo ob osuševalnih jarkih na območju do Plešivice (Schaub & Schnitzler 2007, Zahn *et al*. 2008). Pri tem morajo prečkati nekaj bolj odprtih predelov kot tudi osvetljeno in prometno cesto ter železniško progo. Ker smo male podkovnjake nekajkrat slišali v gozdu na področju Plešivice, najbolj oddaljena lokacija je bila 1,7 km stran od cerkve v Vnanjih Goricah, predvidevamo, da gre najverjetneje za netopirje iz tega kotišča, ta gozd pa bi lahko bil tudi primeren prehranjevalni habitat. V drugih raziskavah je bilo ugotovljeno, da so najpomembnejši prehranjevalni habitati malih podkovnjakov bližnji gozdovi, oddaljeni maksimalno 2,5 do 6,4 km od zatočišča (Schofield 1996, Holzhaider *et al*. 2002, Motte & Libois 2002, Bontadina *et al*. 2002, Zahn & Weiner 2004, Bontadina *et al*. 2006).

Naša raziskava je prispevek k poznavanju ekologije malih podkovnjakov cerkve Svetega Duha v Vnanjih Goricah, čeprav je trajala relativno kratek čas. Za izboljšanje poznavanja kolonije bi bilo treba spremljati kolonijo v drugih delih sezone kot tudi uporabiti dodatne metode (npr. telemetrijo). Za uspešno varstvo malih podkovnjakov je poleg varovanja zatočišča pomembno tudi poznavanje letalnih poti in rabe habitatov v njegovi okolici.

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The second record of *Lasiommata petropolitana* (Fabricius, 1787) in Croatia

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Abstract. After the first confirmed record of *L. petropolitana* in Croatia on Mt Snježnik, another specimen of this species was caught on the nearby Obruč Mt in May 2010. This record expands its known area of occurrence in Croatia to the northwest and suggests that *L. petropolitana* could in the future be found on other mountains of Gorski Kotar and in their surrounding areas.

Keywords: *Lasiommata petropolitana*, Obruč, Croatia, distribution

Izvleček. DRUGA NAJDBA METULJA *LASIOMMATA PETROPOLITANA* (FABRICIUS, 1787) NA HRVAŠKEM – Po prvi potrjeni najdbi vrste *Lasiommata petropolitana* na Snježniku (Hrvaška) je bil maja leta 2010 blizu Obruča ulovljen nov primerek te vrste. Najdba povečuje poznano razširjenost vrste na Hrvaškem proti severozahodu in nakazuje potencialno prisotnost vrste tudi na ostalih vrhovih Gorskega Kotarja in v njihovi okolici.

Ključne besede: *Lasiommata petropolitana*, Obruč, Hrvaška, razširjenost

Lasiommata petropolitana has a scattered distribution in Europe. According to Tolman & Lewington (2008), its range of occurrence spreads from the Pyrenees to Fennoscandia, North Turkey, North Siberia and Amur. In Europe, it is a local species present in the higher mountain ranges of South Europe, from the Pyrenees through the Central Alps, Balkan Mountains and Northern Greece (Tolman & Lewington 2008). The northern populations of *L. petropolitana* in Europe are found in low altitude forests (Higgins & Hargreaves 1983), while southern populations only occur at altitudes above 500 m in the higher mountain ranges (Gotthard 1998). The butterflies fly in one or two generations from April to September. The larvae feed on various grasses of the genera *Festuca, Poa* and *Dactylis* (Higgins & Hargreaves 1983, Benz *et al*. 1987).

In the »Distribution maps of the butterflies of Yugoslavia« (Jakšić 1988), *L. petropolitana* was recorded in the neighbouring states of Slovenia and Bosnia and Herzegovina, while no data was presented for Croatia. Nevertheless, during the last 100 years, *L. petropolitana* has been recorded in Croatia on five different locations: above Samobor (Vukotinović 1879, Grund 1916), near Vinkovci (Koča 1901), in Dalmatia (Stauder 1922), at Beli on the island of Cres (Micevski & Micevski 2006), and on Mt Snježnik (Mihoci & Šašić 2009). However, according to Mihoci & Šašić (2009), the finding of *L. petropolitana* on Mt Snježnik is the first reliable record of this species in Croatia. All other findings are probably misidentifications, as there is no suitable habitat present at these sites, or the description of the locality is too vague.

In June 2009, a short visit to Mt Snježnik resulted in the find of another specimen of *L. petropolitana*, which confirmed the true existence of a resident population of this particular species in Croatia. But even so the question remained whether *L. petropolitana* had an isolated population on Snježnik Mt or it was present on other mountains of Gorski Kotar as well. While a part of Gorski Kotar, Grobničke Alpe above the city of Rijeka, was researched in May 2010, a specimen of *L. petropolitana* was found on a trail leading from the Trstenik valley to the peak of Obruč Mt at approximately 1230 m a.s.l. The specimen was flying along a stony edge of a macadam road and was observed while resting on a stone. After a long hunt, the specimen was caught, identified as *L. petropolitana* and placed in private butterfly collection (Koren, Pazin). The determination is based on Tolman & Lewington (2008) and comparison made with the specimen previously found on Mt Snježnik and with the one recorded by Mihoci & Šašić (2009). Both sites of *L. petropolitana* in Croatia are shown in Fig. 1. The finding of the Northern Wall Brown on Mt Obruč expands the known area of its occurrence in Croatia by approximately 20 kilometres to the northwest and suggests that *L. petropolitana* could be found on other mountains of Gorski Kotar as well.

During this short field trip, the following butterfly species were also recorded: *Erynnis tages* (Linnaeus, 1758), *Ochlodes sylvanus* (Esper, 1777), *Iphiclides podalirius* (Linnaeus, 1758), *Papilio machaon* Linnaeus, 1758, *Pieris rapae* (Linnaeus, 1758), *Pieris napi* (Linnaeus, 1758), *Aricia agestis* (Denis & Schiffermüller, 1775), *Polyommatus icarus* (Rottemburg, 1775), *Vanessa atalanta* (Linnaeus, 1758), *Melitaea athalia* (Rottemburg, 1775), *Pararge aegeria* (Linnaeus, 1758), *Lasiommata megera* (Linnaeus, 1767), and *Coenonympha pamphilus* (Linnaeus, 1758).

Mt Obruč has never been a target of any butterfly survey, and no published records exist about its fauna to our knowledge, so further research of this area is required.

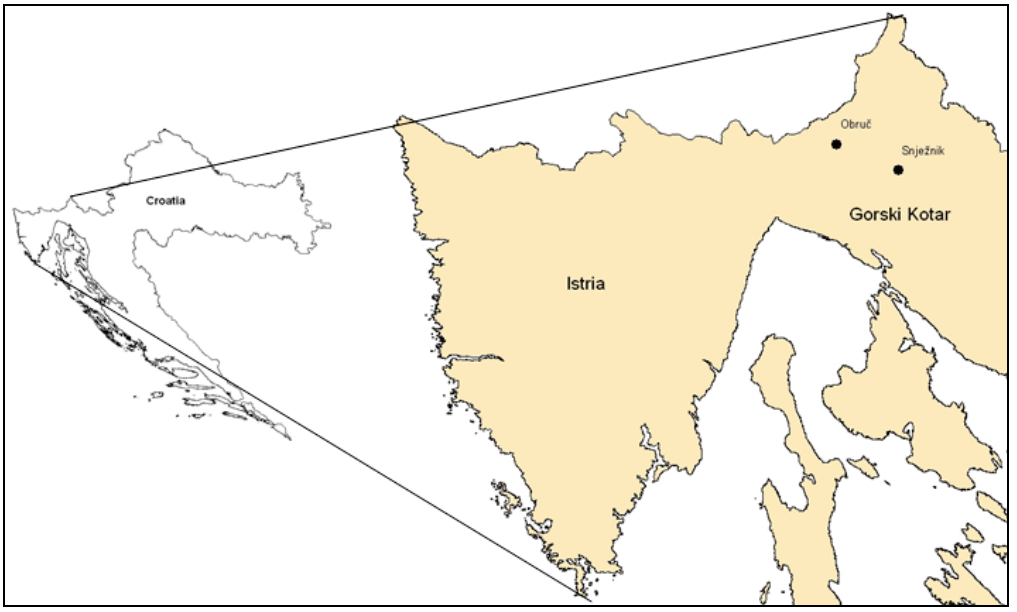

Figure 1. Map of Croatia with the confirmed sites of *L. petropolitana* (black dots).
Slika 1. Zemljevid Hrvaške s potrjenimi nahajališči *L. Petropolitana* (črne pike).

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Record of a Western Whip Snake (*Hierophis viridiflavus*) on the Snežnik Plateau (Southern Slovenia)

NAJDBA ČRNICE (*HIEROPHIS VIRIDIFLAVUS*) NA SNEŽNIŠKI PLANOTI (JUŽNA SLOVENIJA)

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On 19th August 2010, Letizia Kozlan, Matija Špacapan and myself were surveying bear dens on the Snežnik Plateau. At 5 p. m., while driving along an unpaved forest road at 1101 metres a.s.l. below the Goljak peak in the southern part of the Snežnik Plateau (UTM VL54, S Slovenia) in the mosaic of dry high-karst meadows and deciduous forests, we caught sight of a large dark snake in the middle of the road. I stopped the car and managed to catch the snake. After a closer inspection I was able to confirm that it was an adult Western Whip Snake (*Hierophis viridiflavus*). The snake was about 120 cm long and dark coloured, characteristic of the eastern part of the species' range (Fig. 1). After photo-documenting the snake, we released it where we had found it and took GPS location. I caught the snake in accordance with the permission No. 35601-32/2010-6 for the protected reptile and amphibian species handling in Slovenia, issued by the Environment Agency of the Republic of Slovenia on 22nd April 2010.

In Slovenia, the Western Whip Snake reaches the north-eastern border of the species' range (Kreiner 2007). According to the recent review of reptiles' distribution in Slovenia, this snake occurs in the western and south-western parts of the country up to 984 m a.s.l. (Krofel *et al*. 2009). This find, from UTM square VL54 at 1101 m a.s.l., is thus the highest and easternmost record of the Western Whip Snake in Slovenia according to published finds. However, recent finds from Mt. Čaven indicate that it may occur even at 1200 m a.s.l. (B. Kumar, pers. comm.). In Southern Europe, this species can reach up to 1500 m a.s.l., occasionally even up to 2000 m a.sl. (Arnold 2004). Southern and western edges of the Snežnik Plateau are known for their thermophilous conditions that enable other typical lowland species to occur at higher elevations (e.g. Scops Owl *Otus scops*; Krofel 2008), so the present find is not unexpected. Since the Snežnik Plateau is covered by a large non-fragmented complex of Dinaric forest further to the east, I assume that the area around Goljak delineates the eastern boundary of the Western Whip Snake's distribution in Slovenia.

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Figure 1. Western Whip Snake (*Hierophis viridiflavus*) found in August 2010 on the Snežnik Plateau (S Slovenia). Photo: M. Krofel.
Slika 1. Črnica (*Hierophis viridiflavus*), najdena avgusta 2010 na Snežniški planoti (J Slovenija). Foto: M. Krofel.

A contribution to the herpetofauna of Žirje Island (Dalmatia, Croatia)

PRISPEVEK K POZNAVANJU FAVNE PLAZILCEV IN DVOŽIVK OTOKA ŽIRJE (DALMACIJA, HRVAŠKA)

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Many islands of the Croatian part of the Adriatic remain poorly researched. This applies to the island of Žirje as well. No detailed research into the herpetofauna of this island has ever been carried out.

Between July 15th and 24th, 2010, a survey on the distribution of reptiles and amphibians was carried out at Žirje Island.

The island covers 15.43 km^2, or 15.78 km^2 with its surrounding islets and reefs (a total of 17) (Friganović 1994). The highest point on the island is the peak Kapić, 134 m a.s.l. The geological structure of Žirje and its surrounding archipelago is characterized by the domination of the Upper Cretaceous limestones extending in the NW-SE direction. The valley, which is located in the middle of the island, is covered with a thin layer of red soil overlaid with sediments and turned brown (Bognar & Saletto-Janković 1994).

Climate of the area is characterized by mild winters and warm summers. The amount of annual precipitation is 753 mm, with most of the rainfall recorded in winter. The island suffers severe droughts, which are additionally aggravated by the karst soil (limestone formations) (Šegota 1963).

The vegetation on the island consists of macchia of the alliance *Quercion ilicis* and the planted Aleppo pine forest, which propagates subspontaneously, thus superseding the natural vegetation. The arable land is in the valley, where vineyards, fig trees, olive trees, plum trees and vegetables are cultivated (Pandža 2003).

During this survey, a total of 9 reptilian and 1 amphibian species were found to occur on the island. Methods of general collecting were used (Heyer *et al*. 1994), and animals were caught by hand or loop, identified, then photographed and released, or simply identified through visual survey, if possible (Arnold & Overden 2004). Systematic list of the found species, with some additional data, is given in Tab. 1.

The only amphibian found was the European Green Toad (*Pseudepidalea viridis* (Laurenti, 1768)). There is one permanent pond in the valley, which is regularly utilized as a breeding pool for this amphibian.

Reptilians include 3 species of lizards: *Podarcis melisellensis* (Braun, 1877), *Hemidactylus turcicus* (Linnaeus, 1758) and *Pseudopus apodus* (Pallas, 1775).

Dalmatian Wall Lizard (*P. melisellensis*) is the commonest reptile species in this area, abundant through the entire island. Mediterranean Gecko (*H. turcicus*) is quite common around human settlements, whereas the data on its occurrence outside human habitats are scarce. Only two live specimens of European Glass Lizard (*P. apodus*) were encountered, one in the valley, the other one at Koromašna settlement. Additionally, a dead specimen was found in one of the valley's olive groves.

Furthermore, there are 5 species of snakes present on this island, i.e.: *Hierophis gemonensis* (Laurenti, 1768), *Malpolon insignitus* (Geoffroy Saint-Hilaire, 1827), *Telescopus fallax* (Fleischmann, 1831), *Elaphe quatuorlineata* (Lacépède, 1789) and *Zamenis situla* (Linnaeus, 1758). The commonest was the Eastern Montpellier Snake (*M. insignitus*), with the majority of observed specimens concentrated in the valley. It is interesting that nocturnal activity of this species was noticed – one adult specimen was found dead on the island road at 9:44 p.m., freshly run over. Balkan Whip Snake (*H. gemonensis*) was expected to be numerous on the island, but just three specimens were observed, two on the slopes of Kapić hill, and one at the Nozdra vela cove. It is uncertain whether this is due to the time of the survey (July – lower activity rate) or some other factor. European Cat Snake (*T. fallax*) is crepuscular and nocturnal species that is difficult to observe, however, three specimens were found during our night fieldwork. Two specimens were found next to our residence (below Kapić peak), the third at the archeological site of Gradina, all active after 10:00 p.m. The presence of Leopard Snake (*E. situla*) was confirmed during this survey

by two skin sheds, found at the NW part of the island. Determination was done by comparing their head scales (Janev Hutinec & Lupret-Obradović 2005), with the red pigment on visible spots of the shed skin clearly indicating this species. On May 2nd, 2009, during our earlier visit of the island, an adult female Leopard snake was also found, located in the valley of the island, next to the monastery ruins. An additional finding of this species came through personal communication. In the summer of 2008, Jadran Kale and his two sons found a dead adult on the island road and photographed it, while Berislav Horvatić did the determination.

No Four-lined Snake (*E. quatuorlineata*) was found during this survey. However, a photo from Žirje Island was received, featuring a local man killing a snake, believing it was venomous. The author of the photo asked for determination of the species, and as the picture clearly shows an adult Four-lined Snake, it can be assumed that this species inhabits the island as well.

There is also one tortoise species present to this island: *Testudo hermanni* (Gmelin, 1789). Only one Hermann's Tortoise was found (in an olive groove in the valley); the locals confirmed that tortoises were not indigenous to the island.

It would be advisable to continue herpetofauna studies on the island. The results are much better if surveys are carried out in spring time, during the increased animal activity. This survey was conducted in July, when most of the reptilian species have lover activity rate. The obtained results may therefore not show an authentic picture of the island's herpetofauna.

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Table 1. List of reptile and amphibian species observed on the island of Žirje.
Tabela 1. Seznam vrst plazilcev in dvoživk, opaženih na otoku Žirje.

Species		Latitude	Longitude	Date	Time	Leg.
1.	*Pseudepidalea viridis* (Laurenti, 1768)	5554693	4833612	16.07.2010	22:42	Boris Lauš
		5555063	4832615	21.07.2010	22:47	Boris Lauš
2.	*Podarcis melisellensis* (Braun, 1877)	5555323	4832648	15.07.2010	16:58	Boris Lauš
		5553095	4834467	16.07.2010	7:35	Boris Lauš
		5553054	4834626	16.07.2010	8:27	Boris Lauš
		5554813	4833924	17.07.2010	8:57	Boris Lauš
		5553840	4833286	18.07.2010	8:44	Boris Lauš
		5553656	4833202	18.07.2010	9:01	Boris Lauš
		5549906	4835901	18.07.2010	19:49	Boris Lauš
		5549906	4835901	19.07.2010	8:21	Boris Lauš
		5553926	4834943	21.07.2010	17:48	Boris Lauš
		5553351	4835310	24.07.2010	12:11	Boris Lauš
3.	*Hemidactylus turcicus* (Linnaeus, 1758)	5554693	4833612	15.07.2010	22:03	Boris Lauš
		5552921	4834994	16.07.2010	21:59	Boris Lauš
		5553971	4833254	18.07.2010	8:54	Boris Lauš
		5549943	4835931	19.07.2010	8:06	Boris Lauš
		5553132	4834206	20.07.2010	8:37	Boris Lauš
		5553876	4835076	21.07.2010	20:18	Boris Lauš
		5555078	4832624	21.07.2010	22:31	Boris Lauš
4.	*Pseudopus apodus* (Pallas, 1775)	5552438	4834929	17.07.2010	20:12	Boris Lauš
		5553032	4834369	20.07.2010	8:53	Boris Lauš
		5553781	4835041	21.07.2010	18:07	Boris Lauš
5.	*Hierophis gemonensis* (Laurenti, 1768)	5554813	4833924	17.07.2010	9:17	Boris Lauš
		5549328	4836608	19.07.2010	8:42	Boris Lauš
6.	*Malpolon insignitus* (Geoffroy Saint-Hilaire, 1827)	5552096	4835591	16.07.2010	21:44	Boris Lauš
		5552671	4834816	17.07.2010	19:27	Boris Lauš
		5553772	4833212	18.07.2010	9:01	Boris Lauš
		5553180	4834328	20.07.2010	8:45	Boris Lauš
		5551987	4835405	20.07.2010	9:22	Boris Lauš
7.	*Telescopus fallax* (Fleischmann, 1831)	5554693	4833612	15.07.2010	22:13	Boris Lauš
		5554693	4833612	19.07.2010	22:47	Boris Lauš
		5555120	4832603	21.07.2010	22:35	Boris Lauš
8.	*Zamenis situla* (Linnaeus, 1758)	5553031	4834685	27.08.2008		Jadran Kale (det. Berislav Horvatić)
		5553304	4834259	02.05.2009	12:55	Boris Lauš
		5550084	4835922	18.07.2010	20:11	Boris Lauš
		5549553	4836243	20.07.2010	16:13	Boris Lauš
9.	*Elaphe quatuorlineata* (Lacépède, 1789)	5550631	4836409	June/2008		Mikula Jajac (det. Boris Lauš)
10.	*Testudo hermanni* (Gmelin, 1789)	5553908	4833550	16.07.2010	9:24	Boris Lauš

Winter observations of Eurasian Lynx (*Lynx lynx*) inspecting karst caves and dolines in the Northern Dinaric Mountains, Slovenia

OPAŽANJA PREGLEDOVANJA KRAŠKIH JAM IN VRTAČ S STRANI EVRAZIJSKEGA RISA (*LYNX LYNX*) V SEVERNIH DINARIDIH

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Between 6th and 8th February 2005, I was snow tracking a Eurasian Lynx (*Lynx lynx*) on the Menišija Plateau in the »Ljubljanski vrh« hunting reserve in the Northern Dinaric Mountains, Slovenia. Very likely the same lynx, an older female whose home range covered Menišija, the Logatec Plateau and part of Rakitna, was a month later captured and radio-collared in the same area (Krofel *et al*. 2006). Snow tracking data were obtained with the aid of a handheld GPS and all the observer's comments recorded on a dictaphone. The total length of the recorded lynx track measured 7.0 km (Fig. 1). During the snow tracking, I frequently observed that the lynx approached a karst cave or smaller holes in the bedrock. Footprints in the snow indicated that the lynx obviously inspected it, as she was circling around, sitting in front or going inside, if the cave was large enough. I was under the impression that the lynx knew these caves from before, as on several occasions she turned from her path, went straight to the opening, inspected it, and then continued in the same direction. Several times, the lynx also went into doline (smaller sinkholes or larger collapse dolines). During this tracking session, I recorded the lynx inspecting a cave 11 times (once every 636 m on average), 7 of which were large (> 0.5 m diameter) vertical caves, 1 large horizontal cave and 3 smaller holes. Eight times she entered a sinkhole (every 875 m on average) and 3 times approached a large collapse doline (every 2333 m on average). During this snow tracking I also found two kill sites. On the first location I found intestines of a rodent, caught by the lynx on its way, while on the second location (point B in Fig. 1) there was a carcass of a 10 month old male European roe deer (*Capreolus capreolus*). Inspection of this carcass showed that the lynx (probably the same animal) killed it a few days earlier and has now returned to continue feeding. I also regularly observed similar inspections of caves and other karst phenomena while snow tracking other lynx in different parts of the Northern Dinaric Mountains (e.g. Fig. 2). Although I found no direct evidence indicating the reason for this behaviour, the studies of carnivores' diet in this region provide a possible hypothesis. Recently it has been shown that edible dormouse (*Glis glis*) is an important alternative prey of Eurasian lynx in the Northern Dinaric Mountains and that lynx are able to catch them even during the winter (Krofel *et al*., submitted) when this large rodent is hibernating (Kryštufek 2007). Dormice are often using caves and other openings in the karst landscape of the Dinaric Mountains for hibernation (Polak 1997). So the explanation for the observed behaviour of inspecting caves and holes could be that the lynx were searching for hibernating dormice. Similarly, remains of an edible dormouse were found in winter scats of beech marten (*Martes foina*) in the Northern Dinaric Mountains, and Polak (1994) suggested that martens could be catching them underground during their hibernation. Searching for dormice could also explain inspections of dolines, since such places often provide openings into the systems of underground caves. In addition, in the Northern Dinaric Mountains the chamois (*Rupicapra rupicapra*), lynx's occasional prey, are often concentrated in large collapse dolines, where larger rock cliffs on their edge provide preferred habitat for this ungulate (personal observations). Other possible explanation could be that lynx are visiting entrances to caves by virtue of their marking behaviour. During snow tracking in the Dinaric Mountains, it has been observed that lynx use prominent locations like large rocks and cliffs for urine marking (Krofel 2008), and it is generally thought that lynx commonly use exceptional and contrasting objects that differ from the surroundings (Skrbinšek & Potočnik 2005, Zachariae 2008). During my snow tracking, however, I did not observe the lynx marking in the vicinity of any of the caves she visited, despite the fact that urine marking is usually easy to observe during snow tracking. Therefore searching for prey, especially dormice, is in my opinion the most likely explanation for the observed behaviour.

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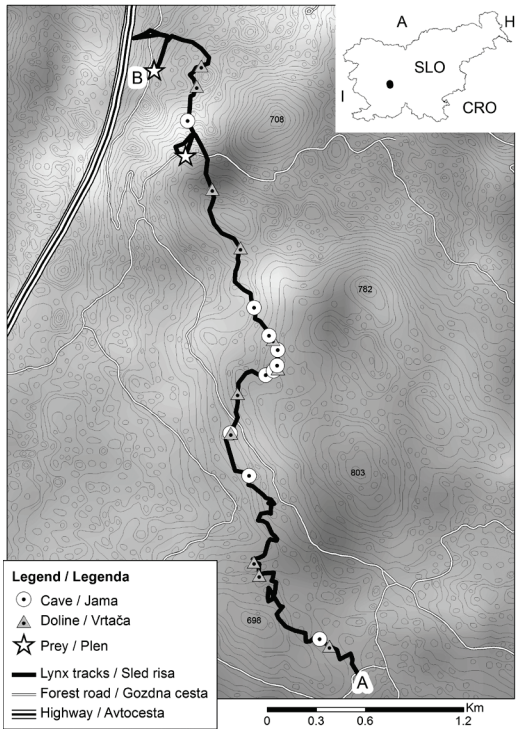

Figure 1. Mapped tracks of the Eurasian Lynx (*Lynx lynx*) on the Menišija Plateau in the Northern Dinaric Mountains, Slovenia from 6 - 8 Feb 2005 with indicated locations of caves or smaller openings (»Cave«) and smaller dolines – sinkholes – or larger collapse dolines (»Doline«) inspected by the lynx. Locations of prey remains are shown as well. Contour line interval is 10 m. Smaller map indicates location of the track inside Slovenia. A – beginning of the track, B – end of the track.

Slika 1. Vrisana pota evrazijskega risa (*Lynx lynx*) na Menišiji, severni Dinaridi, Slovenija, zabeležena med 6. in 8. februarjem 2005 z označenimi lokacijami jam in lukenj (»Jama«) ter vrtač in udornic (»Vrtača«), ki jih je risinja pregledala na svoji poti. Prikazani sta tudi lokaciji dveh najdenih ostankov plena. Ekvidistanca med plastnicami znaša 10 m. Manjši zemljevid kaže lokacijo sledi v Sloveniji. A – začetek sledenja, B – konec sledenja.

Figure 2. Snow track of a Eurasian Lynx (*Lynx lynx*) leading into a karst cave on the Snežnik Plateau in the Northern Dinaric Mountains, Slovenia, 20 Nov 2007. Photo: Miha Krofel.

Slika 2. Sled evrazijskega risa (*Lynx lynx*), ki vodi v kraško jamo, na Snežniški planoti, severni Dinaridi, Slovenija, 20.11.2007. Foto: Miha Krofel.

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