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Recent ostracods (Crustacea: Ostracoda) of Alpine springs and adjacent springbrooks of the Southern Limestone Alps, Slovenia

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Abstract. The ecology and distribution of ostracods in Alpine springs and springbrooks from Slovenia is presented. Benthos sampling was performed and major environmental characteristics (discharge, substrate composition, temperature, dissolved oxygen, conductivity, pH, alkalinity, sulphate, nitrate, calcium, magnesium) were measured in 12 springs and adjacent springbrooks. Sampling campaign was carried out on six sampling occasions (spring, summer, autumn in 2009 and 2010). Fourteen ostracod species were found among other fauna. The commonest and most abundant species were *Psychrodromus fontinalis* (Wolf, 1920) and *Cavernocypris subterranea* (Wolf, 1920), while the other species occurred at one or two sites at the most. Substrate composition and water temperature were statistically significant variables in explaining ostracod assemblages composition in this study.

Key words: microcrustacea, species-environment relationship, biodiversity, distribution

Izvleček. Recentni dvoklopniki (Crustacea: Ostracoda) v alpskih izvirih in izvirskih potokih Južnih Apneniških Alp v Sloveniji – Prispevek predstavi ekologijo in razširjenost dvoklopnikov (Ostracoda) v alpskih izvirih in izvirskih potokih Slovenije. Vzorčenje bentosa in meritve okoljskih dejavnikov smo opravili spomladi, poleti in jeseni v letih 2009 in 2010 v 12 izvirih in izvirskih potokih. Najdenih je bilo 14 vrst dvoklopnikov. Najbolj pogosti in številčni sta bili vrsti *Psychrodromus fontinalis* (Wolf, 1920) in *Cavernocypris subterranea* (Wolf, 1920). Druge vrste so se pojavljale posamično, na eni ali dveh lokacijah. Sestava substrata in temperatura vode sta bila edina statistično značilna okoljska dejavnika, ki sta določala sestavo združbe dvoklopnikov.

Ključne besede: nižji raki, odnos med vrstami in okoljem, biodiverziteta, distribucija

Introduction

Research in ecology and distribution of recent ostracods in spring environments has progressed rapidly in Europe over the past 20 years (Roca & Baltanas 1993, Särkkä et al. 1997, Stoch 1998, Gerecke et al. 1998, Stoch 2003, Gerecke et al. 2005, Rossetti et al. 2005, Pieri et al. 2007, Bottazzi et al. 2008, Stoch et. al. 2011, Zhai et al. 2014). However, in the Alps, only the springs in Trentino Province, Italy (Stoch 1998, Stoch et al. 2011), in the Regional Nature Park of the Julian Pre-Alps (Friuli-Venezia Giulia Province), Italy (Stoch 2003), and in the Berchtesgaden National Park, Bavaria, Germany (Gerecke et al. 1998), have been systematically investigated for ostracods (among other taxa). In Slovenia, such studies are lacking.

Within this study, 12 springs and springbrooks in the Alpine Region of Slovenia, which is part of the Southern Limestone Alps, were investigated over three seasons and two years in order to provide a better understanding of the spatio-temporal variability in environmental factors and macro- and meio-benthos. In this paper, the data on ostracod species distribution and their relationship to the major environmental factors are presented.

Materials and methods

The investigated Alpine springs are located within the catchment of the Sava River and are distributed across three mountain ranges (Julian Alps, Karavanke, and Kamniško-Savinjske Alps) (Fig. 1). The majority of springs are situated along deep, narrow Alpine valleys at altitudes from 600 to 943 m a.s.l., while three of them are located at higher altitudes (1,108–1,232 m a.s.l.) (Tab. 1). All selected springs are located within forested areas and are rheocrene where the groundwater discharges through the spring directly into the confined stream channel (width 0.2–1.2 m).

The climate of the study area is alpine, with a mean annual temperature of 4 to 9 °C and annual precipitation from 1,721 to 2,335 mm (Ogrin 1998). The catchment is composed of carbonate rock, predominantly Triassic age limestone with some dolomite and dolomitized limestone. The dominant hydrogeological units that are recharging the springs are highly permeable karst aquifers with fissured porosity. More detailed hydrogeological descriptions of springs are presented in Kanduč et al. (2012).

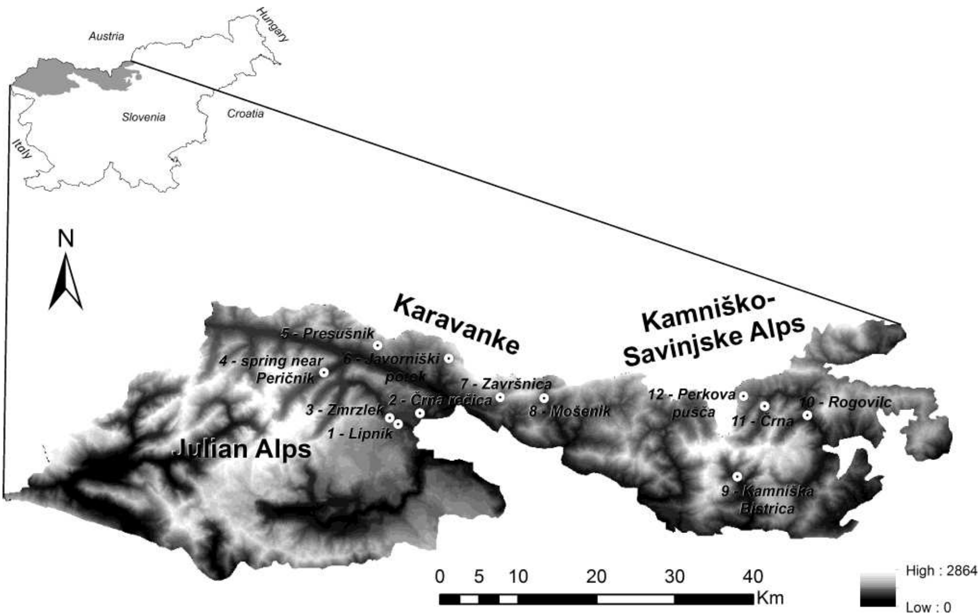


Figure 1. Map of the study area and locations of the springs.
Slika 1. Karta območja in lokacije izvirov.

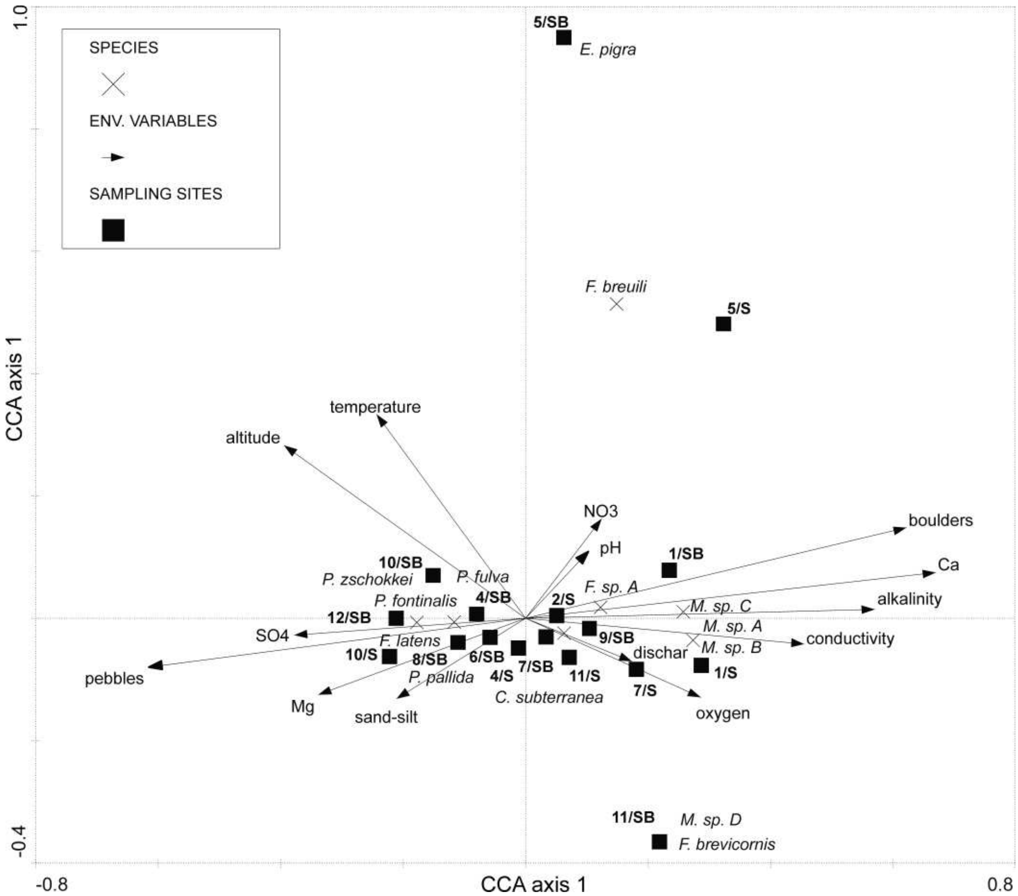
Table 1. The geographical coordinates and altitudes of the studied springs.
Tabela 1. Koordinate in nadmorska višina raziskovanih izvirov.

Spring code*	Spring name	Gauss-Krueger X	Gauss-Krueger Y	Altitude (m)
	Julian Alps			
1	Lipnik, Radovna, Bled	5138308	5425554	650
2	Črna rečica, Spodnje Gorje	5139683	5428322	645
3	Zmrzlek, Radovna, Bled	5139090	5424476	710
4	sping at Peričnik waterfall, Mojstrana	5144888	5416086	720
	Karavanke			
5	Presušnik, Mojstrana	5148330	5422931	1220
6	Javorniški potok, Jesenice	5146689	5432032	1108
7	Završnica, Jesenice	5141732	5438568	943
8	Mošenik, Tržič	5141621	5444173	807
	Kamniško-Savinjske Alps			
9	Kamniška Bistrica, Kamnik	5131603	5468851	600
10	Rogovilc, Mozirje	5139436	5477797	669
11	Črna, Luče	5140596	5472340	740
12	Perkova pušča, Pavličevo sedlo	5141860	5469638	1232

*Spring numbers correspond with the codes used in the CCA ordination diagram (Fig. 2).

Figure 2. CCA ordination diagram with sampling sites, species and environmental variables. Codes for the sampling sites are composed of the number that correspond with the spring number in Tab. 1 and Fig. 1 and indicate the geographical location and abbreviation S/SB that gives information whether the sample was taken from the spring (S) or springbrook (SB).

Slika 2. CCA ordinacijski diagram z vzorčnimi mesti, vrstami in okoljskimi spremenljivkami. Oznake za vzorčna mesta so sestavljene iz številke lokacije, ki je navedena v Tab. 1 in na Sl. 1 kot številka izvira in označuje geografsko lokacijo. Dodatna oznaka S pomeni izvir, SB pa izvirski potok.



At each spring, benthos from the spring (S) and from the adjacent springbrook (SB) approximately 5–10 m downstream from the spring was collected by a semi-quantitative kick sampling method. The substrate was kicked by foot for 3 min and a hand net (mesh size 100 μm) was used to collect benthos. Additionally, larger stones were picked and washed out into the hand net. Biological samples were preserved in 70% ethanol and taken to the laboratory for further processing. Substrate composition, percentage of boulders and cobbles (>6.4 cm), pebbles and gravel (6.4–0.2 cm), sand and silt (<0.2 cm) were determined by visual estimation (Armitage et al. 1995). Oxygen (WTW Multiline P4, CellOx 325), temperature and conductivity (WTW Multiline P4, TetraCon 325), and water levels and flow velocities (OTT

ADC flow meter) were measured on sites. For the laboratory analyses, 250 ml of water was collected in polyethylene bottles. The sampling campaign was carried out over three seasons (spring, summer, autumn) and two years (2009, 2010) (N=6).

In the laboratory, pH was measured using a WTW pH 540 GLP, with a TetraCon 325 probe. Alkalinity was determined using titration after Gran, and was expressed as $CaCO_3$ equivalent per litre. Nitrate, sulphate, calcium and magnesium were analysed by ion chromatography (Metrohm, 761 Compact IC). Biological samples were sorted, the specimens counted and ostracods identified to the species level using Meisch (2000) identification key.

The Kruskal-Wallis non-parametric test was performed on environmental variables to determine if there are statistically significant differences between the sampling sites. Canonical correspondence analysis (CCA) was used to investigate the relationship among species data and environmental variables. The species abundance data were log(x+1) transformed to down-weight highly abundant species. Significance of environmental variables in CCA was tested by Monte Carlo permutation test (999 permutations) using forward selection procedure. CCA was run by CANOCO 4.5 program (ter Braak & Smilauer 2002).

Results

Environmental characteristics of Alpine springs and springbrooks

The discharge varied greatly between the springs (Tab. 2). The highest was in the Kamniška Bistrica spring (over 212 l s^{-1}), whereas in other springs discharges were substantially lower (<28 l s^{-1}). The lowest variation in discharge was observed in Perkova Pušča spring and in the spring at Peričnik waterfall. The predominant substrates were boulders, cobbles, pebbles and gravel, although in some springs sand and silt prevailed (e.g. Črna and Perkova Pušča). Mean water temperature per spring ranged between 4.9 to 7.8 ºC. Seasonal and yearly variation in water temperature was low for all springs (SD<0.4 ºC) except Presušnik (SD=1.4 ºC). Mean pH per spring ranged from 6.8 to 8.1, mean alkalinity from 927 to 3,062 µeq l^{-1}, mean conductivity from 90 to 275 µS cm^{-1}, and oxygen concentrations from 8.3 to 12.5 mg l^{-1}. Mean concentrations of ions in the water varied from 1.4 to 2.7 mg l^{-1} for nitrate, from 1.1 to 12.5 mg l^{-1} for sulphate, from 13.4 to 64.2 mg l^{-1} for calcium and from 3.5 to 10.6 mg l^{-1} for magnesium (Tab. 2). The Kruskal-Wallis non-parametric test was significant ($p<0.001$) for all measured physico-chemical variables, indicating that at least one sampling site is significantly different from other sampling sites when considering individual variables.

Ostracod assemblages

The number of ostracod specimens varied greatly between the spring and springbrook (Tab. 3). Similarly, variation in abundance was high across the studied springs. The highest total abundances were found at the Peričnik waterfall (158 specimens in the spring and 119 specimens in the springbrook) and in the springbrook of Perkova pušča (128 specimens). No ostracod specimens were collected in the Zmrzlek spring and adjacent springbrook, in the springs of Javorniški potok, Mošenik, Kamniška Bistrica and Perkova pušča and in the Črna rečica springbrook. The highest species richness was observed in the Lipnik springbrook (5 species). Only one species was collected in the Črna rečica, Presušnik and Završnica springs.

Altogether, 14 ostracod species and 588 specimens were collected during 6 sampling campaigns. The commonest and most abundant species were *Psychrodromus fontinalis* (Wolf, 1920) and *Cavernocypris subterranea* (Wolf, 1920) with 321 and 215 specimens collected altogether. *P. fontinalis* was collected from 2 springs and 5 springbrooks and *C. subterranea* from 6 springs and 7 springbrooks. *Fabaeformiscandona brevicornis* (Klie, 1925), *Eucypris pigra* (Fischer, 1851) and two *Mixtacandona* species (sp. C, sp. D) were collected only from one site.

The canonical correspondence analysis (CCA) performed on species abundance and measured environmental characteristics (altitude, discharge, substrate, temperature, dissolved oxygen, conductivity, pH, alkalinity, sulphate, nitrate, calcium, magnesium), based on the first two axes explained 41.6% of total variation in the species data. The first axis explained 25.8% of species-environment relationship and the second axis an additional 22.9%. The first axis was primarily a gradient in substrate granulometric composition, and conductivity and alkalinity linked to calcium content, and the second axis a gradient in altitude and water temperature. A high correlation between water temperature and altitude is due to rather high temperatures in the Presušnik that is located at the highest altitude. Based on Monte Carlo permutation test, percentage of the boulders and cobbles in the substrate and water temperature showed to be statistically significant ($p<0.05$) for shaping ostracod assemblages. Other important, but not significant variables were percentage of pebbles and gravel, pH, conductivity and calcium content. CCA ordination diagram indicates that species of the genus *Mixtacandona* prefer oxygenated waters with higher conductivity, Ca contents and alkalinity. The sample sites were distributed mainly along the first axis, where the most distant were the groups of Lipnik spring, Lipnik springbrook and Završnica spring, and Perkova Pušča springbrook and Rogovilc spring and springbrook. Along the second axis, Presušnik spring and springbrook and Črna springbrook differed mostly from the other sites.

Table 2. Main environmental characteristics of the springs studied. Mean values and standard deviation for two years (2009, 2010) and three sampling campaigns (spring, summer, autumn) are presented. Since the differences between the springs and springbrooks were low, only the values for the springs are presented. Temp – water temperature; Cond – conductivity.

Tabela 2. Glavne značilnosti raziskovanih izvirov. Prikazane so srednje vrednosti in standardne deviacije za obe leti (2009, 2010) in tri sezonska vzorčenja (pomlad, poletje, jesen). Zaradi majhnih razlik med izviri in izvirskimi potoki so prikazane samo vrednosti za izvire. Temp – temperature vode; Cond – prevodnost.

	Discharge	**Boulders /cobbles**	**Pebbles /gravel**	**Sand /silt**	**Temp**	**pH**	**Cond**	**Oxygen**	**NO_3^-**	**SO_4^{2-}**	**Ca^{2+}**	**Mg^{2+}**	**Alkalinity**
	$l\ s^{-1}$	**%**	**%**	**%**	**ºC**		**$\mu S\ cm^{-1}$**	**$mg\ l^{-1}$**	**$mg\ l^{-1}$**	**$mg\ l^{-1}$**	**$mg\ l^{-1}$**	**$mg\ l^{-1}$**	**$Eq\ l^{-1}$**
Julian Alps													
Lipnik	14.5±7.3	80	10	10	6.7±0.1	7.7±0.2	247±64	10.7± 0.7	2.1±0.3	2.5±0.6	64.2±6.4	3.5±0.6	2754 ±226
Črna rečica	18.2±7.9	60	30	10	7.5±0.1	7.7±0.2	261±74	12.2±2.2	2.7±0.3	3.1±0.6	60.4±3.9	9.8±3.0	3062±270
Zmrzlek	10.1±4.8	80	20	0	6.0±0.1	7.9±0.2	204±56	11.3±0.5	1.7±0.1	1.7±0.3	53.2±5.4	4.6±0.7	2446±227
Peričnik	3.4±0.4	30	60	10	6.0±0.2	8.1±0.1	166±39	11.0±0.6	1.7±0.1	1.8±0.2	35.6±1.5	6.8±0.3	1937±81
Karavanke													
Presušnik	1.6±0.6	40	40	20	7.5±1.9	7.9±0.2	203±44	9.6±0.8	2.4±0.2	3.4±0.7	51.9±3.1	6.4±0.6	2529±115
Javorniški potok	28.0±5.1	80	20	0	4.9±0.1	8.0±0.1	170±39	12.5±0.9	2.5±0.1	2.6±0.1	37.9±2.3	6.2±0.3	1972±95
Završnica	21.8±5.7	50	50	0	5.8±0.3	7.9±0.1	179±38	11.3±0.7	2.5±0.1	2.7±0.3	42.9±2.2	4.5±0.3	2049±70
Mošenik	24.9±4.2	0	90	10	7.2±0.4	7.9±0.1	207±43	11.4±3.5	2.4±0.1	12.5±1.8	41.8±2.6	8.7±0.4	2079±43
Kamniško-Savinjske Alps													
Kamn. Bistrica	212.7±87.3	80	20	0	5.4±0.2	8.0±0.1	148±28	12.0± 0.6	1.5±0.2	1.1±0.4	32.5±1.6	3.5±0.5	1574±102
Rogovilc	1.5±0.7	40	50	10	7.8±0.2	8.0±0.1	275±43	10.9±0.5	2.6±0.2	10.6±3.8	55.1±3.8	9.4±2.5	2822±183
Črna	8.0±1.9	0	40	60	7.3±0.4	7.8±0.1	259±37	10.7±1.2	2.0±0.1	3.5±0.1	49.2±0.9	10.6±0.3	2811±88
Perkova pušča	1.1±0.2	0	40	60	7.4±0.1	6.8±0.4	90±13	8.3±0.3	1.4±0.2	2.6±0.4	13.4±1.1	3.9±0.3	927±64

Table 3. List of ostracod species and their total abundances in the springs (S) and springbrooks (SB).
Tabela 3. Seznam vrst in skupno število osebkov v izvirih (S) in izvirskih potokih (SB).

	Lipnik		**Črna rečica**		**Zmrz-lek**		**Perični k**		**Presuš-nik**		**Jav. potok**		**Završ-nica**		**Moše-nik**		**Kamn. Bistrica**		**Perkov a pušča**		**Rogo-vilc**		**Črna**		**Total**
	S	**SB**	**S**	**SB**	**S**	**SB**	**S**	**SB**	**S**	**SB**	**S**	**SB**	**S**	**SB**	**S**	**SB**	**S**	**SB**	**S**	**SB**	**S**	**SB**	**S**	**SB**	
Psychrodromus fontinalis (Wolf, 1920)							11	104				12		2		19				121	4	48			**321**
Cavernocypris subterranea (Wolf, 1920)	4	18	1				147	7	1			6	1	11		9		4					4	2	**215**
Mixtacandona sp. B	4	7																							**11**
Potamocypris zschokkei (Kaufmann, 1900)																2				4	2	2			**10**
Potamocypris fulva (Brady, 1868)								8																	**8**
Mixtacandona sp. A	6	1																							**7**
Fabaeformiscandona sp. A		2												3											**5**
Fabaeformiscandona latens (Klie, 1940)																				3					**3**
Fabaeformiscandona breuili (Paris, 1920)		1								1															**2**
Potamocypris pallida Alm, 1914																2									**2**
Mixtacandona sp. C	1																								**1**
Fabeaformiscandona brevicornis (Klie, 1925)																								1	**1**
Mixtacandona sp. D																								1	**1**
Eucypris pigra (Fischer, 1851)										1															**1**
Total abundances per spring/spring brook	**15**	**29**	**1**	**0**	**0**	**0**	**158**	**119**	**1**	**2**	**0**	**18**	**1**	**16**	**0**	**32**	**0**	**4**	**0**	**128**	**6**	**50**	**4**	**4**	**588**

Discussion

The ostracods were present at all studied locations with the exception of Zmrzlek, which is an intermittent karst spring and was dry during both summer samplings. The overall species richness of ostracods was relatively high, with a total of 14 species. The other studies on spring ostracods carried out throughout Europe resulted in species numbers from 3 to 34 (Tab. 4). Due to different numbers of springs that were sampled during those investigations, species richness cannot be directly compared. But the calculated mean number of species per spring ranged from 0.1 to 0.7 for listed studies and 1.2 for this study, indicating high ostracod biodiversity in the Slovenian part of the Southern Limestone Alps. For example, only 18 species (0.2 species per spring) were recorded for 110 Alpine springs of Trentino Province investigated during the CRENODAT project (Stoch et al. 2011). Similarly, only three species (0.2 species per spring) were collected in 20 springs of the Julian Pre-Alps, Italy, a low number probably related to the temporary regime of these environments (Stoch 2003). Bottazzi et al. (2008) summarized previous unpublished investigations carried out in the Alpine and Pre-Alpine regions in Italy and reported a total of 21 ostracod species. Unfortunately, in this summarization there are no data on the number of sampled springs. Furthermore, in the Northern Limestone Alps in Germany, 11 species (0.6 species per spring) were collected from 19 springs located in the Alps of Berchtesgaden (Upper Bavaria) (Gerecke at al. 1998). One of the reasons for much higher average number of species per spring in this study could be due to higher sampling intensity, where each sampling site was sampled on six occasions. It was previously shown that increased temporal sampling intensity increases the observed species richness (Mori & Brancelj 2013).

Table 4. Number of ostracod species collected during different studies of spring meiofauna across Europe.
Tabela 4. Pregled raziskav izvirov v Evropi z navedenim številom najdenih vrst dvoklopnikov ter številom vzorčevanih izvirov.

No of species	No of springs	Average No of species per spring	Type of spring	Region	Reference
3	20	0.2	Rheocrene	Regional Nature Park of the Julian Pre-Alps, Italy	Stoch 2003
9	23	0.4	Rheo/Limno/Helocrene	Adamello Brenta National Park, Italy	Stoch 1998
11	19	0.6	Rheo/Helocrene	Alps of Berchtesgaden, Germany	Gerecke at al. 1998
12	31	0.4	Limnocrene	The river Po, S sub-catchment, Italy	Rossetti et al. 2005
13	19	0.7	Rheo/Rheo-limnocrene	Northern Apennines, Italy	Bottazzi et al. 2008
16	28	0.6	Limnocrene	The river Po, N sub-catchment, Italy	Pieri et al. 2007
17	31	0.5	Not known	Finland	Särkkä et al. 1997
18	110	0.2	Rheocrene	Trentino Province, Italy	Stoch et al. 2011
21	149	0.1	Helocrene	Central Pyrenees, Spain	Roca & Baltanas 1993
28	41	0.7	Rheo/Limno/Helocrene	Luxemburg	Gerecke et al. 2005
34	74	0.5	Helocrene	Western Carpathians, Czech Republic, Slovakia	Zhai et al. 2014

The commonest and most abundant species, present in the half of the studied springs, were *P. fontinalis* and *C. subterranea*. In this study, the temperature and altitudinal range of those two species was from 4.9±0.1 to 7.8±0.2 ºC and above 600 m a.s.l. During investigation of ostracods in Friuli-Venezia Giulia Region (NE Italy), Pieri et al. (2009) observed that those two species, accompanied with *Cryptocandona vavrai* Kaufmann 1900*, Cyclocypris mediosetosa* Meisch 1987 and *E. pigra*, were present only in the northern part of the region, in springs and peat bogs at altitudes higher than 840 m a.s.l. Meisch (2000) classified those two species as typical cold stenothermal, stygophilic species frequently found in springs, springbrooks and also groundwaters (caves, interstitial habitats) (Meisch 2000). Their distribution is Palaearctic (Martens & Savatenalinton 2011).

With the exception of *P. zschokkei* (collected from 4 sites), all other species in this study were collected only from one or two sites (either spring or springbrook). This pattern is similar to that observed during the study of 110 springs in Trentino Province, Italy (Stoch et al. 2011), where the commonest species, i.e. present in more than 10 springs, were *P. fontinalis*, *P. pallida*, *P. zschokkei*, and *E. pigra*, and to the pattern observed for 19 springs in the Alps of Berchtesgaden, where the commonest and most abundant species were *E. pigra* and *P. fontinalis*, followed by *Candona neglecta* Sars (Gerecke et al. 1993), while all other species occurred scattered in the small number of springs. Bottazzi et al. (2008) reported a similar species composition for Italian alpine and pre-alpine springs as in our study, with the exception of the genus *Mixtacandona* that was found only during this study. *Mixtacandona* is an exclusively groundwater genus with an array of species inhabiting karst as well as alluvial aquifers that exhibit high degree of endemism at the species level (Rogulj & Danielopol 1993, Mori & Meisch 2012). Most probably, the historical events in the studied area are the reason for four different *Mixtacandona* species found during this investigation.

The CCA analysis of environmental data and ostracod assemblages revealed the distribution of sampling sites along the gradient of substrate composition, conductivity, calcium content and alkalinity. Significant variables for shaping ostracod assemblage composition were water temperature and substrate composition. Those results indicate the importance of hydrogeochemistry for shaping the studied assemblages. Stoch et al. (2011) demonstrated that altitude, water chemistry, and water flow were the main environmental descriptors of meiofaunal distribution patterns in Trentino springs, while substrate was not so important. The main reason for that was highly heterogeneous substrate in the studied springs and strong altitudinal and geological gradient that override the influence of the substrate type. Zhai et al. (2014) have shown that mineral content of spring water (conductivity) and total organic carbon in the substrate significantly affected the ostracod assemblages in the western Carpathian springs, while the substrate composition and altitude were not important. However, the altitudinal gradient in their study was quite low (640±146 m a.s.l.). Based on those findings, it is clear that environmental predictors for ostracod assemblage composition differ among the studies due to different altitudinal and environmental range of the springs studied.

The presented study revealed high species richness of ostracods in Slovenian Alpine springs and adjacent springbrooks and contributed new knowledge on their distribution and ecology. The commonest and most abundant species were the widespread species occurring in the springs and groundwaters across Europe, while several species from the genus *Mixtacandona* and *Fabaeformiscandona* are most probably endemic for this area, indicating the effect of historical events (glaciations). Among the measured variables, water temperature and substrate composition were significant for shaping ostracod assemblages, while conductivity linked to calcium content and pH were also important.

Povzetek

V zadnjih 20 letih so bile v Evropi opravljene številne raziskave ekologije in razširjenosti dvoklopnikov (Crustacea, Ostracoda) v izvirih. Kljub temu je poznavanje razširjenosti in dejavnikov, ki vplivajo na pojavljanje dvoklopnikov v alpskih izvirih, z izjemo Italije, slabo. V tem prispevku so predstavljeni rezultati dveletne raziskave, kjer smo v 12 izvirih na območju alpske biogeografske regije v Sloveniji sistematično vzorčili bentos v izvirih in izvirskih potokih ter hkrati merili okoljske dejavnike. Vzorčenje je potekalo spomladi, poleti in jeseni, v letih 2009 in 2010. Za raziskovane izvire, ki ležijo med 600 in 1.232 m n. m. v., so značilne nizke srednje vrednosti temperatur vode (4.9–7.8 °C) z majhnim sezonskim in medletnim spreminjanjem, srednjimi pretoki od 1,1 do 212,7 l s^{-1}, heterogen substrat ter visoke vrednosti kisika. Med raziskavo smo našli 14 vrst dvoklopnikov, ki se, z izjemo dveh vrst (*Psychrodromus fontinalis* in *Cavernocypris subterranea*), večinoma pojavljajo na eni ali dveh lokacijah. Zanimivost raziskave je pojavljanje rodu *Mixtacandona*, ki je tipična podzemna vrsta, pogosta v kraških podzemnih vodah. Na podlagi obravnavanih spremenljivk smo ugotovili, da sta sestava substrata in temperatura vode statistično značilna okoljska dejavnika, ki vplivata na sestavo združb v raziskovanih alpskih izvirih in izvirskih potokih.

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Favna nočnih metuljev (Lepidoptera) na izbranih osvetljenih cerkvah v Sloveniji

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Izvleček. Negativni vpliv svetlobnega onesnaževanja na nočne metulje je znan, vendar premalo raziskan pojav. V letih 2011–2013 smo na 15 izbranih cerkvah v različnih biogeografskih regijah Slovenije in na Koči na Sabotinu preučevali nočne metulje na osvetljenih delih fasad. Skupno smo zabeležili 609 vrst nočnih metuljev, kar je približno 20 % vseh v Sloveniji živečih vrst metuljev. Največ vrst je bilo najdenih na Koritnem na Pohorju (214 vrst) in na Koči na Sabotinu (213 vrst). Na tej lokaciji je bilo ugotovljenih tudi največ ogroženih vrst metuljev v Sloveniji, in sicer osem od skupno 18 vrst. Glavni razlog za takšen odklon je ohranjenost habitatov v okolici osvetljenega objekta, deloma pa tudi dejstvo, da tu ni bilo svetlobnega onesnaževanja, saj objekt pred raziskavo ni bil nikoli osvetljen. Ugotavljamo, da svetlobno onesnaženje privablja veliko število vrst nočnih metuljev, zato bi ga bilo treba ustrezno omejiti; tako z ustrezno zakonodajo kot tudi v praksi. V prispevku podajamo natančnejše podatke o razširjenosti nekaterih redkih vrst, zbranih pred in med to raziskavo.

Ključne besede: ogroženost, svetlobno onesnaževanje, favnistična analiza, Lepidoptera, nočni metulji, Slovenija

Abstract. Moth fauna (Lepidoptera) at selected illuminated churches in Slovenia – The negative impact of light pollution on moths is a well-known but under-studied phenomenon. In the 2011-2013 period, the moth fauna on illuminated parts of facades on 15 selected churches from different biogeographical regions of Slovenia and at a mountain cottage on Sabotin hill was studied. In total, 609 species of moths were recorded, which is approximately 20% of all moth species known from Slovenia. The largest number of species was recorded at Koritno in Pohorje Mts (214 species) and at the mountain hut on Sabotin (213 species). This location also hosted the largest number of threatened moth species in Slovenia, as eight out of the total of 18 species were recorded there. The main reason for such diversity is presence of undisturbed habitats in the vicinity, and partly absence of light pollution, as the hut had never been illuminated prior to our survey. Our observations confirm that the light pollution affects large number of moth species and should therefore be limited by suitable legislation and carried out in practice. In addition, we provide data on distribution of some rare species found during the survey and before.

Key words: threat status, light pollution, faunistic analysis, Lepidoptera, moths, Slovenia

Uvod

Slovenija je država z visoko biotsko pestrostjo; to velja tudi za metulje. V Evropi živi okrog 8500 vrst metuljev (Karsholt & Razowski 1996). Za Slovenijo je bila leta 2006 objavljena ocena 3603 vrst (Gomboc & Lasan 2006), vendar to število precej presega do sedaj objavljene sezname vrst dnevnih in nočnih metuljev (Carnelutti 1992a, b, Lesar & Govedič 2010). V zadnjih letih je bilo ugotovljenih več novih vrst metuljev za Slovenijo, tako da njihovo število še vedno narašča (npr. Štanta 2008, Gomboc & Klenovšek 2013).

V Sloveniji živi le 180 dnevnih metuljev (Lepidoptera: Rhopalocera) (Verovnik et al. 2012, Russel et al. 2014), katerih razširjenost in ogroženost v primerjavi z nočnimi metulji je dobro poznana (Verovnik et al. 2012). Nočni metulji niso enakomerno raziskani po celotni državi, saj so raziskave večinoma vezane le na vrstno bolj pestra območja in lokacije, ki so v bližini domovanj popisovalcev (avtorji, lastna opažanja). Zato so pri nočnih metuljih najbolje raziskana območja Primorska, Kras, Kozjansko, Štajerska in Prekmurje, slabše raziskana območja ali »bele lise« pa so Kočevska, Dolenjska, Bela krajina in Posavje (avtorji, lastna opažanja). Večina znanja o razširjenosti nočnih metuljev pri nas je zbrana v zbirkah in popisih posameznikov, saj je favnističnih objav o nočnih metuljih razmeroma malo. Razlogi za razliko v raziskanosti v primerjavi z dnevnimi metulji so predvsem v veliki vrstni pestrosti in raznolikosti nočnih metuljev ter v specifičnih metodah nočnega terenskega dela, ki zahtevajo več časa in napora.

O geografski razporeditvi vrstne pestrosti nočnih metuljev v Sloveniji lahko deloma sklepamo iz primerjave z dnevnimi metulji (Verovnik et al. 2012). Zgostitve vrstne pestrosti dnevnih metuljev so predvsem v Primorsko – Kraški regiji ter v gričevnatih pokrajinah vzhodne Slovenije, kot sta Kozjansko in Goričko, torej jih lahko pričakujemo tudi pri nočnih metuljih.

Raziskave razširjenosti metuljev so pomembne iz različnih razlogov. Osnovni namen je favnistični, saj je dobro favnistično poznavanje osnova za spremljanje diverzitete in stanja populacij. Drugi pomen je biodiverzitetni, saj so metulji indikatorska skupina za ocenjevanje biotske pestrosti kopnih ekosistemov. Tretji je naravovarstveni pomen, saj monitoring določenih vrst (ogrožene, zavarovane) kaže na stanje in daje možnost spremljanja trendov v populacijah. Pomemben je tudi gospodarski vidik, saj so metulji poleg čebel najpomembnejši opraševalci kulturnih in divjih rastlin. Spremljanje razširjenosti metuljev nam lahko veliko pove tudi o posledicah klimatskih sprememb. Tako lahko izginjanje nekaterih vrst metuljev kot tudi pojavljanje novih vrst vsaj delno povežemo s klimatskimi spremembami.

Vpliv umetnega osvetljevanja na nočne metulje

Umetna svetloba privlači nočne metulje (Frank 1988). Njihove oči imajo višek občutljivosti v območju kratkovalovnega dela spektra, zato jih bolj privlačijo svetila z visokim deležem ultravijolične (UV) svetlobe (Rydell 1992, van Langevelde et al. 2011, Barghini et al. 2012). Vsako umetno osvetljevanje nad naravno svetlostjo noči pomeni svetlobno onesnaževanje in motnjo za nočne živali. Metulji, ujeti v soj sijalk, krožijo okoli svetil ali pa obsedijo na njih ali osvetljenih površinah v neposredni bližini. To ima naslednje posledice: pogin zaradi kontakta z vročo žarnico ali ujetje v ohišje svetilke, letanje okoli svetilke do izčrpanosti in pogin, povečano izpostavljenost plenilcem (npr. netopirjem) ter spremembo naravnih vedenjskih vzorcev (Frank 2006, van Langevelde et al. 2011, van Geffen et al. 2014).

Zaradi navedenih posledic imajo umetno osvetljena območja negativni vpliv na nočne metulje. To v veliki meri velja tudi za osvetljene objekte, kot so cerkve v nenaseljenih podeželskih območjih. Pričakovati je, da ima javna razsvetljava največji negativni vpliv na nočne metulje ravno v manj naseljenih pokrajinah, kjer je vrstna pestrost nočnih metuljev večja kot v gosto naseljenih območjih. Za javno razsvetljavo so se v Sloveniji že od srede petdesetih let uporabljale visokotlačne živosrebrne sijalke (Andrej Mohar, ustno), ki močno sevajo tudi v UV delu spektra. V odročnih krajih se take žarnice uporabljajo še danes (Jež, osebna opažanja). V zadnjih desetletjih se površina osvetljenih območij na svetu stalno povečuje (Cinzano et al. 2001, Hölker et al. 2010), tako da vpliv umetnega osvetljevanja na nočne metulje narašča.

Žal v tem obdobju v Sloveniji ni potekal noben monitoring nočnih metuljev, tako da nimamo zanesljivih primerjalnih podatkov s stanjem izpred 20 ali 30 let. V Sloveniji so se sicer raziskave vpliva umetnega osvetljevanja na nočne metulje pričele že sredi petdesetih let prejšnjega stoletja (Michieli 1957, Michieli & Gogala 1962), ko sta avtorja ugotovila, da metulje najbolj privablja emisijska linija 365 nm, ki je v UV delu spektra. Žarnice z visokim deležem UV svetlobe so se pogosto uporabljale za javno razsvetljavo (Papler & Murovec 2011). Kmalu se je pokazalo, da ima takšna javna razsvetljava velik negativni vpliv na nočne žuželke (Brelih & Gregori 1980, Jež 1996, Trilar 2001). Z namenom, da bi zmanjšali svetlobno onesnaževanje in njegove škodljive vplive na naravo, je bila leta 2007 sprejeta Uredba vlade o mejnih vrednostih svetlobnega onesnaževanja okolja (Ur. l. RS 2007).

V okviru triletne raziskave, ki je potekala v okviru projekta »Življenje ponoči« (LIFE09 NAT/SI/000378), smo skušali ugotoviti, kakšen vpliv ima osvetljevanje cerkva na favno nočnih metuljev v Sloveniji in katere vrste se pojavljajo na osvetljenih površinah fasad. Ker so rezultati tudi favnistično zanimivi, predstavljamo vrstno pestrost treh geografsko ločenih območij, Primorske (Kras, Goriška Brda), okolice Vrhnike in Štajerske (Pohorje in Slovenske gorice). Posebej so predstavljene nekatere redke in/ali naravovarstveno pomembne vrste.

Materiali in metode

V naši raziskavi smo izbrali cerkve, ki ležijo zunaj naselij ali na njihovih robovih, kjer je vpliv druge javne razsvetljave manjši. Pri osvetljevanju cerkva smo uporabljali tri različne tipe osvetljave: »originalno« (kot je bila postavljena že pred našo raziskavo) – različni deleži UV in tipi žarnic, »modro« – metal-halogenidne žarnice s filtrom za kratkovalovno svetlobo pri 400 nm in »rumeno« – metal-halogenidne žarnice s filtrom za kratkovalovno svetlobo pri 470 nm. Reflektorji s filtrom so bili opremljeni tudi z zaslonkami, ki so preprečevale sipanje svetlobe mimo cerkva. Vsaka cerkev je bila v obdobju treh let vsakič osvetljena z drugim tipom svetlobe, pri čemer so bili v vsakem trojčku vsako leto trije različni tipi osvetlitev, s čimer smo se izognili vplivu sezone. Zaradi izločitve morebitnega vpliva geografskega območja smo izbirali po tri cerkve (trojčke) tako, da med seboj niso bile oddaljene več kot 10 kilometrov.

Ti trojčki so bili razporejeni v treh geografskih regijah od Primorske prek osrednje Slovenije do Štajerske (Sl. 1). Skupno smo popisovali na petih trojčkih, torej 15 cerkvah (Tab. 1). Dodatno smo preverili tudi prilet živali na Koči na Sabotinu, kjer objekt predhodno ni bil osvetljen, osvetljevali pa smo le eno površino fasade s tremi različnimi tipi osvetlitve v treh zaporednih sezonah.

Slika 1. Lokacije cerkva, vključenih v raziskavo. Sabotin (testna lokacija, na kateri ni bilo predhodne osvetlitve objekta) je označen s temno piko, cerkve pa s svetlimi.
Figure 1. Location of churches included in the study. Sabotin (test location without prior illumination) is marked by a dark dot, other churches are marked by light dots.

Popisi so potekali v treh zaporednih sezonah, od 2011 do 2013. V eni sezoni je bilo opravljenih šest popisov od sredine maja do sredine septembra. Popisovati smo začeli vsaj eno uro po navtičnem mraku. Na vsakem objektu smo popisovali metulje na fasadi in okolici reflektorjev 45 minut; ta časovna omejitev nam je omogočila, da smo v eni noči obiskali vse cerkve v enem trojčku. Popisi so potekali ob ugodnem vremenu (brez dežja, rahel veter) in vsaj en teden pred ali po polni luni. Na vsaki cerkvi smo popisovali številčnost metuljev na vzorčni ploskvi velikosti 10×3 m, na drugih osvetljenih delih fasade in okoli reflektorjev pa smo zgolj beležili pojavljanje vrst. V tem prispevku prikazujemo favnistične podatke. Večina vrst je bila determinirana na terenu, druge pa so bile ulovljene in so shranjene v zbirkah avtorjev. Za določitev smo uporabili standardne priročnike za nočne metulje in Microlepidoptera (npr. Fajčik & Slamka 1998, Belin 2003, Fajčik 2003, Mironov 2003, Leraut 2012, 2014).

Tabela 1. Lokacije cerkva, vključenih v raziskavo vpliva različnih osvetlitev na nočne metulje. Podane so geografske koordinate v referenčnem sistemu WGS84.
Table 1. Position of the churches included in the study of the effect of different types of illumination on moths. Coordinates are in WGS84 reference system.

Št.	Lokacija	X	Y	Trojček
1	Cerkev Sv. Lenarta, Stara Vrhnika	14,281458°E	45,976136°N	Vrhnika
2	Cerkev Sv. Jurija, Velika Ligojna	14,300997°E	45,994306°N	Vrhnika
3	Cerkev Sv. Urha, Zaplana	14,235069°E	45,970314°N	Vrhnika
4	Cerkev Sv. Lenarta, Dolnje Cerovo	13,552086°E	45,977436°N	Goriška Brda
5	Cerkev Sv. Duha, Fojana	13,505792°E	45,997094°N	Goriška Brda
6	Cerkev Sv. Nikolaja, Gornje Cerovo	13,563206°E	45,982233°N	Goriška Brda
7	Cerkev Sv. Mihaela, Skopo	13,821844°E	45,773958°N	Kras
8	Cerkev Marijinega vnebovzetja, Šmarje pri Sežani	13,866758°E	45,721961°N	Kras
9	Cerkev Sv. Jakoba, Veliki Dol	13,752911°E	45,770817°N	Kras
10	Cerkev Sv. Miklavža, Koritno	15,435000°E	46,402350°N	Pohorje
11	Cerkev Sv. Barbare, Malahorna	15,431086°E	46,365658°N	Pohorje
12	Cerkev Sv. Venčeslava, Zgornja Ložnica	15,518425°E	46,384656°N	Pohorje
13	Cerkev Sv. Kunigunde, Gradiška	15,652094°E	46,612481°N	Sl. gorice
14	Cerkev Sv. Urbana, Šober	15,605322°E	46,603597°N	Sl. gorice
15	Cerkev Sv. Kunigunde, Zgornja Kungota	15,612658°E	46,638486°N	Sl. gorice
16	Koča na Sabotinu, Sabotin	13,631397°E	45,990992°N	

Rezultati

Skupno smo v treh letih zabeležili 609 vrst nočnih metuljev (Tab. 2). Po vrstni pestrosti z več kot 200 opaženimi vrstami prednjači Koritno na Pohorju in predhodno neosvetljena Koča na Sabotinu (Sl. 2). Tudi v primerjavi med geografskimi regijami zaradi velikega števila opaženih vrst na Koritnem se odlikuje Pohorski trojček z 272 vrstami (Sl. 3). Vrstno najmanj bogato je območje v okolici Vrhnike (157 vrst).

Tabela 2. Seznam vrst nočnih metuljev na trojčkih cerkva in na Sabotinu, opaženih v okviru raziskave vpliva različnih osvetlitev na nočne metulje. Poimenovanje vrst temelji na seznamu Fauna Europaea (2013).

Table 2. List of moth species at church triplets and Sabotin observed during the study of the effect of different types of illumination on moths. Nomenclature follows Fauna Europaea (2013).

Družina/Vrsta	**Kras**	**Goriška Brda**	**Vrhnika**	**Slovenske gorice**	**Pohorje**	**Sabotin**
Alucitidae						
Alucita hexadactyla Linnaeus, 1758	●					
Alucita huebneri Wallengren, 1859				●		
Blastobasidae						
Blastobasis huemeri Sinev, 1994				●		
Coleophoridae						
Coleophora ornatipenella (Hübner, 1796)		●				
Coleophora uliginosella Glitz, 1872				●		
Cossidae						
Cossus cossus (Linnaeus, 1758)	●		●	●	●	
Dyspessa ulula (Borkhausen, 1790)		●				●
Parahypopta caestrum (Hübner, 1803-1808)	●					
Zeuzera pyrina (Linnaeus, 1761)	●	●			●	●
Crambidae						
Agriphila brioniellus (Zerny, 1914)		●				●
Agriphila geniculea (Haworth, 1811)				●		
Agriphila inquinatella (Denis & Schiffermüller, 1775)	●			●	●	
Agriphila straminella (Denis & Schiffermüller, 1775)					●	
Agriphila tolli (Bleszynksi, 1952)	●	●	●	●	●	
Agriphila tristella (Denis & Schiffermüller, 1775)	●	●	●	●	●	●
Agrotera nemoralis (Scopoli, 1763)	●		●			●
Anania coronata (Hufnagel, 1767)				●		
Anania crocealis (Hübner, 1796)		●	●			●
Anania lancealis (Denis & Schiffermüller, 1775)			●		●	
Anania terrealis (Treitschke, 1829)						●
Anania verbascalis (Denis & Schiffermüller, 1775)		●		●		
Angustalius malacellus (Duponchel, 1836)		●				
Calamotropha paludella (Hübner, 1824)			●			
Catoptria falsella (Denis & Schiffermüller, 1775)	●		●	●	●	
Catoptria myella (Hübner, 1796)	●	●		●	●	●
Catoptria mytilella (Hübner, 1805)						●
Catoptria pinella (Linnaeus, 1758)		●			●	●
Catoptria verellus (Zincken, 1817)			●			
Cholius luteolaris (Scopoli, 1772)						●
Chrysocrambus craterella (Scopoli, 1763)		●				
Chrysocrambus linetella (Fabricius, 1794)		●				
Chrysoteuchia culmella (Linnaeus, 1758)	●			●	●	●
Crambus lathoniellus (Zincken, 1817)	●		●		●	

Družina/Vrsta	**Kras**	**Goriška Brda**	**Vrhnika**	**Slovenske gorice**	**Pohorje**	**Sabotin**
Crambus pascuella (Linnaeus, 1758)				●	●	
Crambus perlella (Scopoli, 1763)			●	●	●	
Cydalima perspectalis (Walker, 1859)				●		
Diasemia reticularis (Linnaeus, 1761)			●	●	●	
Dolicharthria punctalis (Denis & Schiffermüller, 1775)				●	●	●
Eudonia delunella (Stainton, 1849)	●					●
Eudonia lacustrata (Panzer, 1804)	●			●	●	●
Eudonia merculella (Linnaeus, 1758)		●		●		
Eudonia truncicolella (Stainton, 1849)					●	
Evergestis forficalis (Linnaeus, 1758)				●		
Evergestis sophialis (Fabricius, 1787)						●
Loxostege sticticalis (Linnaeus, 1761)				●	●	
Mesocrambus candiellus (Herrich-Schäffer, 1848)		●				
Metacrambus carectellus (Zeller, 1839)		●				
Metasia ophialis (Treitschke, 1829)	●				●	●
Nomophila noctuella (Denis & Schiffermüller, 1775)	●	●	●	●	●	●
Ostrinia nubialis (Hübner, 1796)	●	●		●	●	●
Palpita vitrealis (Rossi, 1794)	●	●	●			●
Paratalanta pandalis (Hübner, 1825)			●			
Pediasia contaminella (Hübner, 1796)	●	●	●	●	●	●
Pediasia lutella (Denis & Schiffermüller, 1775)				●		
Pleuroptya ruralis (Scopoli, 1763)	●			●	●	
Pyrausta aurata (Scopoli, 1763)	●	●			●	●
Pyrausta castalis Treitschke, 1829						●
Pyrausta despicata (Scopoli, 1763)	●	●		●	●	●
Pyrausta ostrinalis (Hübner, 1796)						●
Pyrausta purpuralis (Linnaeus, 1758)	●	●		●	●	
Scoparia ambigualis (Treitschke, 1829)			●			
Scoparia basistrigalis Knaggs, 1866	●	●	●		●	
Scoparia italica Turati, 1919						●
Scoparia perplexella (Zeller, 1839)						●
Scoparia subfusca Haworth, 1811			●			●
Sitochroa palealis (Denis & Schiffermüller, 1775)		●		●	●	
Sitochroa verticalis (Linnaeus, 1758)	●	●	●		●	●
Thisanotia chrysonuchella (Scopoli, 1763)	●	●				
Udea ferrugalis (Hübner, 1796)	●	●	●	●	●	●
Udea olivalis (Denis & Schiffermüller, 1775)					●	
Uresiphita gilvata (Fabricius, 1794)		●				●
Xanthocrambus lucellus (Herrich-Schäffer, 1848)						●
Xanthocrambus saxonellus (Zincken, 1821)						●
Drepanidae						
Drepana falcataria (Linnaeus, 1758)		●	●	●	●	
Habrosyne pyritoides (Hufnagel, 1766)					●	
Sabra harpagula (Esper, 1786)					●	
Tethea ocularis (Linnaeus, 1767)					●	
Tethea or (Denis & Schiffermüller, 1775)				●	●	
Thyatira batis (Linnaeus, 1758)		●	●	●	●	
Watsonalla binaria (Hufnagel, 1767)	●	●	●		●	
Watsonalla cultraria (Fabricius, 1775)					●	
Elachistidae						
Agonopterix arenella (Denis & Schiffermüller, 1775)	●			●		
Agonopterix ciliella (Stainton, 1849)		●	●	●	●	

Družina/Vrsta	**Kras**	**Goriška Brda**	**Vrhnika**	**Slovenske gorice**	**Pohorje**	**Sabotin**
Agonopterix furvella (Treitschke, 1832)						●
Agonopterix kaekeritiziana (Linnaeus, 1767)		●	●		●	
Agonopterix yeatiana (Fabricius, 1781)		●				
Erebidae						
Amata phegea (Linnaeus, 1758)						●
Arctia villica (Linnaeus, 1758)	●		●			●
Arctornis l-nigrum (Müller, 1764)			●		●	
Atolmis rubricollis (Linnaeus, 1758)				●	●	
Calliteara pudibunda (Linnaeus, 1758)					●	
Catephia alchymista (Denis & Schiffermüller, 1775)		●				
Catocala fulminea (Scopoli, 1763)				●	●	
Catocala nupta (Linnaeus, 1767)		●				
Catocala nymphagoga (Esper, 1787)	●					
Catocala promissa (Denis & Schiffermüller, 1775)				●		
Diacrisia sannio (Linnaeus, 1758)	●					
Dysauxes ancilla (Linnaeus, 1767)	●	●				
Dysgonia algira (Linnaeus, 1767)	●	●				
Eilema caniola (Hübner, 1808)	●	●	●			●
Eilema complana (Linnaeus, 1758)	●	●			●	●
Eilema depressa (Esper, 1787)	●	●	●	●	●	●
Eilema griseola (Hübner, 1803)					●	
Eilema lurideola (Zincken, 1817)	●					
Eilema palliatella (Scopoli, 1763)		●				●
Eilema pseudocomplana (Daniel, 1939)	●					●
Eilema pygmaeola (Doubleday, 1847)	●					
Eilema sororcula (Hufnagel, 1766)	●	●	●	●	●	●
Eublemma parva (Hübner, 1808)						●
Euclidia glyphica (Linnaeus, 1758		●				
Euplagia quadripunctaria (Poda, 1761)			●	●	●	
Herminia grisealis (Denis & Schiffermüller, 1775)	●			●		
Herminia tarsicrinalis (Knoch, 1782)	●			●		
Herminia tarsipennalis (Treitschke, 1835)	●					
Herminia tenuialis (Rebel, 1899)		●				
Hypena obsitalis (Hübner, 1813)		●				
Hypena proboscidalis (Linnaeus, 1758)	●		●	●	●	
Hypena rostralis (Linnaeus, 1758)		●		●	●	●
Laspeyria flexula (Denis & Schiffermüller, 1775)					●	
Lithosia quadra (Linnaeus, 1758)			●	●	●	
Lygephila craccae (Denis & Schiffermüller, 1775)	●	●				●
Lygephila pastinum (Treitschke, 1826)				●		
Lygephila viciae (Hübner, 1822)			●			
Lymantria dispar (Linnaeus, 1758)	●					●
Lymantria monacha (Linnaeus, 1758)					●	
Metachrostis velox (Hübner, 1813)						●
Miltochrista miniata (Forster, 1771)		●	●	●	●	●
Odice suava (Hübner, 1813)						●
Orectis proboscidata (Herrich-Schäffer, 1851)	●					●
Paracolax tristalis (Fabricius, 1794)	●	●	●	●	●	●
Pechipogo plumigeralis Hübner, 1825		●				●
Phragmatobia fuliginosa (Linnaeus,, 1758)	●	●	●		●	
Phytometra viridaria (Clerck, 1759)	●					
Polypogon gryphalis (Herrich-Schäffer, 1851)				●	●	

Družina/Vrsta	**Kras**	**Goriška Brda**	**Vrhnika**	**Slovenske gorice**	**Pohorje**	**Sabotin**
Polypogon tentacularia (Linnaeus, 1758)					●	
Rivula sericealis (Scopoli, 1763)	●		●	●	●	
Rhyparia purpurata (Linnaeus, 1758)	●					
Schrankia costaestrigalis (Stephens, 1834)	●	●				
Scoliopteryx libatrix (Linnaeus, 1758)					●	
Spilosoma lubricipeda (Linnaeus, 1758)		●	●	●	●	
Spilosoma lutea (Hufnagel, 1766)				●	●	
Trisateles emortualis (Denis & Schiffermüller, 1775)		●			●	●
Zanclognatha lunalis (Scopoli, 1763)	●	●				●
Zanclognatha zelleralis (Wocke, 1850)	●					●
Gelechiidae						
Acompsia cinerella (Clerck, 1759)					●	
Brachmia blandella (Fabricius, 1798)				●		
Dichomeris limosellus (Schläger, 1849)				●		
Megacraspedus binotella (Duponchel, 1843)	●					
Mirificarma lentiginosella (Zeller, 1839)					●	
Nothris lemniscella (Zeller, 1839)						●
Pseudotelphusa tesella (Linnaeus, 1758)						●
Psoricoptera gibbosella (Zeller, 1839)						●
Recurvaria leucatella (Clerck, 1759)						●
Geometridae						
Alcis repandata (Linnaeus, 1758)	●	●	●		●	
Angerona prunaria (Linnaeus, 1758)	●		●		●	
Anticollix sparsata (Treitschke, 1828)			●			
Apeira syringaria (Linnaeus, 1758)				●		
Artiora evonymaria (Denis & Schiffermüller, 1775)	●					
Ascotis selenaria (Denis & Schiffermüller, 1775)		●		●	●	
Asthena albulata (Hufnagel, 1767)		●				
Biston betularia (Linnaeus, 1758)				●	●	●
Cabera exanthemata (Scopoli, 1763)			●	●	●	
Cabera pusaria (Linnaeus, 1758)		●		●	●	●
Campaea margaritaria (Linnaeus, 1761)		●	●	●	●	●
Camptogramma bilineata (Linnaeus, 1758)	●	●	●	●	●	
Camptogramma scripturata (Hübner, 1799)	●					●
Cataclysme riguata (Hübner, 1813)	●					●
Catarhoe cuculata (Hufnagel, 1767)			●	●	●	
Catarhoe rubidata (Denis & Schiffermüller, 1775)						●
Charissa glaucinaria (Hübner, 1799)						●
Charissa pullata (Denis & Schiffermüller, 1775)			●			●
Charissa variegata (Duponchel, 1830)						●
Chiasmia clathrata (Linnaeus, 1758)	●	●		●	●	
Chlorissa viridata (Linnaeus, 1758)		●				
Chloroclystis v-ata (Haworth, 1809)		●		●	●	●
Coenotephria salicata (Denis & Schiffermüller, 1775)	●					●
Colostygia olivata (Denis & Schiffermüller, 1775)						●
Colostygia pectinataria (Knoch, 1781)		●		●	●	
Comibaena bajularia (Denis & Schiffermüller, 1775)	●			●		●
Cosmorhoe ocellata (Linnaeus, 1758)			●			
Crocallis elinguaria (Linnaeus, 1758)	●		●			●
Cyclophora albiocellaria (Hübner, 1789)					●	
Cyclophora annularia (Fabricius, 1775)	●			●		
Cyclophora linearia (Hübner, 1799)			●	●	●	

Družina/Vrsta	**Kras**	**Goriška Brda**	**Vrhnika**	**Slovenske gorice**	**Pohorje**	**Sabotin**
Cyclophora punctaria (Linnaeus, 1758)		●			●	●
Cyclophora quercimontaria (Bastelberger, 1897)	●					
Cyclophora ruficiliaria (Herrich-Schäffer, 1855)		●				●
Deileptenia ribeata (Clerck, 1759)				●	●	
Dyscia raunaria (Freyer, 1851)	●					●
Ectropis crepuscularia (Denis & Schiffermüller, 1775)		●		●		
Ematurga atomaria (Linnaeus, 1758)	●			●		
Ennomos fuscantaria (Haworth, 1809)			●			
Ennomos quercinaria (Hufnagel, 1767)					●	
Epione repandaria (Hufnagel, 1767)				●		
Epirrhoe alternata (Müller, 1764)		●	●	●		●
Epirrhoe galiata (Denis & Schiffermüller, 1775)	●					●
Epirrhoe molluginata (Hübner, 1813)						●
Epirrhoe rivata (Hübner, 1813)				●		
Eulithis populata (Linnaeus, 1758)					●	
Gandaritis pyraliata (Denis & Schiffermüller, 1775)					●	
Euphyia adumbraria (Herrich-Schäffer, 1852)	●					●
Euphyia biangulata (Haworth, 1809)					●	
Euphyia unangulata (Haworth, 1809)				●		
Eupithecia abietaria (Goeze, 1781)				●		●
Eupithecia alliaria Staudinger, 1870						●
Eupithecia ericeata (Rambur, 1833)	●					
Eupithecia haworthiata Doubleday, 1856			●			
Eupithecia icterata (de Villers, 1789)	●					
Eupithecia lariciata (Freyer, 1841)					●	
Eupithecia nanata (Hübner, 1813)						●
Eupithecia plumbeolata (Haworth, 1809)	●					
Eupithecia selinata Herrich-Schäffer, 1861				●		
Eupithecia semigraphata Bruand, 1850	●					●
Eupithecia subfuscata (Haworth, 1809)				●		
Eupithecia tantillaria Boisduval, 1840			●			
Eupithecia tripunctaria Herrich-Schäffer, 1852					●	
Eupithecia veratraria Herrich-Schäffer, 1848			●			●
Geometra papilionaria (Linnaeus, 1758)			●		●	
Gnophos furvata (Denis & Schiffermüller, 1775)	●					
Gymnoscelis rufifasciata (Haworth, 1809)	●				●	●
Heliomata glarearia (Denis & Schiffermüller, 1775)	●	●				
Hemistola chrysoprasaria (Esper, 1795)	●					
Hemithea aestivaria (Hübner, 1789)			●			
Horisme calligraphata (Herrich-Schäffer, 1838)						●
Horisme radicaria (de La Harpe, 1855)		●				●
Horisme tersata (Denis & Schiffermüller, 1775)		●		●		
Horisme vitalbata (Denis & Schiffermüller, 1775)	●	●		●		●
Hylaea fasciaria (Linnaeus, 1758)				●	●	●
Hypomecis punctinalis (Scopoli, 1763)	●	●	●	●	●	●
Hypomecis roboraria (Denis & Schiffermüller, 1775)			●	●	●	●
Idaea aversata (Linnaeus, 1758)	●	●		●	●	●
Idaea biselata (Hufnagel, 1767)		●		●	●	
Idaea degeneraria (Hübner, 1799)	●	●			●	●
Idaea deversaria (Herrich-Schäffer, 1847)	●	●	●		●	●
Idaea dilutaria (Hübner, 1799)						●
Idaea dimidiata (Hufnagel, 1767)		●		●	●	

Družina/Vrsta	**Kras**	**Goriška Brda**	**Vrhnika**	**Slovenske gorice**	**Pohorje**	**Sabotin**
Idaea filicata (Hübner, 1799)	●	●				●
Idaea fuscovenosa (Goeze, 1781)			●	●	●	
Idaea humiliata (Hufnagel, 1767)	●					
Idaea inquinata (Scopoli, 1763)					●	
Idaea laevigata (Scopoli, 1763)			●			
Idaea moniliata (Denis & Schiffermüller, 1775)	●					●
Idaea obsoletaria (Rambur, 1833)						●
Idaea pallidata (Denis & Schiffermüller, 1775)				●		
Idaea rubraria (Staudinger, 1871)	●	●				●
Idaea rusticata (Denis & Schiffermüller, 1775)	●		●	●	●	●
Idaea seriata (Schrank, 1802)			●	●	●	
Idaea straminata (Borkhausen, 1794)	●		●		●	
Idaea subsericeata (Haworth, 1809)	●	●		●		●
Idaea sylvestraria (Hübner, 1799)						●
Jodis lactearia (Linnaeus, 1758)			●			●
Ligdia adustata (Denis & Schiffermüller, 1775)	●	●	●	●	●	●
Lomaspilis marginata (Linnaeus, 1758)			●			
Lomographa bimaculata (Fabricius, 1775)	●		●	●		
Lomographa temerata (Denis & Schiffermüller, 1775)	●		●		●	
Macaria alternata (Denis & Schiffermüller, 1775)	●	●	●	●	●	●
Macaria liturata (Clerck, 1759)	●	●		●	●	
Macaria notata (Linnaeus, 1758)				●		
Melanthia procellata (Denis & Schiffermüller, 1775)				●		
Menophra abruptaria (Thunberg, 1792)		●				
Mesotype parallelolineata (Retzius, 1783)				●		
Opisthograptis luteolata (Linnaeus, 1758)	●	●	●		●	
Orthonama obstipata (Fabricius, 1794)		●	●			
Ourapteryx sambucaria (Linnaeus, 1758)	●			●	●	
Paradarisa consonaria (Hübner, 1799)						●
Parectropis similaria (Hufnagel, 1767)			●	●		
Pareulype berberata (Denis & Schiffermüller, 1775)			●			
Pasiphila chloerata (Mabille, 1870)				●	●	
Pasiphila rectangulata (Linnaeus, 1758)				●	●	
Pennithera firmata (Hübner, 1822)					●	
Peribatodes rhomboidaria (Denis & Schiffermüller, 1775)	●	●	●	●	●	●
Peribatodes secundaria (Denis & Schiffermüller, 1775)				●	●	
Perizoma alchemillata (Linnaeus, 1758)					●	
Philereme transversata (Hufnagel, 1767)	●					
Philereme vetulata (Denis & Schiffermüller, 1775)	●	●	●			●
Plagodis dolabraria (Linnaeus, 1767)					●	
Plagodis pulveraria (Linnaeus, 1758)	●					
Pseudoterpna pruinata (Hufnagel, 1767)	●					●
Rhodometra sacraria (Linnaeus, 1767)		●				
Rhodostrophia calabra (Petagna, 1786)						●
Rhodostrophia vibicaria (Clerck, 1759)		●				●
Scopula caricaria (Reutti, 1853)				●		
Scopula floslactata (Haworth, 1809)				●		
Scopula imitaria (Hübner, 1799)	●	●				●
Scopula immorata (Linnaeus, 1758)				●	●	
Scopula immutata (Linnaeus, 1758)			●	●	●	

Družina/Vrsta	**Kras**	**Goriška Brda**	**Vrhnika**	**Slovenske gorice**	**Pohorje**	**Sabotin**
Scopula incanata (Linnaeus, 1758)			●		●	
Scopula marginepunctata (Goeze, 1781)	●	●	●			●
Scopula nigropunctata (Hufnagel, 1767)		●	●			●
Scopula ornata (Scopoli, 1763)	●			●	●	●
Scopula rubiginata (Hufnagel, 1767)	●					
Scopula submutata (Treitschke, 1828)						●
Scopula subpunctaria (Herrich-Schäffer, 1847)		●				
Scopula virgulata (Denis & Schiffermüller, 1775)	●		●	●	●	
Scotopteryx coarctaria (Denis & Schiffermüller, 1775)						●
Scotopteryx luridata (Hufnagel, 1767)	●					●
Scotopteryx moeniata (Scopoli, 1763)						●
Selenia lunularia (Hübner, 1788)						●
Selenia tetralunaria (Hufnagel, 1767)	●					
Siona lineata (Scopoli, 1763)				●		
Thalera fimbrialis (Scopoli, 1763)				●		
Thera britannica (Turner, 1925)					●	
Thera variata (Denis & Schiffermüller, 1775)				●	●	●
Thera vetustata (Denis & Schiffermüller, 1775)					●	
Thera obeliscata (Hübner, 1787)			●			
Thetidia smaragdaria (Fabricius, 1787)		●				
Timandra comae Schmidt, 1931	●	●	●	●		
Xanthorhoe ferrugata (Clerck, 1759)			●	●	●	
Xanthorhoe fluctuata (Linnaeus, 1758)		●	●		●	●
Xanthorhoe quadrifasiata (Clerck, 1759)				●	●	
Xanthorhoe spadicearia (Denis & Schiffermüller, 1775)				●	●	
Gracillariidae						
Aspilapteryx limosella (Duponchel, 1843)				●		
Hepialidae						
Pharmacis lupulina (Linnaeus, 1758)			●			
Triodia sylvina (Linnaeus, 1761)	●		●	●	●	
Lasiocampidae						
Dendrolimus pini (Linnaeus, 1758)				●	●	
Gastropacha populifolia (Denis & Schiffermüller 1775)					●	
Gastropacha quercifolia (Linnaeus, 1758)	●					●
Lasiocampa trifolii (Denis & Schiffermüller, 1775)	●					
Macrothylacia rubi (Linnaeus, 1758)				●		
Malacosoma castrensis (Linnaeus, 1758)	●					
Malacosoma neustria (Linnaeus, 1758)						●
Odonestis pruni (Linnaeus, 1758)	●	●	●		●	
Phyllodesma tremulifolia (Hübner, 1810)					●	
Limacodidae						
Apoda limacodes (Hufnagel, 1766)	●					●
Noctuidae						
Abrostola asclepiadis (Denis & Schiffermüller, 1775)	●					●
Abrostola tripartita (Hufnagel, 1766)					●	
Acontia lucida (Hufnagel, 1766)		●		●	●	
Acontia trabealis (Scopoli, 1763)	●	●	●	●	●	●
Acronicta alni (Linnaeus, 1767)					●	
Acronicta cuspis (Hübner, 1813)				●	●	
Acronicta leporina (Linnaeus, 1758)					●	
Acronicta megacephala (Denis & Schiffermüller, 1775)				●	●	

Družina/Vrsta	**Kras**	**Goriška Brda**	**Vrhnika**	**Slovenske gorice**	**Pohorje**	**Sabotin**
Acronicta psi (Linnaeus, 1758)		●		●	●	
Acronicta rumicis (Linnaeus, 1758)			●	●	●	
Acronicta aceris (Linnaeus, 1758)					●	
Actinotia polyodon (Clerck, 1759)			●	●		
Aedia leucomelas (Linnaeus, 1758)		●		●	●	
Agrochola circellaris (Hufnagel, 1766)					●	
Agrochola nitida (Denis & Schiffermüller, 1775)					●	
Agrotis exclamationis (Linnaeus, 1758)	●	●	●	●	●	●
Agrotis ipsilon (Hufnagel, 1766)		●		●		●
Agrotis segetum (Denis & Schiffermüller, 1775)	●	●	●	●		
Amphipoea fucosa (Freyer, 1830)			●			
Amphipyra pyramidea (Linnaeus, 1758)	●	●	●	●	●	●
Amphipyra tetra (Fabricius, 1787)	●					
Anaplectoides prasina (Denis & Schiffermüller, 1775)					●	
Anarta trifolii (Hufnagel, 1766)					●	
Apamea crenata (Hufnagel, 1766)					●	
Apamea epomidion (Haworth, 1809)		●				
Apamea furva (Denis & Schiffermüller, 1775)					●	
Apamea lithoxylaea (Denis & Schiffermüller, 1775)				●	●	
Apamea monoglypha (Hufnagel, 1766)				●	●	
Apamea scolopacina (Esper, 1788)	●			●	●	
Apamea sublustris (Esper, 1788)	●		●	●		
Atethmia centrago (Haworth, 1809)				●		
Athetis hospes (Freyer, 1831)		●				
Atypha pulmonaris (Esper, 1790)	●	●				
Auchmis detersa (Esper, 1787)			●	●		●
Autographa gamma (Linnaeus, 1758)	●	●	●	●	●	●
Axylia putris (Linnaeus, 1761)	●	●	●	●	●	
Bryophila ereptricula Treitschke, 1825					●	
Callopistria juventina (Stoll, 1782)					●	
Callopistria latreillei (Duponchel, 1827)						●
Calophasia platyptera (Esper, 1788)		●				
Caradrina aspersa Rambur, 1834						●
Caradrina clavipalpis Scopoli, 1763	●				●	
Caradrina kadenii Freyer, 1836				●		
Caradrina selini Boisduval, 1840		●				
Charanyca ferruginea (Esper, 1785)						●
Charanyca trigrammica (Hufnagel, 1766)		●		●	●	
Chrysodeixis chalcites (Esper, 1789)		●				
Clemathada calberlai (Staudinger, 1883)						●
Chloantha hyperici (Denis & Schiffermüller 1775)	●	●				
Colocasia coryli (Linnaeus, 1758)	●				●	●
Conisania luteago (Denis & Schiffermüller, 1775)	●	●				
Conistra vaccinii (Linnaeus, 1761)						●
Cosmia affinis (Linnaeus, 1767)	●					
Cosmia pyralina (Denis & Schiffermüller, 1775)				●		
Cosmia trapezina (Linnaeus, 1758)		●	●	●	●	●
Craniophora ligustri (Denis & Schiffermüller, 1775)	●	●	●		●	●
Cryphia algae (Fabricius, 1775)	●	●	●		●	●
Cucullia scrophulariae (Denis & Schiffermüller, 1775)					●	
Cucullia umbratica (Linnaeus, 1758)		●	●	●	●	
Deltote pygarga (Hufnagel, 1766)	●	●				

Družina/Vrsta	**Kras**	**Goriška Brda**	**Vrhnika**	**Slovenske gorice**	**Pohorje**	**Sabotin**
Diachrysia chrysitis (Linnaeus, 1758)			●			
Diachrysia chryson (Esper, 1789)					●	
Diachrysia stenochrysis (Warren, 1913)					●	
Dypterygia scabriuscula (Linnaeus, 1758)	●	●			●	
Episema glaucina (Esper, 1789)			●			
Eucarta amethystina (Hübner, 1803)		●				
Eugraphe sigma (Denis & Schiffermüller, 1775)					●	
Euplexia lucipara (Linnaeus, 1758)			●		●	
Eutelia adulatrix (Hübner, 1813)	●					
Euxoa decora (Denis & Schiffermüller, 1775)			●			
Hada plebeja (Linnaeus, 1761)					●	
Hadena albimacula (Borkhausen, 1792)						●
Hadena caesia (Denis & Schiffermüller, 1775)						●
Hadena filograna (Esper, 1788)						●
Hadena perplexa (Denis & Schiffermüller, 1775)		●			●	
Hecatera bicolorata (Hufnagel, 1766)				●	●	
Hecatera dysodea (Denis & Schiffermüller, 1775)	●	●		●	●	
Helicoverpa armigera (Hübner, 1808)	●	●	●	●	●	●
Heliothis nubigera Herrich-Schäffer, 1851					●	
Heliothis peltigera (Denis & Schiffermüller, 1775)		●			●	●
Hoplodrina ambigua (Denis & Schiffermüller, 1775)	●	●	●	●	●	
Hoplodrina blanda (Denis & Schiffermüller, 1775)	●	●				
Hoplodrina octogenaria (Goeze, 1781)				●	●	
Hoplodrina respersa (Denis & Schiffermüller, 1775)	●				●	●
Lacanobia contigua (Denis & Schiffermüller, 1775)			●		●	
Lacanobia oleracea (Linnaeus, 1758)		●	●	●	●	
Lacanobia suasa (Denis & Schiffermüller, 1775)			●			
Leucania loreyi (Duponchel, 1827)		●				
Luperina dumerilii (Duponchel, 1826)	●	●				●
Lycophotia porphyrea (Denis & Schiffermüller, 1775)						●
Macdunnoughia confusa (Stephens, 1850)		●			●	
Mamestra brassicae (Linnaeus, 1758)	●			●		
Melanchra persicariae (Linnaeus, 1761)			●		●	
Mesapamea secalis (Linnaeus, 1758)	●	●			●	
Mesoligia furuncula (Denis & Schiffermüller, 1775)					●	
Mniotype solieri (Boisduval, 1840)	●					
Moma alpium (Osbeck, 1778)					●	
Mythimna albipuncta (Denis & Schiffermüller, 1775)	●	●	●	●	●	●
Mythimna ferrago (Fabricius, 1787)	●	●			●	
Mythimna l-album (Linnaeus, 1767)	●	●				
Mythimna pallens (Linnaeus, 1758)			●			
Mythimna pudorina (Denis & Schiffermüller, 1775)				●		
Mythimna sicula (Treitschke, 1835)			●			●
Mythimna turca (Linnaeus, 1761)		●	●	●	●	
Mythimna vitellina (Hübner, 1808)					●	
Noctua comes Hübner, 1813	●	●				●
Noctua fimbriata (Schreber, 1759)	●	●			●	
Noctua janthina (Denis & Schiffermüller, 1775)	●	●		●		●
Noctua pronuba (Linnaeus, 1758)		●		●	●	●
Nyctobrya muralis (Forster, 1771)		●				
Ochropleura plecta (Linnaeus, 1761)		●	●	●	●	
Oligia dubia (Heydemann, 1942)	●					

Družina/Vrsta	Kras	Goriška Brda	Vrhnika	Slovenske gorice	Pohorje	Sabotin
Oligia latruncula (Denis & Schiffermüller, 1775)	●	●			●	●
Oligia strigilis (Linnaeus, 1758)	●			●	●	●
Oligia versicolor (Borkhausen, 1792)		●			●	●
Pachetra sagittigera (Hufnagel, 1766)						●
Panthea coenobita (Esper, 1785)					●	
Peridroma saucia (Hübner, 1808)		●				
Phlogophora meticulosa (Linnaeus, 1758)			●	●		
Photedes minima (Haworth, 1809)				●		
Photedes morrisii sohnretheli (Püngeler, 1907)		●				
Polia nebulosa (Hufnagel, 1766)					●	
Polyphaenis sericata (Esper, 1787)	●	●				●
Pseudeustrotia candidula (Denis & Schiffermüller, 1775)			●	●		
Pyrrhia umbra (Hufnagel, 1766)				●	●	
Rhyacia simulans (Hufnagel, 1766)				●		
Sideridis rivularis (Fabricius, 1775)		●	●		●	
Spodoptera exigua (Hübner, 1808)		●			●	
Thalpophila matura (Hufnagel, 1766)	●	●	●	●	●	●
Tholera decimalis (Poda, 1761)			●	●	●	
Tiliacea aurago (Denis & Schiffermüller, 1775)			●			
Trachea atriplicis (Linnaeus, 1758)		●		●	●	
Tyta luctuosa (Denis & Schiffermüller, 1775)	●	●		●	●	
Xanthia icteritia (Hufnagel, 1766)					●	
Xestia c-nigrum (Linnaeus, 1758)	●	●	●	●	●	
Xestia xanthographa (Denis & Schiffermüller, 1775)	●		●			
Nolidae						
Bena bicolorana (Fuessly, 1775)		●	●	●	●	
Earias clorana (Linnaeus, 1761)					●	
Meganola strigula (Denis & Schiffermüller, 1775)		●				●
Nola aerugula (Hübner, 1793)	●			●		●
Nola confusalis (Herrich-Schäffer, 1847)		●			●	
Nycteola asiatica (Krulikovsky, 1904)			●		●	
Nycteola revayana (Scopoli, 1772)	●	●		●	●	●
Nycteola siculana (Fuchs, 1899)		●				
Pseudoips prasinana (Linnaeus, 1758)		●		●	●	●
Notodontidae						
Drymonia dodonaea (Denis & Schiffermüller, 1775)					●	
Drymonia melagona (Borkhausen, 1790)					●	
Drymonia querna (Denis & Schiffermüller, 1775)					●	●
Furcula bicuspis (Borkhausen, 1790)					●	
Furcula bifida (Brahm, 1787)					●	
Harpyia milhauseri (Fabricius, 1775)					●	
Notodonta dromedarius (Linnaeus, 1767)		●			●	
Notodonta ziczac (Linnaeus, 1758)			●			
Paradrymonia vittata (Staudinger, 1892)						●
Phalera bucephala (Linnaeus, 1758)					●	
Pterostoma palpina (Clerck, 1759)		●			●	
Ptilodon capucina (Linnaeus, 1758)				●		
Ptilodon cucullina (Denis & Schiffermüller, 1775)					●	
Spatalia argentina (Denis & Schiffermüller, 1775)	●			●	●	
Stauropus fagi (Linnaeus, 1758)	●	●	●	●	●	●

Družina/Vrsta	**Kras**	**Goriška Brda**	**Vrhnika**	**Slovenske gorice**	**Pohorje**	**Sabotin**
Thaumetopoea pityocampa (Denis & Schiffermüller, 1775)	●					●
Thaumetopoea processionea (Linnaeus, 1758)	●			●	●	
Oecophoridae						
Carcina quercana (Fabricius, 1775)			●			
Dasycera oliviella (Fabricius, 1781)		●				
Harpella forficella (Scopoli, 1763)						●
Holoscolia huebneri Kocak, 1980			●			
Pleurota aristella (Linnaeus, 1767)		●				
Pleurota pyropella (Denis & Schiffermüller, 1775)				●		
Plutellidae						
Plutella xylostella (Linnaeus, 1758)	●		●			
Psychidae						
Bijugis bombycella (Denis & Schiffermüller, 1775)			●			●
Pterophoridae						
Emmelina monodactyla (Linnaeus, 1758)	●	●	●	●	●	
Pterophorus pentadactyla (Linnaeus, 1758)	●	●	●	●	●	
Stenoptilia pelidnodactyla (Stein, 1837)				●	●	
Pyralidae						
Achroia grisella (Fabricius, 1794)			●			
Acrobasis advenella (Zincken, 1818)	●					●
Acrobasis consociella (Hübner, 1813)		●				●
Acrobasis glaucella Staudinger, 1859						●
Acrobasis obtusella (Hübner, 1796)						●
Acrobasis repandana (Fabricius, 1798)					●	
Acrobasis tumidana (Denis & Schiffermüller, 1775)	●				●	●
Aglossa pinguinalis (Linnaeus, 1758)	●	●			●	
Aphomia sociella (Linnaeus, 1758)		●	●	●	●	
Aphomia zelleri Joannis, 1932	●					
Assara terebrella (Zincken, 1818)						●
Cadra furcatella (Herrich-Schäffer, 1849)	●					
Delplanqueia dilutella (Denis & Schiffermüller, 1775)	●					
Dioryctria abietella (Denis & Schiffermüller, 1775)	●	●	●	●	●	●
Dioryctria simplicella Heinemann, 1863					●	
Dioryctria sylvestrella (Ratzeburg, 1840)					●	
Eccopisa effractella Zeller, 1848		●	●			
Elegia similella (Zincken, 1818)					●	
Ematheudes punctella (Treitschke, 1833)	●	●				●
Endotricha flammealis (Denis & Schiffermüller, 1775)	●	●		●	●	●
Ephestia elutella (Hübner, 1796)			●			
Episcythrastis tetricella (Denis & Schiffermüller, 1775)	●					●
Euzophera pinguis (Haworth, 1867)						●
Euzophera bigella (Zeller, 1848)				●		
Galleria mellonella (Linnaeus, 1758)	●					
Glyptoteles leucacrinella Zeller, 1848		●				●
Homoeosoma sinuella (Fabricius, 1794)	●				●	
Homoeosoma inustella Ragonot, 1884						●
Hypochalcia ahenella (Denis & Schiffermüller, 1775)		●			●	
Hypsopygia costalis (Fabricius, 1775)	●	●	●	●	●	
Hypsopygia glaucinalis (Linnaeus, 1758)					●	
Matilella fusca (Haworth, 1811)				●		
Myelois circumvoluta (Fourcroy, 1785)					●	

Družina/Vrsta	**Kras**	**Goriška Brda**	**Vrhnika**	**Slovenske gorice**	**Pohorje**	**Sabotin**
Nephopterix angustella (Hübner, 1796)		●				
Oncocera semirubella (Scopoli, 1763)	●	●	●	●	●	●
Pempelia palumbella (Denis & Schiffermüller, 1775)						●
Pempeliella ornatella (Denis & Schiffermüller, 1775)					●	
Phycita meliella (Mann, 1864)	●					●
Phycita roborella (Denis & Schiffermüller, 1775)		●			●	●
Phycitodes binaevella (Hübner, 1813)						●
Phycitodes inquinatella (Ragonot, 1887)			●			
Pyralis farinalis (Linnaeus, 1758)			●	●		
Pyralis regalis (Denis & Schiffermüller, 1775)	●					●
Sciota hostilis (Stephens, 1834)					●	
Sciota rhenella (Zincken, 1818)				●		
Stemmatophora brunnealis (Treitschke, 1829)	●					
Synaphe punctalis (Fabricius, 1775)	●	●		●		●
Trachonitis cristella (Denis & Schiffermüller, 1775)	●					●
Saturniidae						
Antheraea yamamai (Guérin-Méneville, 1861)	●		●	●	●	
Sphingidae						
Acherontia atropos (Linnaeus, 1758)		●				
Agrius convolvuli (Linnaeus, 1758)	●		●		●	
Deilephila elpenor (Linnaeus, 1758)		●		●	●	
Deilephila porcellus (Linnaeus, 1758)			●	●	●	
Hyles euphorbiae (Linnaeus, 1758)			●			
Hyles gallii (Rottemburg, 1775)					●	
Marumba quercus (Denis & Schiffermüller, 1775)	●	●				
Mimas tiliae (Linnaeus, 1758)	●				●	
Sphinx ligustri (Linnaeus, 1758)	●					
Sphinx pinastri Linnaeus, 1758			●	●	●	
Tineidae						
Morophaga choragella (Denis & Schiffermüller, 1775)			●			
Tinea murariella Staudinger, 1859		●				
Tortricidae						
Acleris forsskaleana (Linnaeus, 1758)	●					
Acleris kochiella (Goeze, 1783)				●		
Acleris rhombana (Denis & Schiffermüller, 1775)		●				
Acleris variegana (Denis & Schiffermüller, 1775)		●				
Aethes hartmanniana (Clerck, 1758)				●		
Agapeta zoegana (Linnaeus, 1767)		●	●	●	●	●
Aleimma loeflingiana (Linnaeus, 1758)	●					
Ancylis apicella (Denis & Schiffermüller, 1775)						●
Archips crataegana (Hübner, 1799)	●					●
Archips podana (Scopoli, 1763)		●				●
Archips rosana (Linnaeus, 1758)	●					●
Archips xylosteana (Linnaeus, 1758)	●	●				●
Celypha lacunana (Denis & Schiffermüller, 1775)				●	●	●
Celypha rivulana (Scopoli, 1763)				●	●	
Celypha striana (Denis & Schiffermüller, 1775)		●			●	●
Choristoneura hebenstreitella (Müller, 1764)		●				●
Cochylimorpha jucundana (Treitschke, 1829)						●
Crocidosema plebejana Zeller, 1847		●				
Cydia amplana (Hübner, 1800)				●		
Cydia fagiglandana (Zeller, 1841)			●		●	●

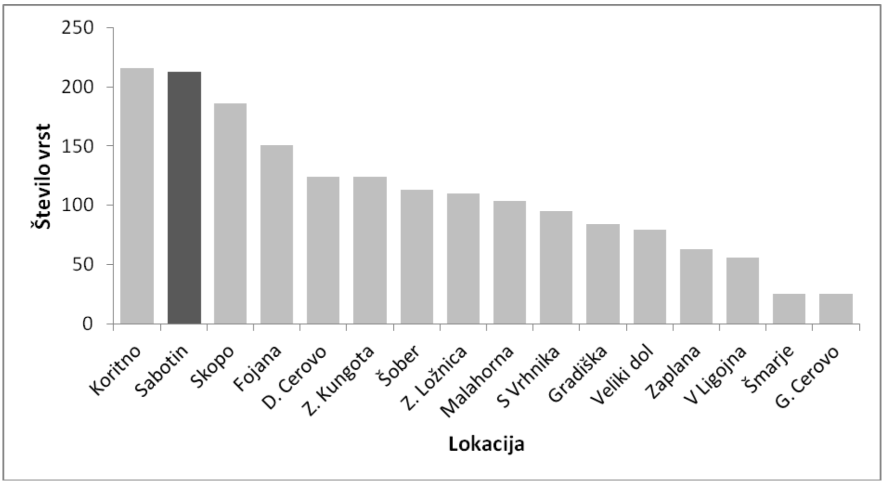
Družina/Vrsta	**Kras**	**Goriška Brda**	**Vrhnika**	**Slovenske gorice**	**Pohorje**	**Sabotin**
Cydia splendana (Hübner, 1799)		●				●
Cydia pyrivora (Danilevsky, 1947)					●	
Dichrorampha petiverella (Linnaeus, 1758)				●		
Endothenia marginana (Haworth, 1811)		●				
Endothenia quadrimaculana (Haworth, 1811)				●	●	
Epagoge grotiana (Fabricius, 1781)						●
Eucosma albidulana (Herrich-Schäffer, 1851)						●
Eucosma conterminana (Guenée, 1845)		●				
Eudemis porphyrana (Hübner, 1799)	●					
Gypsonoma sociana (Haworth, 1811)						●
Hedya nubiferana (Haworth, 1811)				●	●	●
Hedya pruniana (Hübner, 1799)	●					
Notocelia incarnatana (Hübner, 1800)	●					
Notocelia roborana (Denis & Schiffermüller, 1775)	●					
Notocelia uddmanniana (Linnaeus, 1758)		●		●	●	
Orthotaenia undulana (Denis & Schiffermüller, 1775)						●
Pammene fasciana (Linnaeus, 1761)		●				
Pandemis corylana (Fabricius, 1794)	●			●		
Pandemis dumetana (Treitschke, 1835)					●	
Philedone gerningana (Denis & Schiffermüller, 1775)		●				
Piniphila bifasciana (Haworth, 1811)						●
Syndemis musculana (Hübner, 1799)				●		
Thiodia torridana (Lederer, 1859)						●
Tortrix viridana (Linnaeus, 1758)	●					●
Yponomeutidae						
Yponomeuta cagnagella (Hübner, 1813)	●	●	●	●	●	
Yponomeuta evonymella (Linnaeus, 1758)	●					
Yponomeuta padella (Linnaeus, 1758)					●	
Yponomeuta plumbella (Denis & Schiffermüller, 1775)		●				●
Zelleria plumbeella Staudinger, 1871					●	
Ypsolophidae						
Ypsolopha mucronella (Scopoli, 1763)				●		
Ypsolopha scabrella (Linnaeus, 1761)						●

Skupaj smo zabeležili 18 vrst, ki imajo v Sloveniji status ogrožene vrste in/ali so zavarovane (Tab. 3). Med zavarovanimi vrstami je tudi črtasti medvedek (*Euplagia quadripuntaria*), ki je prednostna vrsta za varovanje po Habitatni direktivi (Direktiva Sveta 92/43/EGS 2009).

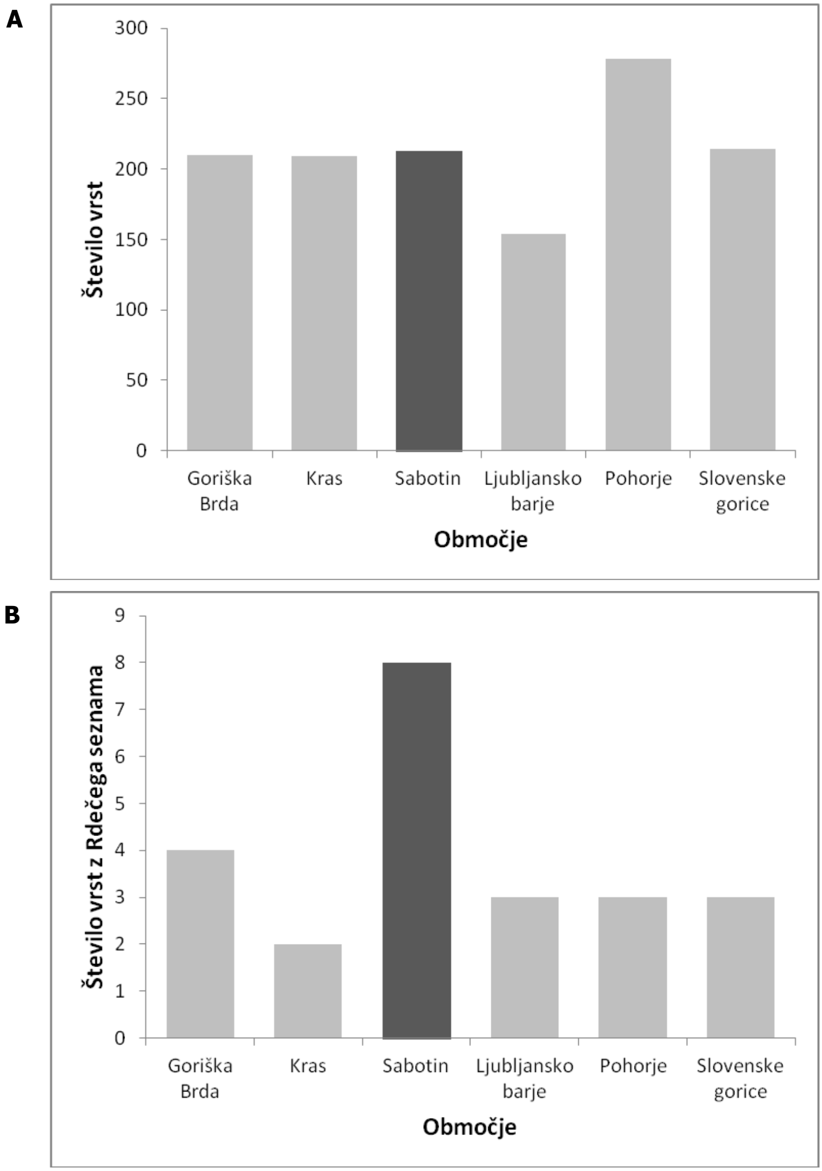
Tabela 3. Seznam ogroženih (Ur. l. RS 2002) in zavarovanih vrst (Ur. l. RS 2004a), ki so bile najdene v okviru raziskave vpliva različnih osvetlitev na nočne metulje, ter njihova geografska (povzeto po Fauna Europaea 2013) in ekološka pripadnost (določevalni viri v poglavju Materiali in metode). Oznake 1A in 2A pomenijo, da je vrsta razvrščena v Dodatek 1 oziroma 2 na seznamu zavarovanih vrst v Sloveniji, oznaka E pa prizadeta vrsta po kriterijih IUCN.
Table 3. List of endangered (Ur. l. RS 2002) and protected (Ur. l. RS 2004a) species observed during the study of the effect of different types of illumination on moths. Their geographic (Fauna Europaea 2013) and ecological (see taxonomical references in Materials and methods section) characteristics are given. Tags 1A and 2A indicate that the species is classified in Appendixes 1 or 2 in the list of protected species in Slovenia, with label E indicating endangered species according to the IUCN criteria.

Vrsta	**Status ogroženosti**	**Geografska in ekološka pripadnost**
Eilema palliatella	1A, 2A	Južno- in srednjeevropska, termo-kserofilna
Eilema pseudocomplana	E, 2A	Južnoevropska, termo-kserofilna
Euplagia quadripunctaria	1A, 2A	Vseevropska, mezofilna
Rhyparia purpurata	E, 2A	Vseevropska, termo-kserofilna
Scopula subpunctaria	E, 2A	Južno- in srednjeevropska, termofilna
Paradrymonia vittata	E, 1A	Južnoevropska, termo-kserofilna
Odice suava	E, 2A	Južnoevropska, termo-kserofilna
Metachrostis velox	E, 2A	Južnoevropska, termo-kserofilna
Clemathada calberlai	1A	Južnoevropska, mezofilna
Eucarta amethystina	E, 2A	Južno- in srednjeevropska, higrofilna
Atethmia centrago	E, 2A	Južno- in srednjeevropska, higrofilna
Amphipoea fucosa	E	Vseevropska, mezofilna
Photedes morrisii	E, 2A	Vseevropska, higrofilna
Scoparia perplexella	1A, 2A	Južnoevropska, kserofilna
Angustalius malacellus	E, 2A	Južno- in zahodnoevropska, termo-kserofilna
Diasemia reticularis	E	Vseevropska, migrant, mezofilna
Gastropacha populifolia	E, 1A, 2A	Vseevropska, mezofilna
Xanthocrambus lucellus	E, 2A	Južno- in srednjeevropska, kserofilna

Slika 2. Razporeditev vrstne pestrosti po objektih, vključenih v raziskavo. S temnejšim odtenkom je označena testna lokacija (Sabotin), na kateri ni bilo predhodne osvetlitve objekta. Podatki za vsa tri leta opazovanj (2011–2013) so združeni na posamezno lokacijo.
Figure 2. Species diversity of each object included in the study. Sabotin (test location without prior illumination) is in darker shade. Data for all three years of observation are grouped under each location.



Slika 3. Število vrst (a) in število ogroženih vrst (Rdeči seznam RS) (b) po geografskih območjih, vključenih v raziskavo. Štete so vse najdbe na vseh cerkvah v trojčku skupaj v celotnem obdobju popisov (2011-2013). S temnim odtenkom je označena testna lokacija (koča na Sabotinu), na kateri pred našo raziskavo objekt ni bil osvetljen.
Figure 3. Number of species (a) and number of threatened species (Red List RS) (b) in different geographic regions included in the survey. All records from church triplets are pulled together over the entire survey period (2011-2013). Dark-shaded column denotes test locality (Sabotin mountain hut), where the facility had not been illuminated prior to our survey.



Že na prvi pogled pritegne primerjava med Sabotinom in drugimi lokacijami ali trojčki (Sl. 3). Lokacija Sabotin v preteklosti ni bila osvetljena in ima največ, kar osem ogroženih in/ali zavarovanih vrst. Na drugih lokacijah, ki so bile pred tem osvetljene že več let, so največ štiri take vrste, oziroma na ravni trojčkov od ena do pet.

Na trojčku Goriška Brda je bilo najdenih pet ogroženih in/ali zavarovanih vrst (Tab. 3). Na Fojani so bile opažene *Eilema palliatella*, *Angustalius malacellus*, *Scopula subpunctaria* in *Eucarta amethystina*, v Dolnjem Cerovem pa *Photedes morrisii*.

Na trojčku Kras sta bili opaženi samo dve ogroženi in/ali zavarovani vrsti. To sta *Eilema pseudocomplana* in *Rhyparia purpurata*, ki sta bili najdeni le v Skopem.

Na trojčku Vrhnika so bile opažene tri ogrožene in/ali zavarovane vrste (Tab. 3). To so *Euplagia quadripunctaria* in *Diasemia reticularis*, obe najdeni na Vrhniki, ter *Amphipoea fucosa*, najdena na Veliki Ligojni.

Na trojčku Pohorje so bile najdene tri ogrožene in/ali zavarovane vrste (Tab. 3). To so *Euplagia quadripunctaria* na Koritnem, *Gastropacha populifolia* v Zgornji Ložnici in *Diasemia reticularis* v Zgornji Ložnici in v Malahorni.

Na trojčku Slovenske gorice so bile ugotovljene tri ogrožene in/ali zavarovane vrste (Tab. 3). *Euplagia quadripunctaria* in *Atethmia centrago* sta bili opaženi v Zgornji Kungoti, *Diasemia reticularis* pa na Gradiški.

Na Sabotinu je bilo opaženih osem ogroženih in/ali zavarovanih vrst (Tab. 3): *Eilema palliatella*, *Eilema pseudocomplana*, *Scoparia perplexella*, *Xanthocrambus lucellus*, *Clemathada calberlai*, *Metachrostis velox*, *Odice suava* in *Paradrymonia vittata*. Lokacija Sabotin kaže visoko stopnjo specifičnosti tako po številu vrst ogroženih in/ali zavarovanih vrst kot tudi po njihovi sestavi, saj z izjemo dveh vrst iz rodu *Eilema* druge vrste niso bile najdene na nobenem drugem vzorčnem območju. Ta specifičnost se kaže tudi v naboru drugih vrst, saj jih je bilo kar 68 takih (31,9 %), ki jih nismo našli na nobeni drugi lokaciji.

Zanimiva je favnistična primerjava posameznih lokacij ali trojčkov glede na evropsko razširjenost in habitat vrst. Večina ugotovljenih ogroženih in/ali zavarovanih vrst ima namreč južnoevropsko do jugovzhodno evropsko razširjenost in so izrazito ksero-termofilne, saj naseljujejo suha, topla in stepska življenjska okolja. Družbo jim delata še južnoevropska mezofilna vrsta *Clemathada calberlai* in jugovzhodno evropska vrsta *Paradrymonia vittata*, ki naseljuje tople in suhe vrzelaste gozdove podobno kot *Rhyparia purpurata*, ki pa ima vseevropsko razširjenost. Sledijo mezofilne do higrofilne južno- in srednjeevropske vrste *Euplagia quadripunctaria*, *Eucarta amethistina* in *Atethmia centrago*. Seznam zaključujejo tri mezofilne do higrofilne vrste: *Gastropacha populifolia*, *Amphypoea fucosa* in *Diasemia reticularis*; slednja je tropska vrsta, ki se v Evropi pojavlja kot migrant (Leraut 2012).

Tako je na Sabotinu sedem vrst iz skupine ksero-termofilnih južnoevropskih in jugovzhodno evropskih vrst in ena mezofilna. Podobno je na trojčku Goriška Brda, kjer imamo tri vrste z enako ekološko oznako, dve pa sta higrofilni. Na Kraškem trojčku sta samo dve vrsti, od katerih je ena, *Eilema pseudocomplana*, tipična ksero-termofilna južnoevropska vrsta, druga, *Rhyparia purpurata*, ki je sicer prav tako termofilna vrsta, pa že kaže bolj vseevropsko razširjenost. Ne preseneča, da na vseh primorskih lokacijah med ogroženimi in/ali zavarovanimi vrstami prevladujejo ksero-termofilne južno- in jugovzhodno evropske vrste, ki jih na drugih lokacijah v osrednji in vzhodni Sloveniji ne najdemo. Tudi obratno, saj vrst iz trojčkov Vrhnika, Pohorje in Slovenske gorice ne najdemo na primorskih trojčkih. Tako imamo na trojčku Vrhnika tri vrste, od katerih sta dve mezofilni travniški vrsti, tretja pa je mezofilna gozdna vrsta. Vse tri imajo vseevropsko razširjenost. Na trojčku Pohorje imamo tri vrste, dve sta gozdni, ena je higrofilna travniška, vse tri pa so vseevropske. Tudi na trojčku Slovenske gorice so tri vrste, od katerih sta dve mezofilni gozdni ena pa je higrofilna travniška. Dve vrsti imata vseevropsko razširjenost, ena pa južno- do srednjeevropsko.

Za nekatere zanimivejše in redkejše vrste, opažene pred in v času projekta, podajamo natančnejše podatke o najdbah:

- *Parahypopta caestrum*
  Veliki Dol 27. 6. 2012 leg. & coll. R. Štanta, Sabotin 8. 8. 2013 leg. & coll. B. Zadravec
- *Eupithecia alliaria*
  Sabotin 19. 8. 2011, 14. 8. 2012, 8. 8. 2013 vse leg. & coll. B. Zadravec
- *Artiora evonymaria*
  Skopo 28. 7. 2011 leg. & coll. R. Štanta
- *Eilema palliatella*
  Fojana 11. 6. 2011, Sabotin 31. 7. 2011 obe leg. & coll. B. Zadravec
- *Eilema pseudocomplana*:
  Sabotin 17. 7. 2012 leg. & coll. B. Zadravec, Skopo 4. 8. 2013 leg. & coll. R. Štanta
- *Caradrina selini*
  Nanos 10. 5. 2007, 13. 5. 2008, 15. 4. 2009, 15. 8. 2009 vse leg. & coll. R. Štanta, Kromberk 18. 4. 2007, 24. 4. 2009, Sabotin 3. 5. 2009, Ozeljan 5. 5. 2011 vse leg. & coll. B. Zadravec
  Dolnje Cerovo 15. 5. 2013, Sabotin 15. 5. 2013 obe leg. & coll. B. Zadravec
- *Photedes morrisii sohnretheli*
  Dolnje Cerovo 15. 6. 2012 leg. & coll. B. Zadravec
- *Oligia dubia*
  Skopo 30. 5. 2011, 10. 6. 2011 leg. & coll. R. Štanta
- *Clemathada calberlai*
  Grgar 26. 5. 2000 leg. R. Štanta, B. Zadravec, M. Zadrgal; Kromberk - Breg 15. 5. 2001 leg. R. Štanta, M. Zadrgal, Kromberk - Podrob 2. 5. 2005, 24. 4. 2009, 9. 5. 2010 vse leg. B. Zadravec, Skalnica 13. 5. 2008 leg. B. Zadravec, Korada 21. 5. 2009 leg. R. Štanta, B. Zadravec, M. Zadrgal, Šmaver 14. 5. 2010 leg. B. Zadravec, Sabotin 22. 4. 2011 leg. R. Štanta, M. Zadrgal, Sabotin – Brestje 30. 5. 2014 leg. R. Štanta, B. Zadravec, M. Zadrgal, Čolnica nad Kanalom 20. 6. 2014 leg. M. Zadrgal.
  Sabotin 8. 8. 2013 leg. & coll. B. Zadravec

Diskusija

Ena glavnih ugotovitev te raziskave je, da osvetljevanje objektov kulturne dediščine privablja veliko število vrst nočno aktivnih metuljev, saj je bilo kar 20 % vseh v Sloveniji znanih vrst najdenih že v okviru naše raziskave. Glede na majhno število vzorčnih mest in nepopolno pokritost biogeografskih regij v Sloveniji je ta visoki delež še toliko bolj zaskrbljujoč. Pri tem moramo poudariti, da so učinki osvetljevanja na nočne metulje kumulativni, saj je bila večina objektov v raziskavi osvetljena že daljše obdobje. Kumulativni učinek dolgotrajnega osvetljevanja je najbolj razviden iz primerjave trojčkov s Sabotinom, kjer objekt pred tem ni bil nikoli osvetljen. Predvsem po številu v Sloveniji ogroženih vrst je daleč največ pozornosti zbujal Sabotin, po številu opaženih vrst pa je zaostal le za Koritnim na Pohorju. Za ti dve vzorčni mesti so značilni naravni gozdni sestoji v bližnji okolici, torej je vrstna pestrost lahko povezana tudi z ohranjenostjo habitatov v okolici objektov (Verovnik et al. 2015).

Biogeografsko 60 % ugotovljenih vrst spada med sibirsko-evropske in azijsko-evropske vrste, torej večinoma vseevropske vrste, ki so bodisi mezofilne ali higrofilne. Sledijo evropske, centralnoevropske in vzhodnoevropske vrste z 20 %, medtem ko je južnoevropskih vrst in vrst iz širšega mediteranskega prostora, ki so večinoma termo-kserofilne, okoli 10 %. Ostane še nekaj kozmopolitskih in ne dovolj poznanih vrst. Rezultat je glede na razporeditev trojčkov v treh geografskih regijah pričakovan. Omenjeno razmerje vrst se približno ohranja tudi v primerjavi trojčkov med seboj, s tem da imajo tisti iz osrednje Slovenije in Štajerske za polovico manjši delež južnoevropskih in mediteranskih vrst. Pričakovano je takih vrst največ na Primorskem, vendar so tudi med trojčki opazne razlike. Največ smo jih našli na topli in suhi lokaciji na Sabotinu, sledijo Goriška Brda, najmanj pa jih je bilo na trojčku Kras z nekoliko hladnejšim osrednjim delom kraške planote.

Glede na ekološke značilnosti smo med vsemi vrstami skupaj zabeležili največ mezofilnih vrst (skoraj 70 %), okrog 20 % je bilo kserofilnih in nekaj pod 10 % higrofilnih in povsod pojavljajočih se vrst. Večino mezofilnih ter higrofilnih in povsod razširjenih vrst smo našli na trojčkih v okolici Vrhnike in na Štajerskem. Največ kserofilnih vrst, ki naseljujejo različna suha travišča in grmišča ali tople vrzelaste gozdove, je na Primorskem, kjer po številu kserofilnih vrst ponovno prednjači Sabotin, sledijo Goriška Brda in na koncu kraški trojček z največ mezofilnimi vrstami na Primorskem. Trojček Goriška Brda ima v primerjavi z drugimi primorskimi lokacijami največ higrofilnih in povsod razširjenih vrst.

Komentar k nekaj zanimivejšim in redkejšim vrstam

Parahypopta caestrum

Njeno območje razširjenosti je vezano na hranilne rastline gosenic iz rodu *Asparagus* in zajema južno in delno srednjo Evropo ter jugozahodno Azijo. V Sloveniji je vrsta znana le s Primorske. Na Krasu, predvsem na njenem severozahodnem delu, bogatim z divjim špargljem *Asparagus acutifolius*, ni redka. Najdemo jo tudi na apnenčastih južnih obronkih Goriških Brd (Štanta, Zadravec, lastna opažanja). V sklopu naše raziskave smo jo našli tako na Krasu kot v Goriških Brdih.

Eupithecia alliaria

Lokalna vrsta, ki jo najdemo v širšem območju Sredozemlja, od Portugalske do Kavkaza. Pri nas je bila prvič najdena na Knežaku (Lasan 1997), pozneje smo jo našli tudi na Nanosu in Krasu (Štanta, lastna opažanja). Pojavlja se v juliju in avgustu. Najdba na Sabotinu v času projekta je bila pričakovana, saj je območje bogato z različnimi vrstami luka (*Allium* sp.), na katerih se hrani gosenica.

Artiora evonymaria

To srednje- in jugovzhodno evropsko vrsto najdemo tudi na Balkanskem polotoku. Je redka in lokalna vrsta (Leraut 2009), ki leta od konca junija do začetka septembra. Gosenica se prehranjuje z navadno trdolesko *Euonymus europaea.* V Sloveniji je bila najdena v predalpski in subpanonski regiji (Carnelutti 1992a) ter pozneje še na Primorskem v Vipavi in Podnanosu (Flamigni et al. 2007). Najdba v Skopem na Krasu povezuje najbližje znane lokacije v Vipavski dolini in Staranzanu v sosednji Julijski krajini (Flamigni et al. 2007) ter potrjuje, da vrsta poseljuje tako tople in suhe kot tudi izrazito vlažne biotope.

Eilema palliatella

Ta evrazijska vrsta je pri nas znana iz predalpske in primorske regije (Carnelutti 1992a), vendar je zelo redka. Ima eno generacijo, ki leta v juliju in avgustu. Čeprav je zanjo značilen siv pas na zgornjem delu spodnje strani zadnjih kril in telo bolj rumene barve, je že malo obletele primerke težko ločiti od sorodnih vrst *E. complana*, *E. pseudocomplana* in *E. caniola*. V Sloveniji je zavarovana. Najdba v Goriških Brdih in na Sabotinu ne preseneča.

Eilema pseudocomplana

Ta toploljubna vrsta je lokalno razširjena od Španije prek severnega Sredozemlja, Male Azije in južne Rusije do Irana. Ima eno generacijo, ki pri nas leta julija in avgusta. Na Krasu je bila že opažena (Lasan 1997) in verjetno tu sploh ni redka, je pa zaradi podobnosti s svetlimi primerki *E. complana* verjetno večkrat prezrta. Najdba na Sabotinu je naša trenutno najsevernejša znana lokacija.

Caradrina selini

Je zahodnopalearktična vrsta, ki je lokalno razširjena skoraj po vsej Evropi. V Sloveniji naj bi bila znana le iz Mojstrane (Carnelutti 1992a). V novejšem času smo vrsto večkrat našli na južnih obronkih Trnovskega gozda, Sabotina in Nanosa. Najraje se zadržuje na suhih travnikih. Gosenica se prehranjuje na različnih zeleh, npr. kislicah (*Rumex* spp.), trpotcih (*Plantago* spp.), regratih (*Taraxacum* spp.). Pri nas se pojavlja od aprila do septembra. Tudi najdba v Goriških Brdih in na Sabotinu v času projekta tako ni presenečenje.

Photedes morrisii sohnretheli

Pri nas je bila zabeležena prvič še kot samostojna vrsta *P. sohnretheli* (Lasan 2000). Po trenutno veljavni nomenklaturi v Fauna Europaea (2013) ima status podvrste. Pri nas je bila do sedaj najdena le podvrsta *Photedes morrisii sohnretheli* (Püngeler, 1907). Razširjena je na Obali in na Goriškem (Lasan 2000). Leta od konca maja do julija in je dokaj redka. Najdba v Goriških Brdih ne preseneča. V Sloveniji sta zavarovani obe takrat veljavni vrsti *Chortodes morrisii* in *Chortodes sohnrethelii* (Ur. l. RS. 2004a).

Oligia dubia

Evropski endemit, ki je razširjen v predgorjih Alp, predvsem v jugovzhodnem delu Evrope (Ravaglioli 1984, Fajčik & Slamka 1998). Osebki letajo maja in junija. Ker se od podobne vrste *O. latruncula* loči le po obliki genitalnih organov, je objavljenih podatkov o njenem pojavljanju razmeroma malo. Na Krasu je pogosta (Štanta R., lastna opažanja), zato je bila njena najdba pričakovana.

Clemathada calberlai

V Sloveniji domnevno izumrla vrsta (Carnelutti 1992a), ki jo je nad Novo Gorico po več kot osmih desetletjih ponovno našel Stanislav Gomboc (Habeler & Gomboc 2005). Pozneje smo jo večkrat našli v širši okolici. Vrsta je razširjena še v Franciji, Švici in osrednjem delu Italije. Pri nas je omejena na spodnji del doline Soče z bližnjimi pobočji Banjšic, Goriških Brd in Kambreškega in sploh ni redka (Štanta R., Zadravec B., Zadrgal M., lastna opažanja). Gosenica se prehranjuje z navadnim srobotom (*Clematis vitalba*). Pri nas ima dve generaciji, prva leta od srede aprila do srede junija, druga pa julija in avgusta.

Zaključki

Dosedanje raziskave v evropskem prostoru vsaj posredno kažejo na zmanjševanje pestrosti metuljev zaradi svetlobnega onesnaževanja (Conrad et al. 2006, Mattila et al. 2006, Groenendijk & Ellis 2010, Fox 2012), vendar je učinke le-tega težko ločiti od upadanja pestrosti zaradi izgube habitata, ki je še vedno najpomembnejši dejavnik ogrožanja biodiverzitete na splošno. V Slovenije je to prva tako obsežna raziskava, ki kaže, da svetlobno onesnaževanje vpliva na veliko število vrst nočnih metuljev, ki so tudi zaradi vrstne pestrosti ena izmed najpomembnejših skupin v prehranjevalnih spletih, pomembni pa so tudi kot opraševalci (van Langevelde et al. 2011, Fox 2012). Posledično ima lahko upad njihove številčnosti velik vpliv na ekosisteme kot celota, v končni fazi tudi na ljudi, ki so vezani na opraševalce kulturnih rastlin. Da bi se izognili nadaljnjemu slabšanju kvalitete življenjskih okolij, bi bilo tako smiselno bolj zaostriti zakonodajo, s katero bi preprečili uporabo svetilk s kratkovalovno svetlobo v javni razsvetljavi. Predvsem v varovanih območjih narave bi s predpisi o varstvenih režimih morali zagotoviti minimalno svetlobno onesnaževanje z osvetljevanjem objektov in javno razsvetljavo. To velja predvsem za območja Natura 2000 (Ur. l. RS 2004b), ki so namenjena ohranjanju nočnih metuljev, kot so kraški zmrzlikar (*Erannis ankeraria*), hromi volnoritež (*Eriogaster catax*) in črtasti medvedek (*Euplagia quadripunctaria*) ter za druga ekološko pomembna območja (EPO) (Ur. l. RS 2004c), ki so namenjena ohranjanju ogroženih in zavarovanih vrst nočnih metuljev ali drugih nočno aktivnih žuželk.

V primeru cerkva in drugih kulturnih objektov bi bilo smiselno omejiti osvetljevanje samo na večerni čas. To bi omogočilo metuljem, ki se znajdejo v soju žarometov, da se vrnejo nazaj v svoj življenjski prostor in prispevajo k obstoju svojih populacij. Pri tem moramo poudariti, da je ravno izguba življenjskih okolij največji naravovarstveni problem v Sloveniji in širše, saj svetlobno onesnaženje zgolj pospešuje izumiranje vrst. Upamo, da bomo z opozarjanjem na ta problem še pravočasno preusmerili nezadržni trend zmanjševanja biodiverzitete v njeno ohranjanje z bolj uravnoteženim odnosom do narave.

Summary

High biodiversity is one of the main characteristics of Slovenia, so moths and butterflies are no exception. There are an estimated 3,603 species known all together (Gomboc & Lasan 2006), and new discoveries are still common (e.g. Štanta 2008, Gomboc & Klenovšek 2013). Light pollution is an additional factor that reduces habitat quality for many moth species, as illumination, in particularly UV and other short wavelength light, attracts moths and obstructs their natural behaviour (Rydell 1992, van Langevelde et al. 2011, Barghini et al. 2012). During our three-year study, a part of the project »Life at Night« (LIFE09 NAT/SI/000378), we aimed to determine the impact of artificial church illumination on the moth fauna in Slovenia. In this paper we present the faunistic aspects of our study and compare faunal composition between three geographically separate areas: Primorska (Kras, Goriška Brda), Ljubljana basin (Vrhnika) and Štajerska (Pohorje, Slovenske gorice). We provide comments for some rare and/or threatened species that were observed during the survey.

In total, 609 species were recorded during the three-year survey, representing approximately 20% of the total Lepidoptera fauna in Slovenia. Two sites with more than 200 species observed were Koritno in Pohorje Mts and Sabotin mountain hut in the Primorska region (Fig. 1), the only location with no prior illumination of the object. In terms of geographic regions, the Pohorje area had the highest diversity with a total of 272 species seen (Fig. 2), while Vrhnika with the largest proportion of degraded habitats had the lowest score (157 species). Among the species observed, 18 have a status of endangered species in Slovenia (Tab. 1) and most of them are protected by law. *Euplagia quadripuntaria* was the only species listed on Habitats Directive (92/43/EC) recorded during our survey. Sabotin mountain hut was again dominant in terms of the number of threatened species observed (8 species), indicating more preserved natural habitats in its vicinity, but also absence of light pollution compared to other sites. The following species observed during our survey are either rare or particularly threatened in Slovenia, therefore we provide exact records and comments: *Parahypopta caestrum* (Cossidae), *Eupithecia alliaria* (Geometridae), *Artiora evonymaria* (Geometridae), *Eilema palliatella* (Arctiidae), *Eilema pseudocomplana* (Arctiidae), *Caradrina selini* (Noctuidae), *Photedes morrisii sohnretheli* (Noctuidae), *Oligia dubia* (Noctuidae), and *Clemathada calberlai* (Noctuidae).

In terms of biogeography, 60% of the observed species belong to Euro–Siberian or Euro–Asiatic group of species, and are either mesophilous or hygrophilous in terms of habitat selection. Twenty percent of the species have predominantly European distribution (Central or Eastern European), while 10% are South European, mostly xerophilous species. Such faunal composition is typical for inland regions of Slovenske gorice, Pohorje and Vrhnika area, while in Primorska the percentage of South European species in larger. This region is also characterised by larger proportion of xerophilous species compared to other regions.

This is the first comprehensive survey of impact of artificial illumination on moths in Slovenia and shows that light pollution affects a large number of moth species. Due to large moth diversity and their important role in food webs and as pollinators (van Langevelde et al. 2011, Fox 2012), their decline could consequently have negative impacts on the ecosystems as a whole. To avoid contiguous deterioration of the habitat quality, it would be advisable to enforce a more rigorous legislation that would prevent the use of lamps with short-wave light in public lighting, in particularly in protected areas such as Natura 2000 sites (UL RS 49/2004), which are intended for the conservation of moths. As far as churches and other cultural heritage sites are concerned, it would be reasonable to restrict the illumination only to evening time. This would allow the butterflies that find themselves in the limelight to return to their habitat and contribute to the existence of their populations. We hope that our results will contribute towards higher public awareness of the problem of light pollution and reverse the downward trend of biodiversity loss.

Zahvala

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The Grecian anomalous blue *Polyommatus* (*Agrodiaetus*) *aroaniensis* (Brown, 1976) (Lepidoptera: Lycaneidae) discovered in Croatia, at the north-western edge of its distribution

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Abstract. In 2014 and 2015, a survey to improve the knowledge about the distribution of butterflies of the subgenus *Polyommatus* (*Agrodiaetus*) was carried out in southern Croatia. The first observations of a new species for the country, *P. aroaniensis*, were made. These localities present the northwesternmost points of the species distribution, with the closest known population occurring in Bosnia and Herzegovina. New localities for the three species, *P. admetus*, *P. damon*, and *P. ripartii*, were also recorded, extending the range of the latter two species. Our findings increase the number of recorded butterfly species in Croatia to 197.

Key words: Lika, Croatia, Lepidoptera, Lycaneidae, *Polyommatus, Agrodiaetus,* new records

Izvleček. Modrin *Polyommatus* (*Agrodiaetus*) *aroaniensis* (Brown, 1976) (Lepidoptera: Lycaneidae) najden na Hrvaškem, na severozahodni meji njegove razširjenosti – V letih 2014 in 2015 smo raziskovali razširjenost metuljev podrodu *Polyommatus (Agrodiaetus)* v južnem delu Hrvaške. Prvič smo zabeležili vrsto *P. aroaniensis*. Te lokalitete ležijo na najbolj severozahodnem delu območja razširjenosti te vrste, katere naslednja najbližja populacija je znana iz Bosne in Hercegovine. Našli smo tudi nove lokalitete za tri vrste *P. admetus*, *P. damon* ter *P. ripartii* in tako povečali znano območje razširjenosti slednjih dveh vrst. Z našimi najdbami se je število zabeleženih vrst dnevnih metuljev na Hrvaškem povzdignilo na 197.

Ključne besede: Lika, Hrvaška, Lepidoptera, Lycaneidae, *Polyommatus*, *Agrodiaetus*, nove najdbe

Introduction

So far, three species belonging to the subgenus *Polyommatus* (*Agrodiaetus*) have been recorded in Croatia: *Polyommatus* (*Agrodiaetus*) *damon* (Denis & Schiffermüller, 1775), *Polyommatus* (*Agrodiaetus*) *admetus* (Esper, 1783) and *Polyommatus* (*Agrodiaetus*) *ripartii* (Freyer, 1830) (Šašić & Mihoci 2011). All three species are very local, with their known range limited to the southern part of the country, mainly Dalmatia, Dalmatinska Zagora and southern Lika. They belong to the butterfly species group with dot-like distributions, and their range is discontinuous in the Balkans (Tolman & Lewington 2008, Vila et al. 2010). Generally, all the mentioned species are local and rare in Europe (Tolman & Lewington 2008).

Only a few historical records from Croatia exist prior to the 20th century for *P. admetus* (Koren 2010a) and a single record for *P. damon* (Mann 1869). In addition, *P. ripartii* had been recorded only a few years ago in Croatia (Koren 2010b). For all three species, several new records expanding their known range in Croatia have been gathered and published in the last few years (Mihoci et al. 2006, Koren et al. 2011, Tvrtković et al. 2012, Koren & Lauš 2013, Koren et al. 2015). However, their distribution in the country is far from well known. Almost every surveyed region of southern Croatia yields new records, while most of the historical studies do not contain data about these species. This is partially due to their relatively short flight period, usually from mid-July to the beginning of September. Additionally, they are usually present in the areas that are distanced from the sea or other interesting Mediterranean areas, which are more frequently visited by entomologists (e.g. Habeler 1976). It was only in the last several years that we started to survey lesser known regions of Croatia, especially Lika, the border with Bosnia and Herzegovina, and the mountains in this bordering region. More detailed surveys resulted in many new and interesting species records (e.g. Koren et al. 2011, Tvrtković et al. 2011).

Here we present new records of the three species belonging to the subgenus *Polyommatus* (*Agrodiaetus*) from Croatia, and the first records of the fourth species of the subgenus, *Polyommatus aroaniensis* (Brown, 1976).

Materials and methods

Butterflies belonging to the subgenus *Polyommatus* (*Agrodiaetus*) were observed and/or collected during 2014 and 2015 in Croatia, ranging from Lika in the northern part of the survey area to southern Dalmatia in the south. Several specimens per locality were collected and placed into the first author's collection. For each specimen, basic habitat description, altitude and coordinates were taken. On all localities, the habitat type was registered and later cross-checked with the Republic of Croatia Database of Habitat Types (Državni zavod za zaštitu prirode 2008). The altitude was measured in the field using Garmin GPS devices, or later using Google Earth software. Specimens were identified to the species rank in accordance with the descriptions given by Tolman & Lewington (2008). Nomenclature follows the Fauna Europaea list of European butterflies (Fauna Europaea 2015). For each species, known altitudinal ranges were also calculated, based on the species-locality records.

Results

According to the literature and newly collected records, the butterflies of the subgenus *Polyommatus* (*Agrodiaetus*) are known from six regions in Croatia, stretching from the Lika region to Dalmatinska Zagora (Dalmatia) (Fig. 1a). An additional region, where we did not confirm any of the four species, but historical records for *P. admetus* exist, is marked with the question mark (Kozjak Mountain in the vicinity of Split, according to Stauder 1923).

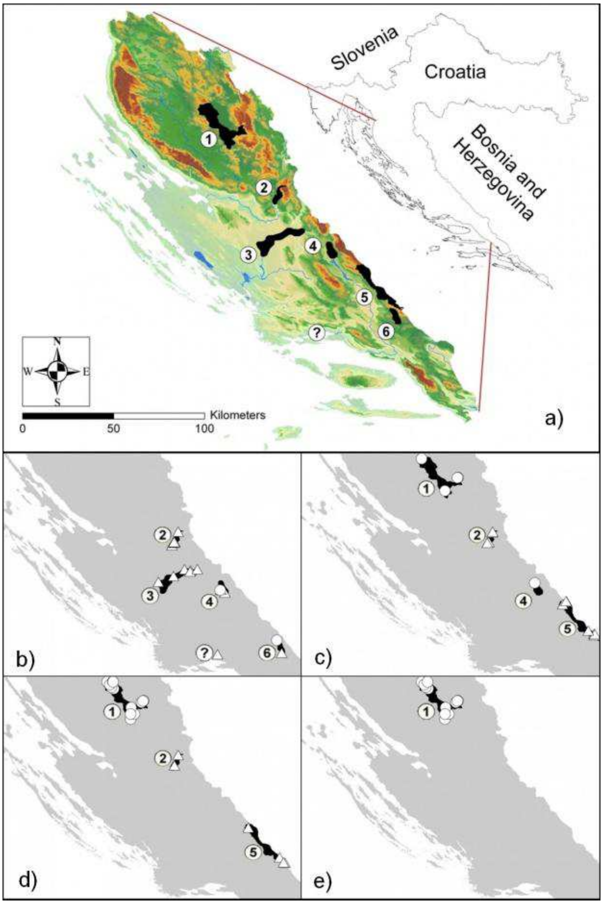

Figure 1. Map of the surveyed regions of the four species of the subgenus *Polyommatus* (*Agrodiaetus*) in Croatia (a), with all records of the four species in Croatia on maps below: *P. admetus* (b), *P. damon* (c), *P. ripartii* (d) and *P. aroaniensis* (e). Numbers and black silhouettes refer to regions: 1 - Ličko sredogorje, 2 - Poštak Mountain and Zrmanja spring, 3 - Upper part of the Krka River, 4 - Cetina spring, 5 - Mountains Troglav and Kamešnica, 6 - Voštane - Tijarica, ? – unconfirmed record from Kozjak Mt. Literature records are presented with white triangles, while new records gathered in 2014 and 2015 are presented with white circles.

Slika 1. Karta raziskovanih regij štirih vrst podrodu *Polyommatus* (*Agrodiaetus*) na Hrvaškem (a), z vsemi znanimi podatki za štiri vrste na kartah spodaj: *P. admetus* (b), *P. damon* (c), *P. ripartii* (d) in *P. aroaniensis* (e). Oznake in črna področja se nanašajo na regije: 1. Ličko sredogorje, 2. Poštak in izvir reke Zrmanje, 3. gornji del reke Krke, 4. izvir reke Cetine, 5. hribi Troglav in Kamešnica, 6. Voštane - Tijarica, ? – nepotrjena najdba s hriba Kozjak. Literaturni podatki so predstavljeni z belimi trikotniki, novi podatki zbrani v 2014 in 2015 pa z belimi krogi.

Within these six regions, we visited several localities in order to confirm the presence of the *Polyommatus* (*Agrodiaetus*) butterflies (Tab. 1, Fig. 1a). *Polyommatus admetus* was recorded on two new localities (Fig. 1b), *P. damon* on five new localities, and in two new regions (Ličko sredogorje and Cetina spring, Fig. 1c), and *P. ripartii* on 13 new localities and one new region (Ličko sredogorje, Fig. 1d). *P. damon* was confirmed on each studied locality within Ličko sredogorje and Cetina spring also being new for this species. Aside from the species already known from the country, we recorded an additional new species – *P. aroaniensis*, on 12 localities within one region (Ličko sredogorje) (Fig. 1e, Fig. 2).

Table 1. List of new records of the four species of the subgenus *Polyommatus* (*Agrodiaetus*) in Croatia, with description of locality, region number (according to the map in Fig. 1a), dates of visit, number of observed specimens (N), coordinates (X and Y in WGS84 decimal degrees) and altitude (Z).
Tabela 1. Seznam novih najdb štirih vrst podrodu *Polyommatus* (*Agrodiaetus*) na Hrvaškem, z navedeno lokaliteto, številko regije (v skladu z zemljevidom na Sl. 1a), datumi obiskov, številom opaženih osebkov (N), koordinatami (X in Y v WGS84 decimalnih stopinjah) in nadmorsko višino (Z).

Locality	Region No.	Date	N	Y	X	Z [m]
Polyommatus damon						
Cetina village, Cetina River spring	4	6.8.2015	>5	43,97678	16,43013	392
crossroad toward Srednja gora, about 5 km SW from Udbina	1	4.8.2014	>5	44,48584	15,73214	759
Kozja Draga, locality 1, NW from Udbina	1	2.8.2014	>10	44,55868	15,82837	884
Kozja Draga, locality 2, NW from Udbina	1	29.7.2015	>10	44,56016	15,83255	987
Kneževići village	1	28.7.2015	1	44,66228	15,54793	926
Polyommatus ripartii						
Komić, Balić-bunar, Udbina	1	27.7.2014	>10	44,45777	15,73282	834
turnoff toward Srednja gora, about 5 km SW from Udbina	1	4.8.2014	2	44,48584	15,73214	759
grasslands 4.5 km S from Udbina	1	3.8.2014	>5	44,48637	15,76173	700
grasslands towards Čojluk, 3.5 km SW from Udbina	1	3.8.2014	3	44,52165	15,73645	722
Kozja Draga, locality 3, NW from Udbina	1	2.8.2014	>5	44,55063	15,8165	834
Kozja Draga, locality 1, NW from Udbina	1	2.8.2014	>5	44,55868	15,82837	884
Kozja Draga, locality 2, NW from Udbina	1	29.7.2015	>5	44,56016	15,83255	958
Svračkovo selo	1	27.7.2015	10	44,62524	15,59953	718
Ljubovo, locality 1, NW from Svračkovo Selo	1	28.7.2015	15	44,63319	15,58182	856
Ljubovo, locality 2, NW from Svračkovo Selo	1	28.7.2015	5	44,64771	15,56841	928
Kneževići village	1	28.7.2015	3	44,66228	15,54793	926
Brestovača medow, W from Bunić	1	29.7.2015	5	44,66302	15,59378	916
towards Brestovača meadow, W from Bunić	1	29.7.2015	4	44,66523	15,59152	919
Polyommatus admetus						
Rože -Voštane, slopes near the rode	6	5.8.2015	1	43,6578	16,86279	923
Kosore, Cetina river bank	4	6.8.2015	1	43,93645	16,42894	383
Polyommatus aroaniensis						
Komić, Balić-bunar, Udbina	1	27.7.2014	5	44,45777	15,73282	671
turnoff toward Srednja gora, about 5 km SW from Udbina	1	4.8.2014	1	44,48584	15,73214	759
grasslands 4.5 km S from Udbina	1	3.8.2014	>5	44,48637	15,76173	700

Locality	Region No.	Date	N	Y	X	Z [m]
grasslands toward Čojluk, 3.5 km SW from Udbine	1	3.8.2014	1	44,52165	15,73645	722
Kozja Draga, locality 3, NW from Udbina	1	2.8.2014	3	44,55063	15,8165	834
Kozja Draga, locality 1, NW from Udbina	1	2.8.2014	4	44,55868	15,82837	884
Kozja Draga, locality 2, NW from Udbina	1	29.7.2015	>50	44,56016	15,83255	958
Svračkovo Selo	1	27.7.2015	5	44,62524	15,59953	718
Ljubovo, locality 1, NW from Svračkovo Selo	1	28.7.2015	6	44,63395	15,58049	858
Ljubovo, locality 2, NW from Svračkovo Selo	1	28.7.2015	3	44,64771	15,56841	928
Kneževići village	1	28.7.2015	2	44,66228	15,54793	926
Brestovača medow, W from Bunić	1	29.7.2015	2	44,66302	15,59378	916

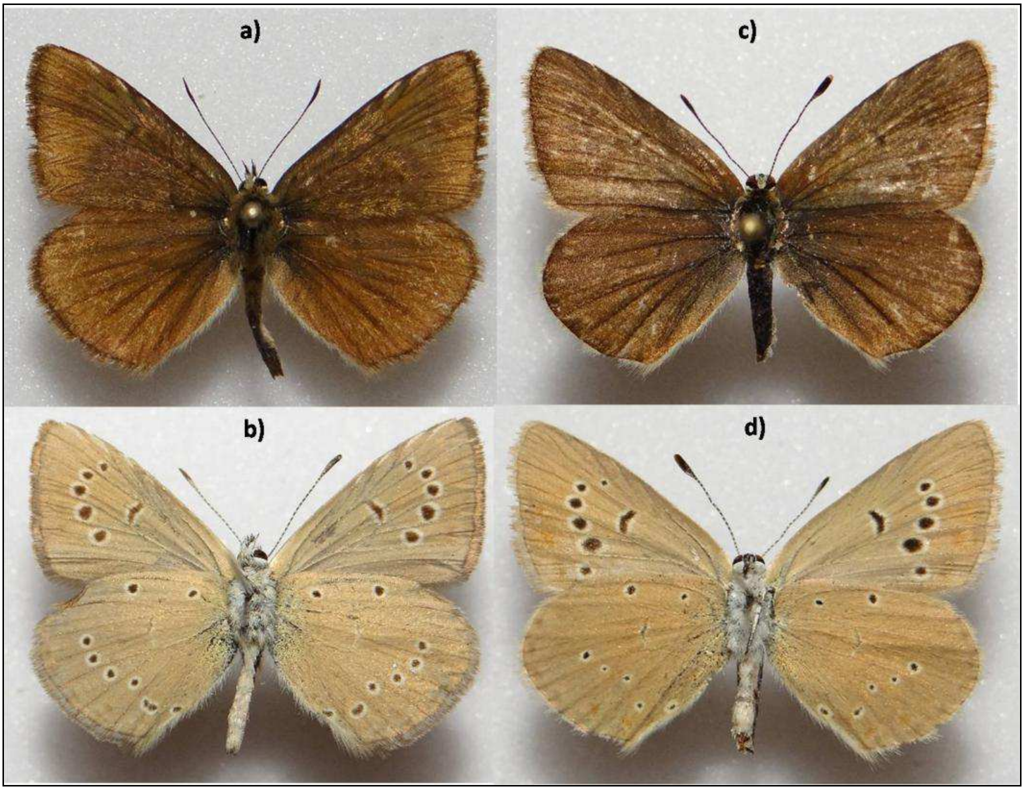

Figure 2. Male (a, b) and female (c, d) specimens of *P. aroaniensis* from Kozja Draga locality in Croatia (photo: Toni Koren).
Slika 2. Samec (a, b) in samica (c, d) vrste *P. aoraniensis* z lokalitete Kozja Draga na Hrvaškem (foto: Toni Koren).

As shown on the maps, *P. admetus* is most widespread in Dalmatia, with the northernmost record in Lika, on the Poštak Mountain (Fig. 1b). *P. damon* (Fig. 1c) and *P. ripartii* (Fig. 1d) share localities and habitats, with the exception of the spring of the Cetina River, where only *P. damon* was recorded. Records of these two species in Ličko sredogorje are 36 km away from the closest known population on Poštak Mountain, and present the northernmost distribution for these species in Croatia. *P. aroaniensis* is only found in the northernmost region (Ličko sredogorje) (Fig. 1e).

Altitudinal ranges of the four species greatly overlap (Fig. 3). *P. admetus* records range from 235 to 1089 m a.s.l., with most records from between 200 and 400 m a.s.l. The highest record is on Poštak Mountain (1,089 m a.s.l.). The altitudinal ranges for *P. damon* and *P. ripartii* show similar patterns, and extend from 200 to 1,400 m, with a gap in records for altitudes between 400 and 700 m a.s.l. Records of these two species at lower altitudes (200-400 m a.s.l.) are connected with river spring areas (the Zrmanja and Cetina Rivers), and need to be clarified further. Most of the records for *P. ripartii* range from 700 to 1,100 m a.s.l., and for *P. damon* from 700 to 1,400 m a.s.l. Records of *P. aroaniensis* have all been made between 600 and 1,000 m a.s.l., showing preferences for moderate altitudes.

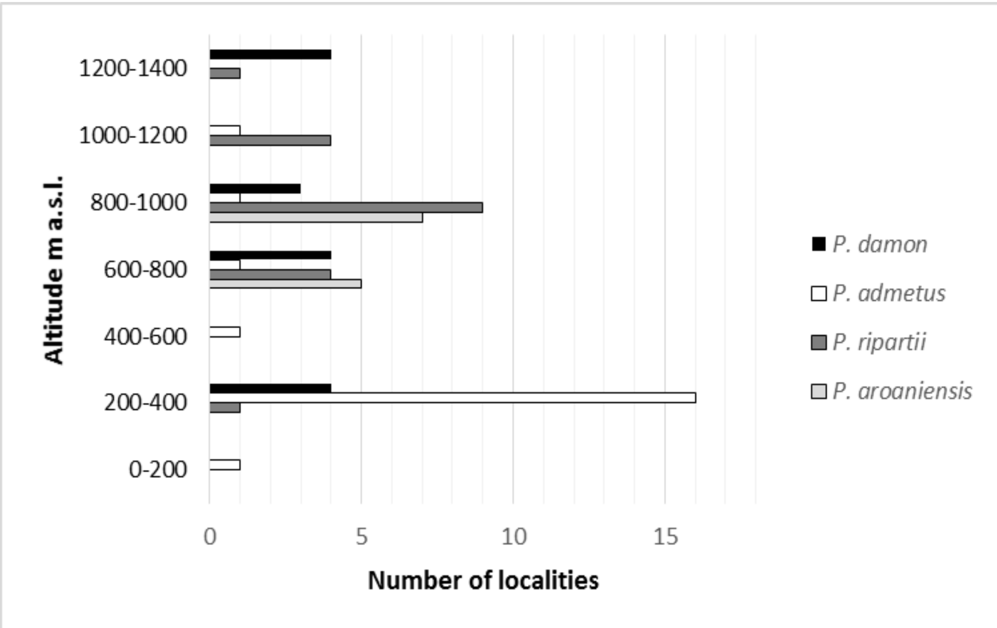

Figure 3. Altitudes at which the four species of the subgenus *Polyommatus* (*Agrodiaetus*) were recorded, including all the literature records and the records presented in this study.
Slika 3. Nadmorske višine, na katerih so bile najdene štiri vrste podrodu *Polyommatus* (*Agrodiaetus*) na Hrvaškem, upoštevajoč vse literaturne podatke in nove podatke iz te raziskave.

As it turns out, all four species are dependent on one habitat type: dry grasslands (Fig. 4a). On all visited localities, these grasslands combine a mixture of European dry heaths and grasslands with mat grass (*Nardus stricta*), sub-Mediterranean and epi-Mediterranean dry grasslands with bushes, rocky pastures on dry grasslands. The only exception is the region of Ličko sredogorje with presence of an additional grassland type of subatlantic mesic grasslands and highland meadows on carbonate soils. The mixture of grasslands types on all localities is always bordered by termophilous oak forests at lower altitudes or with beech forests at higher altitudes. The locality Kozja Draga was the only place where we recorded the larvae host plant of *P. aroaniensis*, *Onobrychis arenaria* (Kit.) DC. (Fig. 4b).

Figure 4. Landscape in Ličko sredogorje, with sub-Mediterranean and epi-Mediterranean dry grasslands with bushes, bordering on thermophilous oak forest (a), and *Onobrychis arenaria* (b), larval host plant of *Polyommatus aroaniensis*, found in Ličko sredogorje (photo: Boris Lauš).

Slika 4. Pokrajina v Ličkem sredogorju, s sub-mediteranskimi in epi-mediteranskimi travniki z grmovjem, ki mejijo na termofilni hrastov gozd (a), ter *Onobrychis arenaria* (b), hranilna rastlina modrina *P. aroaniensis*, zabeležena na območju Ličkega sredogorja (foto: Boris Lauš).

Discussion

According to literature and recent data, *P. admetus* is distributed from the Kamešnica Mountain, following the Cetina spring area, Krka River, Zrmanja spring area and Poštak Mt. in the north of Croatia (Koren 2010a, Koren & Lauš 2013, Koren et al. 2015). Several literature records exist for this species, but during our survey we provided only two new records, which are clustered within the known species distribution (Koren 2010a). The literature record from Kozjak Mt. was not confirmed during our surveys. This species is widely distributed in Dalmatia, but is still local. The altitudinal range indicates that it has an affinity towards lower altitudes, and in most parts of southern Croatia it has indeed been found between 0 and 300 m a.s.l. This may be the reason for the wider distribution of *P. admetus*. Additional records for the species are expected, especially from other micro-localities in the same distribution range.

Historically, *P. damon* was first mentioned for Dalmatia by Mann (1869), but without stating the exact locality. The first recent record is from Mt. Kamešnica (Mihoci et al. 2006) where it was confirmed again, as well as at Troglav Mt. (Koren & Lauš 2013). Also, it was recorded on Poštak Mt. (Koren et al. 2015) and at the spring of the Zrmanja River (Koren et al. 2011). Our new records greatly increase its known distribution toward the north-west. However, the species is also very local in this region, but the butterflies can be locally very common where the habitat is suitable.

The third species, *P. ripartii*, was recorded near the Zrmanja River spring for the first time in Croatia in 2010 (Koren 2010b), and was soon after recorded on the Mts. Troglav, Kamešnica (Koren & Lauš 2013) and Poštak (Koren et al. 2015). Like *P. damon*, the new records from Lika greatly increase its known range of distribution to the north-west.

So far, no records of these species exist from the neighbouring Velebit Mt. (Mihoci et al. 2007), but with our records being fairly close, it is possible that some of these species could be recorded also on the northeastern side of this mountain.

The most surprising record was that of *P. aroaniensis*. The distribution of the species is restricted to the southern Balkans, and includes Bosnia & Herzegovina (Verovnik et al. 2015), Macedonia (Kolev & van der Poorten 1997, Melovski & Božinovska 2014), Bulgaria (Kolev & van der Poorten 1997, Abadjiev & Beshkov 2007), and Greece (Kolev & van der Poorten 1997, Tolman & Lewington 2008, Pamperis 2009). The recently discovered population from Bosnia and Herzegovina is located approximately 270 km to the south-east from the population in Croatia (Verovnik et al. 2015). It is considered to be rare in Bulgaria, reported from several localities in the mountains in the south-western part of the country (Pirin and Slavyanka) and around Sliven (Stara Planina) (Abadjiev & Beshkov 2007). In Greece, it is considered to be widespread but generally local. Up to now it has been recorded from the Phalakron massif, Vernon Mts., Smolikas massif, Timphristos Mt., Parnassos massif, Panakon Mts., Chelmos massif; Menalon Mts. and Taygetos Mts. (Tolman & Lewington 2008).

P. aroaniensis was first recorded in 2014 on several localities, but only a single specimen was collected. In 2015, we continued with the survey and recorded it on 11 new localities, all scattered on the outer edge of Krbavsko polje karst field. The habitat mostly consisted of thermophilous dry calcareous grasslands, partially covered with bushes.

P. aroaniensis usually lacks the white line on the underside of the hind-wings, therefore it can be easily separated from *P. damon* and *P. ripartii*. It also differs from *P. admetus* by the lack of two lines of dots on the edge of the hind-wing underside. Also, *P. admetus* always lacks the white line on the outer side of the hind-wings. As *P. aroaninensis* flies syntopic with *P. damon* and *P. ripartii*, careful examination of the specimens is needed in order to distinguish them. But even this could prove to be not 100% correct, and further studies on the differences in the genetics between these species would be needed.

Our records from Croatia represent the northwestern distribution limit of *P. aroaniensis* in Europe, with the closest known populations recorded from Gacko, in Bosnia & Herzegovina (Verovnik et al. 2015) and Macedonia (Kolev & van der Poorten 1997, Melovski & Bozhinovsk 2014).

With the recent discoveries of this species in Bosnia & Herzegovina and Macedonia, the range of *P. aroaniensis* in Europe has been greatly expanded in the last few years. As with other species of the subgenus *Polyommatus* (*Agrodiaetus*) mentioned in this paper, their distribution in Croatia was discovered only in the last decade. *P. aroaniensis* flies in a single generation from July to August (Tolman & Lewington 2008). Its larval host plant is exclusively *Onobrychis arenaria* (Kit.) DC. (Tolman & Lewington 2008), which was recorded on this locality.

It seems that, at least in Croatia, *P. aroaniensis* and *P. admetus* could be mutually exclusive, as these two species do not occur together. On the other hand, *P. damon* and *P. admetus* usually share many localities with either of the two species.

In the recent overview of Croatian butterflies, 195 species were recorded (Šašić & Mihoci 2011). However, *Hipparchia senthes* (Fruhstorfer 1908) was excluded from the list as it was based on an erroneous record (Koren et al. 2013a), while two additional species were recorded: *Pyrgus malvoides* (Elwes & Edwards, 1897) (Koren et al. 2013b) and *Melitaea ornata* (Christoph, 1893) (Koren & Štih 2013). Since no previous records of *P. aroaniensis* existed for Croatia, we add it as the 197th species on the butterfly list of Croatia.

Our surveys during the recent years greatly increased the knowledge about the distribution of species from the subgenus *Polyommatus* (*Agrodiaetus*) in Croatia. However, nothing about their ecology, conservation status and phylogenetics is known. Many of these species were described in the last few decades (e.g. Brown 1976, Coutsis & De Prins 2005) and their species status is mostly confirmed (Vila et al. 2010), but a genetic study of the newly recorded populations from Croatia would be necessary for taxonomical as well as conservation purposes.

Povzetek

Doslej so bile na Hrvaškem zabeležene tri vrste metuljev, ki pripadajo podrodu *Polyommatus* (*Agrodiaetus*): *P. damon*, *P.admetus* in *P. ripartii*. Vse tri so zelo lokalno razširjene v južnem delu države, predvsem v Dalmaciji, dalmatinski Zagori in južni Liki. V letih 2014 in 2015 smo raziskali južni del Hrvaške z namenom zbrati dodatne lokacije metuljev teh vrst. *Polyommatus admetus*, *P. damon* in *P. ripartii* smo našli na več novih lokalitetah in s tem slednjima dvema razširili prej znano območje razširjenosti. Poleg teh treh smo prvič na območju Hrvaške zabeležili še vrsto *P. aroaniensis*, doslej znano le iz južnega dela Bosne in Hercegovine. Naše najdbe ponazarjajo novo severozahodno mejo razširjenosti te vrste, tako da se je z njenim odkritjem število dnevnih metuljev na Hrvaškem povečalo na 197.

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Found after 60 years: the hows and whys of *Sphaeromides virei montenigrina* (Crustacea: Isopoda: Cirolanidae) rediscovery in Obodska pećina, Montenegro

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Abstract. Despite being the biggest isopod crustacean in Dinarides, little is known about the genus *Sphaeromides* and its taxonomical status. *Sphaeromides virei montenigrina*, one of the three subspecies, has been known only thanks to a female specimen found and described in the late 1950s. Despite the intensive search, almost 60 years were needed to discover additional specimens in the cave Obodska pećina, Montenegro. In this study we present a review of the possible reasons for this long lasting search.

Key words: Dinarides, *Sphaeromides virei*, *montenigrina*, stygobiont, Obodska pećina, Rijeka Crnojevića

Izvleček. Najden po 60 letih: razlogi za ponovno odkritje *Sphaeromides virei montenigrina* (Crustacea: Isopoda: Cirolanidae) v Obodski pećini v Črni gori – Čeprav so predstavniki rodu *Sphaeromides* največji podzemni raki enakonožci Dinarskega krasa, je o rodu le malo znanega, taksonomski status pa je še nedodelan. *Sphaeromides virei montenigrina*, eno od treh podvrst, ki je bila opisana v 50-ih letih prejšnjega stoletja, smo donedavna poznali le po samici, najdeni septembra 1956. Kljub pogostemu vzorčenju je bilo potrebnih skoraj 60 let, da je bilo odkritih nekaj dodatnih osebkov v jami Obodska pećina v Črni gori. V prispevku obravnavamo morebitne razloge za to.

Ključne besede: Dinaridi, *Sphaeromides virei*, *montenigrina*, stigobiont, Obodska pećina, Rijeka Crnojevića

Introduction

The biggest isopod crustacean living in the subterranean habitats of Dinaric karst is the well over 20 mm long and supposedly predatory *Sphaeromides virei* (Brian, 1923). This stygobiont, permanent resident of subterranean aquatic habitats, is known from more than 50 karst caves and springs connected to phreatic waters all along the Dinaric karst, from the extreme northeast of Italy to southern Montenegro (Sket 1964, own data). Beside the species from the Dinarides, several congeners have been recognized in different parts of southern

Europe – southern France and Stara planina in Bulgaria and eastern Serbia (Sket 2012). Range fragmentation of the genus is traditionally explained by historical events, i.e. the retreat of the Tethys Sea, and the genus itself is perceived to be a »Tethyan relict« without known marine ancestors (Baratti et al. 2010a).

Three subspecies have been recognized within the Dinaric species *S. virei*: *S. v. virei* (Brian, 1923), *S. v. montenigrina* Sket, 1957 and *S. v. mediodalmatina* Sket, 1964. While the type subspecies is found in caves in a belt along the northeastern coast of the Adriatic Sea, both latter subspecies are found within Montenegrin and Dalmatian mainland and inland, respectively (Sket 1964). Lately, specimens of *S. v. virei* and *S. v. mediodalmatina* were found living in syntopy in a spring cave Karišnica near Zadar, a fact raising questions about their taxonomic status (Sket 2012). The species status of both taxa was additionally supported by high molecular distances on cytochrome oxidase subunit I and 16S rRNA gene phylogenetic trees (Baratti et al. 2010b).

Contrary to both northern subspecies, *S. v. montenigrina* has been known only from the type locality, Obodska pećina in Montenegro (Sket 1957, Sket 1964, Sket 2012). Moreover, it is known from a single female specimen caught by the late Egon Pretner in September 1956, in a residual pool. In the ensuing year, it was described by Sket (1957), who reported on the repetitive unsuccessful searches for additional specimens few years later (Sket 1964). Despite regular visits and sampling – Sket visited the cave about ten times, while a couple of his colleagues visited it less often, all mainly in favourable hydrological conditions – no specimen was collected until this spring. Meanwhile, several malacostracan species were found (Culver et al. 2004), even one new species (Fišer et al. 2006), but not a single specimen of *Sphaeromides*.

In the light of a recent finding, this paper presents information on rediscovery of this elusive and mystic subspecies, and possible explanations for its almost 60 years long unsuccessful sampling.

Material and methods

Rijeka Crnojevića catchment, including Obodska pećina (42.351987 N, 19.004982 E) (Figs. 1, 2), is situated in southwestern Montenegro, at the southeastern part of the Dinaric karst. Owing to the intensive karstification by the end of Pliocene, 2.58 mya, there are no major surface watercourses in the area (Bonacci & Živaljić 1993). These activate only after a heavy rainfall or intensive snow melting. Largely disintegrated fluviokarst, present in the valley, is a remnant of the historical river Cetinjska Rijeka that flowed from Ivanova korita to Cetinjsko polje and across Dobrsko selo to Rijeka Crnojevića (Radulović 1989). Pliocene tectonic movements at the boundary of Cetinjsko polje interrupted hydrographic connections between the upper and lower parts of the river catchments, forcing the water to form exclusively underground water flow networks. Consequently, the main spring in the Obodska pećina is at 60 m a.s.l., while the permanent springs are situated along the river bed, below the level of the cave entrance. Although the entrance parts of the cave are mostly dry throughout the year, its maximum water discharge reaches up to 280 m^3s^{-1} (Bonacci & Živaljić 1993).

Figure 1. Entrance of Obodska pećina viewed from inside-out (photo: Primož Presetnik).
Slika 1. Vhod v Obodsko pećino, fotografiran iz notranjosti (foto: Primož Presetnik).

The cave entrance is a 12×14 m opening (Bonacci 1987) formed in Mesozoic stratified limestones and dolomites (Živaljević et al. 1971). The main gallery with dimensions reaching up to 35 m in diameter is oriented southwest and was partly formed by the water flow. The bottom of the gallery is covered by monumental limestone blocks, rock pebbles and sand as a result of ceiling breakdowns and water discharge, respectively (Fig. 1). In the dry season, the main gallery ends with a lake, 50 m long and 20 m wide. The lake ends with a siphon, leading to another cave gallery and further to unexplored submerged passages, approximately 340 m from the cave entrance (Ferk 2008).

In the time of our (T.D.) visit on 1. 5. 2015, the water level was slightly raised and the water discharge was high due to the heavy spring rainfall. The water in the terminal lake was muddy and the visibility was approximately 1 m. Since just a small portion of the lake could be checked from the rocks on the shore, we decided to try with snorkelling. Visual inspection started upstream along the right lake bank, continued to the siphon, and finished downstream along the left lake bank. The sampling was carried out with the permission No. UPI-341/6 given by the Montenegrin authorities.

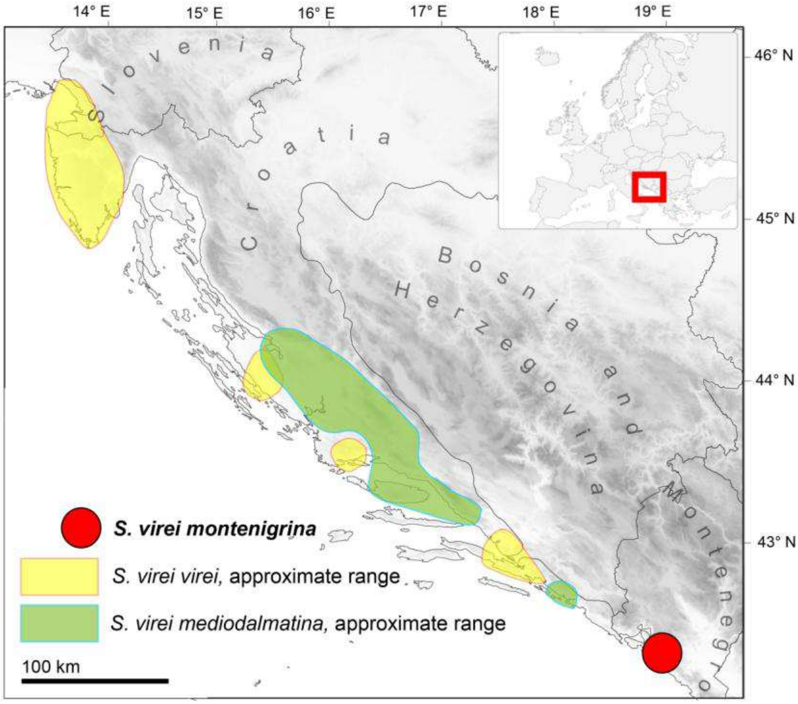

Figure 2. Approximate distribution ranges of the three *Sphaeromides virei* subspecies based on all known sites (Sket 1964, Sket, unpublished data) .
Slika 2. Približna razširjenost treh podvrst *Sphaeromides virei* na podlagi vseh znanih nahajališč (Sket 1964, Sket, neobjavljeni podatki).

Results and discussion

After almost 60 years, three specimens of *S. v. montenigrina* were found in the underground lake in Obodska Pećina, the only known locality of the subspecies (Figs. 1, 2). One specimen was found above the lake's inflow siphon, while the other two were collected close to the lake outflow siphon, within 25 cm distance. The specimens: i) 17 mm male, ii) 11 mm juvenile and iii) 10 mm juvenile, were immediately preserved in 70 % EtOH (specimens i and ii) and 96 % EtOH (specimen iii) and labelled. Specimens i and ii were used for morphological identification and possible male description, while the third specimen will be used to infer molecular relations within the genus *Sphaeromides* (see morphologically similar subspecies in Fig. 3). All the specimens are deposited in the Zoological Collection of the Biology Department, Biotechnical Faculty, University of Ljubljana, Slovenia.

Figure 3. *Sphaeromides virei mediodalmatina* from the river Ruda spring in southern Croatia (photo: T. Delić).
Slika 3. *Sphaeromides virei mediodalmatina* iz izvira reke Rude na jugu Hrvaške (foto: T. Delić).

There are several assumptions that could throw light on why this subspecies was found never again after 1956. We present only the most plausible ones. First, a (sub)population of *Sphaeromides* from Obodska pećina could live at the edge of the (sub)species range. Such marginal (sub)populations often exhibit sub-optimal habitats (according to suitability) and consequently, they often occur at low abundance and are more sensitive to habitat changes (Hanski 2012). According to Cukrov and Ozimec (2014), the nearest *S. v.* cf *montenigrina* population should be present in the cave system Vilina špilja – izvor Omble near Dubrovnik (Croatia). Subsequent identification of those specimens as *S. v. mediodalmatina* (not published) left Obodska pećina as the only known locality for *S. v. montenigrina*. That, however, doesn't exclude the possibility of more stable subspecies populations existing at yet unknown or inaccessible places.

Second, high water levels that are usually connected with lower visibility could also be a reason for repeated unsuccessful sampling. Although silty sediments are generally missing in Obodska pećina (Ferk 2008), visibility is reduced due to higher concentration of organic and inorganic matter in the water current. In the periods of high precipitation, the cave lake turns into a muddy river (Ferk 2008), which implies that a good time for sampling is only during the low-water periods. Low water and a small stream running through the cave were present also during the first discovery of the subspecies (Pretner, pers. comm.).

Obviously connected to the second is the third explanation considering an inappropriate sampling method. As mentioned, a dipnet sampling from the bank is possible only in a small portion of the lake, and only when the water is low and transparent. Therefore, cave diving, snorkelling or the deployment of baited traps seem to be more efficient methods. While only professionals are capable of safe cave diving or snorkelling, anyone can set the baited traps.

Fourth, the most discouraging reason is the devastating human impact on nature of the Rijeka Crnojevića catchment. The catchment area, variable at different spatial and temporal scales, covers only 76 km^2 of mostly Mesozoic limestones (Bonacci 1987, Bonacci and Živaljić 1993). It is the particularly threatened by the largest urban area within the catchment, the city of Cetinje. Urban and industrial development of the town in the 20th century wasn't followed by effective measures to protect and conserve the environment. The resulting aftereffect is a possible harmful impact of communal and industrial waste water from urban areas on the natural resources (Radulović 2012). According to Tomović (2008), up to 60% of wastewater is discharged into sewers in Montenegro. Inappropriate management of wastewater and general lack of strategic development in karst areas are not the only issues affecting these fragile ecosystems. Changing of hydrographic conditions, the epigean or the subterranean (hypogean) ones, can also have a negative impact. As an illustrative example, nature of Cetinjsko polje was altered by construction of a reservoir after the extreme floods in 1986. After these, precipitation accumulation in the polje was changed (Radulović 2012), affecting the interconnection between the upper and lower catchment areas. So far, there has been no report on changes in the water regime in Obodska pećina, but we cannot completely exclude its possible effects.

Despite numerous visits, the remarkable size of the subspecies and occasional findings of other crustacean species, no less than 60 years were needed to rediscover the *Sphaeromides* population in Obodska pećina. This and similar findings throughout the Dinaric karst demonstrate that the high frequency of cave visits is an important, yet not sufficient prerequisite for the (successful) exploration of subterranean biodiversity. Additionally, usage of diverse sampling techniques, together with taking into account local climate and effects of altered land use, can bring new insights into the world's hottest subterranean point – the Dinaric karst.

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Faunistic results from the 2nd Balkan OdonatOlogical Meeting – BOOM 2012, Serbia

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Abstract. As a part of the Balkan odonatological cooperation, the 2nd Balkan OdonatOlogical Meeting (BOOM 2012) was held in Vojvodina (Serbia). Altogether, between 7. and 12. 8. 2012, 24 localities were surveyed and 34 dragonfly species found. This represents more than half of the hitherto recorded dragonfly species for the country. Significant results include the second record and a new locality of *Aeshna grandis* for Serbia and the first confirmation of successful reproduction of *Anax ephippiger* in the country. New data on several species with a comparably low number of previously published records for Vojvodina, i.e. *Somatochlora meridionalis*, *Cordulia aenea*, *Gomphus flavipes*, *Sympetrum flaveolum*, *Sympetrum vulgatum* and *Lestes dryas*, is also presented and briefly discussed.

Key words: dragonflies, Odonata, distribution, Vojvodina, Serbia, the Balkans

Izvleček. Favnistični rezultati 2. Mednarodnega srečanja odonatologov Balkana – BOOM 2012, Srbija – Kot del širšega balkanskega odonatološkega sodelovanja je bilo v Vojvodini (Srbija) organizirano 2. Mednarodno srečanje odonatologov Balkana (BOOM 2012). Na pregledanih 24 lokalitetah je bilo med 7. in 12. 8. 2012 popisanih 34 vrst kačjih pastirjev, kar je več kot polovica vseh znanih vrst kačjih pastirjev Srbije. Pomembnejši rezultati vključujejo drugo nahajališče rjave deve (*Aeshna grandis*) in prvo potrditev uspešnega razmnoževanja afriškega minljivca (*Anax ephippiger*) za državo. Poročamo tudi o novih nahajališčih v Vojvodini redkih vrst kačjih pastirjev. Ti so: sredozemski lesketnik (*Somatochlora meridionalis*), močvirski lebduh (*Cordulia aenea*), rumeni porečnik (*Gomphus flavipes*), rumeni in navadni kamenjak (*Sympetrum flaveolum*, *Sympetrum vulgatum*) in obrežna zverca (*Lestes dryas*).

Ključne besede: kačji pastirji, Odonata, razširjenost, Vojvodina, Srbija, Balkan

Introduction

The dragonfly fauna of Serbia is not sufficiently known in comparison to central and western European countries. Although numerous papers with dragonfly records from the country have been published over the past decade, most of them include only a small number of records or cover only a small portion of this central country of the Balkan Peninsula. For Serbia, Jović (2013) gives a checklist of 67 dragonfly species, although 4 of them are listed with specific remarks.

Becoming a tradition, the 2nd Balkan OdonatOlogical Meeting (BOOM 2012) was organized between 6. and 13. 8. 2012 by the Biology and Ecology Students' Scientific Research Association Josif Pančić (Novi Sad, Serbia) and the Slovene Dragonfly Society (Ljubljana, Slovenia) in the beginning of August 2012 in Serbia – more precisely, mostly in its northern province of Vojvodina. The main concept of BOOM is to gather young odonatologists each year in a different Balkan country. With fieldwork in the focus, BOOM gives the opportunity of gaining experience in dragonfly identification, and to gather new data on dragonfly distribution in selected areas (Vinko 2011a).

One of the main goals of BOOM 2012 was to collect new data on the distribution of dragonfly species in different parts of the Pannonian plain in the northern Serbian province of Vojvodina, including the »Zasavica« Special Nature Reserve, which is partly situated in the southeast of the province. For the territory of the Vojvodina region, Santovac (2007) listed 51 dragonfly species, while an additional 5 were reported by Jović et al. (2007, 2009). For the »Zasavica« Special Nature Reserve, a total of 39 dragonfly species have been reported (Jović et al. 2007, Aranđelović & Miljanović 2009, Rajkov & Šćiban 2012).

Materials and methods

During BOOM 2012 dragonflies and damselflies were surveyed between 7. and 12. 8. 2012, mostly from 9 am to 6 pm. The weather during the survey period was sunny, sometimes with high noon temperatures up to at least 33°C. In general, the weather was very favourable for odonates, and mostly without rain or wind.

At all sites, we searched for adult and teneral individuals, as well as exuviae. Adult and teneral individuals were identified on site, without collecting samples. All obtained records were compiled into species lists after each locality visit. No specific sampling for larvae was done. Dijkstra (2006) field guide was used for identification of adults, while exuviae and larvae were identified with the aid of Gerken & Sternberg (1999) and Kohl (1998).

Results and discussion

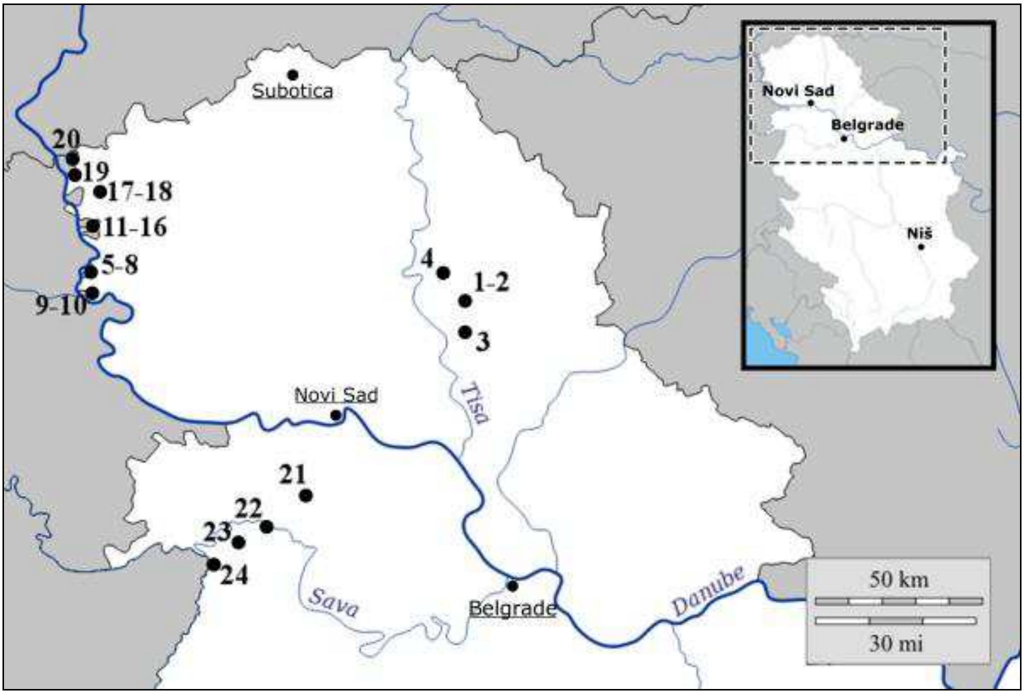
Altogether, 185 records of 34 species from 24 localities were collected (Tab. 1, Fig. 1). The list of recorded species with the locality data is presented in Tab. 2, while habitat type for each locality is presented in Tab. 1.

Table 1. List of the localities investigated during the 2nd Balkan OdonatOlogical Meeting (BOOM 2012). For each locality, geographical coordinates and survey dates are given. For localities 11–16, only approximate coordinates are given.
Tabela 1. Seznam preučevanih lokalitet v okviru 2. Mednarodnega srečanja odonatologov Balkana (BOOM 2012). Za vsako lokaliteto sta dodana zapis geografskega položaja in datum preučevanja. Za lokalitete 11–16 je podan le približen geografski položaj.

N	Locality name	Coordinates (WGS84) [Lat., Long.]	Alt. [m]	Date	Habitat type
INLAND SALT MARSHES OF CENTRAL BANAT					
1.	Melenci, Velika Rusanda lake	45.528878°, 20.298627°	72	7.8.2012	Larger part of Rusanda salt lake, 0.5–1.5 m deep, mostly *Phragmites australis* along the shore
2.	Melenci, Mala Rusanda lake	45.513139°, 20.294841°	71	7.8.2012	Smaller part of Rusanda salt lake, with *Bolboschoenus maritimus*
3.	Elemir, Okanj bara	45.465313°, 20.294337°	72	7.8.2012	Salt lake – large (total surface: 1.5 km^2) elongated and shallow (average depth: 1–1.5 m), partly overgrown with *P. australis* and *B. maritimus*
4.	Novi Bečej, »Slano kopovo« Special Nature Reserve	45.616852°, 20.211287°	73	8.8.2012	Shallow, open salt lake, with *B. maritimus* and *P. australis* belts along the shore
»GORNJE PODUNAVLJE« SPECIAL NATURE RESERVE – APATINSKI RIT (APATIN MARSH)					
5.	Apatin, Zverinjak	45.628677°, 18.953118°	82	9.8.2012	Shallow, sunny pool with free water surface and patches of *Schoenoplectus* sp.
6.	Apatin, Petreš	45.613088°, 18.934626°	82	9.8.2012	Wide, shallow channel with floating mats of *Trapa natans*
7.	Apatin, Zverinjak, 4 km from the beginning	45.607529°, 18.945321°	79	9.8.2012	Shallow, sunny pools covered with *Nymphoides peltata* and *Carex* sp. along the shore
8.	Apatin, Osmica	45.590610°, 18.918144°	81	9.8.2012	Larger, deeper marsh, with *Carex* sp. and willow trees along the shore; water surface covered with *T. natans* and *N. peltata*
9.	Apatin, »Bestrement«	45.562617°, 18.954058°	82	9.8.2012	Large (about 1 km long) shallow marsh, overgrown with *P. australis*
10.	Apatin, Srebrenica	45.552262°, 18.942327°	83	9.8.2012	Oxbow, with steep bare banks, partly shaded by forest
»GORNJE PODUNAVLJE« SPECIAL NATURE RESERVE – MONOŠTORSKI RIT (MONOŠTOR MARSH)					
11.	Kupusina, Šargan, oxbow	45.728130°, 18.930281°	83	10.8.2012	Shallow unshaded oxbow at the edge of forest, with dense vegetation
12.	Kupusina, Jama, oxbow	45.728130°, 18.930281°	83	10.8.2012	Shallow unshaded oxbow at the edge of forest, with dense vegetation
13.	Kupusina, road to oxbow	45.728130°, 18.930281°	83	10.8.2012	Tarmac road
14.	Kupusina, oxbow	45.728130°, 18.930281°	83	10.8.2012	Deep oxbow, with steep and mostly bare banks and some *P. australis*, partly shaded by forest
15.	Kupusina, oxbow at the Danube river	45.728130°, 18.930281°	83	10.8.2012	Shallow oxbow at the edge of forest along the Danube
16.	Bar »Smuđ«	45.728130°, 18.930281°	83	10.8.2012	Building, bar near the river shore

N	Locality name	Coordinates (WGS84) [Lat., Long.]	Alt. [m]	Date	Habitat type
17.	Bezdan, Plazovići, channel, near the bridge	45.813385°, 18.966709°	88	10.8.2012	Small channel with dense submerged vegetation
18.	Bezdan, Štrbac, large seasonal pond	45.819587°, 18.961205°	82	10.8.2012	Large seasonal pond, overgrown with *Carex* sp., dry at the time of visit
19.	Kotur, Bajski kanal, channel	45.894364°, 18.869875°	84	10.8.2012	Large channel with open water surface and *P. australis* along the shores
20.	Bezdan, Baračka channel	45.858963°, 18.874152°	81	10.8.2012	Channel, covered with *Nymphaea alba* and *Nuphar luteum*
FRUŠKA GORA					
21.	Stejanovci, stream	45.047226°, 19.719589°	109	11.8.2012	Open stream, running through agricultural land
»ZASAVICA« SPECIAL NATURE RESERVE					
22.	Modran, Zasavica River	44.966938°, 19.577427°	74	12.8.2012	Channel with *Stratiotes aloides*
23.	Batar, small river	44.927591°, 19.473615°	77	12.8.2012	River, partly dry at the time of visit
DRINA RIVER					
24.	Crna Bara, gravel pits near Drina River	44.863285°, 19.379865°	77	12.8.2012	Gravel pits of various depths and in different succession stadiums

Figure 1. Geographical position of localities investigated during the 2nd Balkan OdonatOlogical Meeting (BOOM 2012).
Slika 1. Geografski položaj lokalitet, preučevanih v okviru 2. Mednarodnega srečanja odonatologov Balkana (BOOM 2012).



During the six-day survey, the number of observed species comprised more than half of all known dragonfly species in the country.

Previous BOOM, organized in Slovenia in 2011, has set the expected results pretty high, with a clear concept to comprehensively show the odonate diversity of the region at all altitudes, and a total of 50 recorded dragonfly species (Vinko 2011b). On the other hand, a late summer, the only lowland approach for BOOM 2012 chosen in Serbia, together with an extremely dry year, resulted in a more modest total number of recorded species – 34 (Tab. 2).

Table 2. Checklist of Odonata species recorded during the 2nd Balkan OdonatolOgical Meeting (BOOM 2012). References for localities, where each species was observed, are given (see Tab. 1).

Tabela 2. Seznam vrst kačjih pastirjev, najdenih v okviru 2. Mednarodnega srečanja odonatologov Balkana (BOOM 2012). Zapisu vrste je dodan seznam lokalitet, na katerih je bila vrsta najdena (glej Tab. 1).

	Species	**Locality numbers**
	CALOPTERYGIDAE	
1.	*Calopteryx splendens* (Harris, 1782)	21
	LESTIDAE	
2.	*Lestes barbarus* (Fabricius, 1798)	1–4, 9, 18
3.	*Lestes dryas* Kirby, 1890	1, 4, 12
4.	*Chalcolestes parvidens* (Artobolevskii, 1929)	4, 9, 14, 20, 23
5.	*Lestes virens* (Charpentier, 1825)	1, 4
6.	*Sympecma fusca* (Vander Linden, 1820)	10, 11, 18
	COENAGRIONIDAE	
7.	*Ischnura elegans* (Vander Linden, 1820)	1–8, 11, 12, 14, 17, 19, 20–24
8.	*Ischnura pumilio* (Charpentier, 1825)	3, 4, 11
9.	*Enallagma cyathigerum* Charpentier, 1840	1–4
10.	*Coenagrion puella* (Linnaeus, 1758)	11
11.	*Erythromma viridulum* (Charpentier, 1840)	8, 11, 12, 14, 17, 19, 20, 22, 24
	PLATYCNEMIDIDAE	
12.	*Platycnemis pennipes* (Pallas, 1771)	1, 11, 19, 20, 24
	AESHNIDAE	
13.	*Aeshna affinis* Vander Linden, 1820	2, 4, 5, 8, 9, 11, 12, 14, 23, 24
14.	*Aeshna grandis* (Linnaeus, 1758)	14
15.	*Aeshna isoceles* (Müller, 1767)	3
16.	*Aeshna mixta* Latreille, 1805	12, 22
17.	*Anax ephippiger* (Burmeister, 1839)	7, 12
18.	*Anax imperator* Leach, 1815	2, 5–7, 11, 12, 19, 24
19.	*Anax parthenope* (Selys, 1839)	2, 3, 6, 8, 11, 12, 19, 20, 24
	GOMPHIDAE	
20.	*Gomphus flavipes* (Charpentier, 1825)	4, 8, 15
	CORDULIIDAE	
21.	*Cordulia aenea* (Linnaeus, 1758)	15 (larva)
22.	*Somatochlora meridionalis* Nielsen, 1935	10
	LIBELLULIDAE	
23.	*Libellula fulva* (Müller, 1764)	22
24.	*Orthetrum albistylum* (Selys, 1848)	1, 3, 5–8, 11–13, 17–19, 24
25.	*Orthetrum brunneum* (Fonscolombe, 1837)	24
26.	*Orthetrum cancellatum* (Linnaeus, 1758)	1, 3, 4, 15, 17–20, 24
27.	*Orthetrum coerulescens* (Fabricius, 1798)	21
28.	*Sympetrum sanguineum* (Müller, 1764)	1, 4–9, 11, 12, 14, 17–20, 22–24
29.	*Sympetrum fonscolombii* (Selys, 1840)	1, 3, 4, 7, 8, 18, 23, 24
30.	*Sympetrum meridionale* (Selys, 1841)	1–10, 12, 14, 18, 24
31.	*Sympetrum vulgatum* (Linnaeus, 1758)	13, 19, 20, 24
32.	*Sympetrum striolatum* (Charpentier, 1840)	10, 16, 17, 19
33.	*Sympetrum flaveolum* (Linnaeus, 1758)	1, 3
34.	*Crocothemis erythraea* (Brullé, 1832)	1, 2, 6, 7, 8, 11, 12, 17–20, 22, 24

The commonest species were *Ischnura elegans* and *Sympetrum sanguineum*, both found at 17 localities (71% of all investigated localities). *Sympetrum meridionale* was found at 14 localities (58% of all investigated localities) and *Crocothemis erythraea* and *Orthetrum albistylum* at 13 (54% of all investigated localities). Nine species, i.e. *Calopteryx splendens*, *Coenagrion puella*, *Aeshna grandis*, *Aeshna isoceles*, *Cordulia aenea*, *Somatochlora meridionalis*, *Libellula fulva*, *Orthetrum brunneum* and *Orthetrum coerulescens*, were observed at only one of the sites. Even though no specific sampling for larvae was done, one larva of *Cordulia aenea* was identified using 10× hand magnifying glass with the identification keys on a single site (L 15).

With 13 species recorded for the Slano kopovo Special Nature Reserve (L 4), results of this study present the first known published data on dragonfly fauna for this area. Prior to this study, Svetozar Santovac (pers. comm.) recorded 9 dragonfly species from Slano kopovo, but these records were published under a much wider locality of Novi Bečej (Santovac 2007). Altogether, the dragonfly fauna of Slano kopovo comprises 19 species.

The records collected for the »Gornje Podunavlje« Special Nature Reserve are especially significant as they represent the very first data on dragonfly fauna of this area after a period of more than 60 years without systematic research. Main references for nearby Apatin date back to the 1940s (Pongracz 1944, Adamović 1949; cited in Santovac 2007). Moreover, the two very significant findings within the meeting were made in this Reserve. Firstly, there is the observation of several teneral individuals of *Anax ephippiger* (Fig. 2) at shallow pools along the embankment at Zverinjak locality (L 7). This is the first confirmation of the species' successful reproduction in Serbia. Swarms of *A. ephippiger* have been observed and documented in the country on only two occasions (Jović et al. 2009), although they have been reported more often from Hungary (Dijsktra 2006), with reproduction also confirmed (Ambrus et al. 1996a). Secondly, there is the observation of two adult individuals of *Aeshna grandis*, which is the second finding of this species in Serbia and the first record for Vojvodina province. Its presence in Serbia has only recently been discovered – in 2009, at a locality near the Drina River, south of Zasavica (Jović et al. 2010). The nearest known localities in the Pannonian basin are along the Drava River in Hungary (Toth 2001) and in Podravina, Croatia, with records becoming more frequent further west towards Slovenia (Jović et al. 2010). In Hungary, *A. grandis* has otherwise been recorded only in the west, near the Slovenian border (Ambrus et al. 1992) and in the far northwest of the country, near the Austrian-Slovakian border (Ambrus et al. 1992, 1996b, Dijsktra 2006).

Figure 2. Sighting of fresh *Anax ephippiger* confirms successful reproduction of this species in Serbia (photo: M. Vrhovnik).
Slika 2. Najdba svežih osebkov afriškega minljivca (*Anax ephippiger*) potrjuje uspešno razmnoževanje te vrste v Srbiji (foto: M. Vrhovnik).

Somatochlora meridionalis is another species new for the fauna of Gornje Podunavlje. Although it typically breeds in running waters (Dijkstra 2006), a single male specimen was found patrolling along a channel with completely stagnant water (L 10). Other characteristics of the water body (partly shaded, devoid of aquatic vegetation, muddy bottom) seem to match the requirements of *S. meridionalis*. In Vojvodina, the species had previously been reported only from Zasavica (Jović et al. 2007, Rajkov & Šćiban 2012). The species has also been recorded along the edges of the Pannonian basin in Croatia (Perović & Perović 2007, Štih et al. 2011, Grgić 2013), Hungary (Ambrus et al. 1992, Wildermuth 2008), Slovenia (Kotarac 1997), Austria (Höttinger 2008), Slovakia (Dijkstra 2006) and Romania (Manci 2012).

The record of *Sympetrum flaveolum* at Okanj bara (L 3) is the third known site for the species in Vojvodina province (Santovac 2007, Santovac & Anđus 1995–98 cited in Santovac 2007), with all three closely located in Central Banat. One of the two previously published records for locality Belo Blato remains questionable – it is only listed in Santovac (2007), but not in the original cited source, Santovac & Anđus (1995–98). A review of the material in the collections could help resolve this issue.

Gomphus flavipes, a species from Annex IV of the Habitats Directive, has been recorded at new sites along the Danube River (L 8, L 15), and these records are the first for the »Gornje Podunavlje« Reserve. *G. flavipes* is nationally protected in Serbia, but is rather common along the Danube, Sava and Tisa Rivers (Adamović 1949, Anđus 1992, Santovac 2007, Rajkov & Šćiban 2012, Đurđević & Rajkov 2012). The species is included in Annex IV of the Habitats

Directive, but is no longer considered threatened in Europe, with the populations increasing (Kalkman et al. 2010).

For several more species with a comparably low number of previously published records for Vojvodina province – *Lestes dryas*, *Cordulia aenea* and *Sympetrum vulgatum* – new localities have been discovered. *Sympetrum vulgatum* is also considered rare in Serbia (Jović et al. 2009).

During the survey, a special effort was given to confirm the presence of two enigmatic species, *Aeshna viridis* and *Lestes macrostigma*, for which reliable recent records are lacking.

A. viridis was reported from Vojvodina (Hajdukovo, near Subotica) by Gergelji & Hulo (1995). The same record was also listed by Santovac (2007), and again by Jović (2013) as the only one for Serbia, with a comment that revision of voucher specimens was not possible. Having in mind that there are no known suitable habitats for *A. viridis* in the wider area of the locality – stangant waters covered with mats of water soldier (*Stratiotes aloides*) (Vukov et al. 2004) – the record can be considered questionable.

Efforts made to find *A. viridis* within the meeting proved unsuccessful. Two localities were visited as plausible candidates for either the presence of this dragonfly or the associated plant, *S. aloides*. A small part of Baračka channel at »Gornje Podunavlje« Special Nature Reserve (L 20) was examined for the presence of *S. aloides.* An earlier record of submerged populations of *S. aloides* nearby is the only recent data for the entire Reserve (Vukov et al. 2004), so this gave hope that there are some suitable habitats for *A. viridis.* Unfortunately, the part of the channel at the locality seems to be mostly covered by *Nymphaea alba* and *Nuphar luteum* – no *S. aloides* has been observed. On the other hand, the visit to the Zasavica River (L 22) resulted in finding only one exuvia of another *Aeshna* species, *A. mixta*, in spite the presence of strong populations of *S. aloides*, covering most of the water surface at the locality. It must, though, be pointed out that the recent clear cutting of shrubs and trees along the banks, together with hot and sunny weather at the time of visit, could have had a negative effect on the presence and activity of *A. viridis* adults.

For *L. macrostigma*, the published records from the Pannonian part of Serbia are also very scarce (Adamović 1949, Gergelji & Hulo 1995), while a museum specimen exists only for the record by Adamović (1949) from the vicinity of Belgrade. Even though the flight period of the species was over, we tried to assess the suitability of habitats for *L. macrostigma* available at salt lakes Mala Rusanda, Slano kopovo and Okanj bara (L 2–4). The vegetation suitable for oviposition – *Bolboschoenus maritimus* (Dijkstra 2006) – is present at these localities. Furthermore, there are recent records of *L. macrostigma* for Okanj bara and Mala Rusanda lakes, made by Provincial Institute for Nature Conservation, Novi Sad (Nataša Pil, pers. comm.), that are still awaiting verification and present good enough grounds for future investigations.

In total, the faunistic results of BOOM 2012 present a significant improvement in the knowledge of the dragonfly fauna in Vojvodina (Serbia), and confirm the importance of the meeting as part of odonatological research in the Balkans.

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SHORT COMMUNICATION

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First records of European free-tailed bat *Tadarida teniotis* Rafinesque, 1818 (Chiroptera: Molossidae) in Friuli Venezia Giulia region in NE Italy

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Abstract. The European free-tailed bat *Tadarida teniotis* is distributed mainly in the southern part of Europe, with gaps in the currently known distribution range. During the 2014 bat detector survey in Friuli Venezia Giulia in Italy, the species was recorded for the first time in the region. It was observed at three sites in Laghetti delle Noghere Nature Reserve (ca. 600 m from the border with Slovenia), where it was also feeding, and at a site near the border with the Veneto region. With these observations, the number of all recorded bat species in Friuli Venezia Giulia increased to 30. It remains to be answered with further studies, whether *T. teniotis* is a regular part of the regional fauna or an occasional vagrant only.

Key words: Chiroptera, *Tadarida teniotis*, Friuli Venezia Giulia, first records, echolocation

Izvleček. Prvi podatki o dolgorepem netopirju *Tadarida teniotis* Rafinesque, 1818 (Chiroptera: Molossidae) v Furlaniji - Julijski krajini na SV Italije – Dolgorepi netopir *Tadarida teniotis* je razširjen predvsem v južnih delih Evrope, z vrzelmi v trenutno znanem območju razširjenosti. V letu 2014 smo to vrsto našli prvič v pokrajini Furlaniji Julijski krajini v Italiji med popisovanjem netopirjev z ultrazvočnimi detektorji. Zabeležili smo jo na treh mestih v naravnem rezervatu Laghetti delle Noghere (cca. 600 m od meje s Slovenijo), kjer se je tudi prehranjevala, in na enem mestu blizu meje s pokrajino Veneto. S temi opažanji se je število vrst netopirjev v Furlaniji Julijski krajini povzpelo na 30. Nadaljnje raziskave bodo pokazale, ali vrsta *T. teniotis* stalno živi v regiji, ali pa se tam pojavlja le občasno.

Ključne besede: Chiroptera, *Tadarida teniotis*, Furlanija Julijska krajina, prvi podatki, eholokacija

Introduction

The European free-tailed bat, *Tadarida teniotis* Rafinesque, 1818, is the only representative of the family Molossidae in Europe. Its northern border of distribution range extends from southern France, southern Switzerland, Italy, Croatia, Bosnia and Herzegovina, Montenegro to Macedonia and Bulgaria (Aulagnier et al. 2008, Dietz & Kiefer 2014). Straying individuals have also been found in northern Switzerland and southern Germany

(Dietz & Kiefer 2014), with possible observations from Crimea (Uhrin et al. 2007). In Italy, *T. teniotis* is relatively common in central and southern parts of the country (Lanza 2012), while in the north it has been reported from Lombardy (Fornasari et al. 1999), Trentino Alto Adige (Gulino & Dal Piaz 1939, Vernier 1999, Niederfriniger 2002) and Veneto (Vernier 2000).

Tadarida teniotis is a fast flying bat, able to reach speeds of over 50 km/h (Marques et al. 2004, Dietz & Kiefer 2014). Its roosts are found mostly in rocky cliffs, sometimes in tall buildings (Arlettaz 1990, Dietz et al. 2009), where they are difficult to discover. But, the species can be identified rather easily in flight due to its characteristic echolocation calls (Barataud 2014, Dietz & Kiefer 2014).

The Friulian Natural History Museum conducted a project funded by the Public Administration of the Autonomous Region Friuli Venezia Giulia from September 2013 till the end of 2015, with the aim to improve the knowledge on bats of the Friuli Venezia Giulia region (from now on referred to as FVG). In 2014, a bat detector survey on the distribution of *Pipistrellus pipistrellus* and *P. pygmaeus* was conducted (Zagmajster 2014), when also data on other species were gathered. Echolocation calls of *T. teniotis* were registered during this study, presenting the first records of the species in FVG.

Material and methods

Bat detector surveys were conducted in the whole territory of FVG, with priority given to nature conservation and Natura 2000 sites. We observed bats on eleven nights or evenings from the middle of July to the end of September 2014, in the nights without rain and with evening ambient temperatures over 10°C. Bat calls were registered primarily during walking transects and point observations, but also during slow driving by car (up to 40 km/h).

Bat detectors were set in heterodyne mode, frequently scanning between different frequencies (from 20 to 110 kHz; mostly around 40 kHz) to detect bat calls. When a bat was heard, calls were recorded in 10× time expansion mode on D240x ultrasound detector (Pettersson Elektronik AB) and stored on external digital recorder Roland RH-09. All field recordings were studied with the sound analysis program Batsound 4.0 (Pettersson Elektronik AB). Species identification was made based on characteristics of the echolocation calls, measured from spectrogram and power spectrum (FFT, 2048 samples, Hanning window), using various references on bat calls (e.g. Russ 1999, Russo & Jones 2002, Barataud 2014, Dietz & Kiefer 2014, Middleton et al. 2014).

Results with discussion

We recorded the echolocation calls of *T. teniotis* on two nights in 2014 in two different areas of FVG (Tab. 1, Fig. 1).

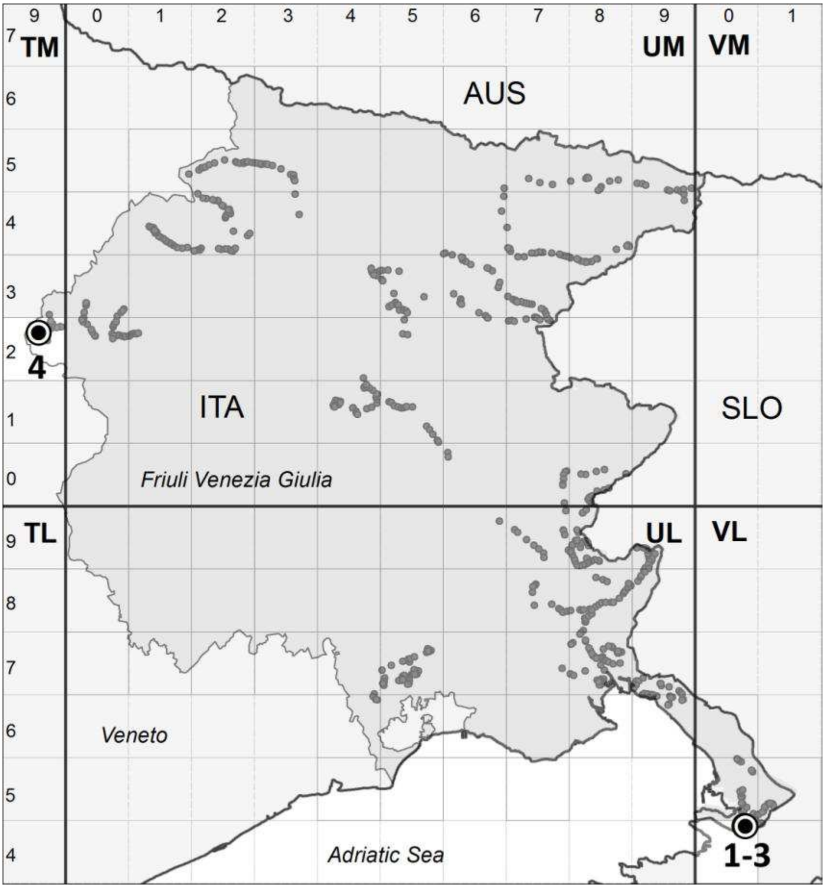

Figure 1. Map of *Tadarida teniotis* localities, recorded in the Friuli Venezia Giulia region in summer 2014 (large circles, numbers below them refer to Tab. 1). Grey dots mark all point observations done during the bat detector study in that same year. Mesh and numbers at the map border refer to the 10×10 km UTM squares.
Slika 1. Karta lokalitet, kjer smo poleti 2014 zabeležili vrsto *Tadarida teniotis* v Furlaniji - Julijski krajini (veliki krogi, številke pod njimi kot v Tab. 1). Sive pike ponazarjajo vse popisne točke v študiji z ultrazvočnimi detektorji v tem istem letu. Mreža in številke ob robu karte se nanašajo na 10×10 km UTM kvadrate.

Table 1. Localities of *Tadarida teniotis* recorded in the Friuli Venezia Giulia region in summer 2014. 10×10 km UTM squares are given (see also Fig. 1), coordinates are in WGS84 decimal degrees (X - longitude, Y - latitude), Z – altitude.
Tabela 1. Lokalitete, kjer smo poleti 2014 zabeležili vrsto *Tadarida teniotis* v Furlaniji Julijski krajini (glej tudi Sl. 1). Podani so 10×10 km UTM kvadrati, koordinate so v WGS84 decimalnih stopinjah (X – zemljepisna dolžina, Y – zemljepisna širina), Z – nadmorska višina.

No	Locality description	UTM	X [°E], Y [°N]	Z [m]	Date	Time
1	At the road, near NE edge of the N-central pond of Laghetti delle Noghere, San Dorligo della Valle, Trieste	VL04	13.817670 45.587407	5	17.-18.7.2014	00:57
2	At the NE edge of the N-central pond of Laghetti delle Noghere, San Dorligo della Valle, Trieste	VL04	13.817654 45.587296	5	17.-18.7.2014	00:58
3	At the E-central edge of the largest (E) pond of Laghetti delle Noghere, San Dorligo della Valle, Trieste	VL04	13.819124 45.586883	5	17.-18.7.2014	01:31, 01:39
4	Shrubs and open land at Strada Regionale 251 della Val di Zoldo e Val Cellina, 200 m SE from Zona Industriale di Frasein, Erto e Casso, Pordenone	TM92	12.348062 46.268628	815	25.-26.8.2014	00:46

Laghetti delle Noghere Nature Reserve lies in the southeast of FVG, near the Slovenian border. It encompasses six ponds that used to be excavation sites of clay for the brick industry, with the Rio Ospo (Osapska reka) River on its northern border. The area around water bodies is overgrown with trees and shrubs. These 12 hectares present an area of semi-natural habitats in otherwise heavily urbanised land of the wider Trieste periphery. We investigated the reserve in the night 17.–18.7.2014, for about two hours (00:30 – 02:20). We recorded echolocation calls of *T. teniotis* at three different localities, with about 40 minutes between the first and the last observations (Tab. 1). The length of species presence, as well as the feeding buzz recorded at the largest pond (No. 3 in Tab. 1), indicated the species was feeding in the area. Foraging of *T. teniotis* near water bodies was observed also by other authors (e.g. Rydell & Arlettaz 1994).

The nature reserve was visited again in the same and the next year (19.8.2014 and 22.10.2015) for the first three hours of the nights, but *T. teniotis* was not recorded again. To establish whether the species regularly occurs in the reserve, the area should be checked more frequently, especially earlier in the summer and in different parts of the nights. The reserve is only about 600 m straight line from the Slovenian border, so a similar approach with bat detectors could reveal species occurrence also in nearby regions in Slovenia, where the species is expected but not yet found (Presetnik et al. 2009).

The fourth locality of *T. teniotis* is situated at the western edge of FVG, near the border with the Veneto region and close to the Dolomiti Friulane Regional Park (Tab. 1, Fig. 1). At the observation site there was an open area close to the road, with some shrubs and bushes. In the night 25.–26.8.2014, a single passing bat was recorded at the site. As our observations did not last longer than recording this bat pass, we cannot say anything about the duration of the species presence there or whether it was feeding.

Feedings sites of *T. teniotis* are situated mostly within 5 km from the colony, but can reach up to 30 km from the roost (Marques et al. 2004). Both areas where we recorded the species have rocky cliffs in vicinity. We checked for potential presence of the species at some rocky cliffs only around the Laghetti delle Noghere reserve. We recorded the species neither in Val Rosandra/Glinščica in Italy (17.–18.7. and 25.–26.7.2014) nor at rocky cliffs near Socerb in Slovenia (25.–26.7.2014), but repeated visits would be necessary. Rarity of *T. teniotis* observations during our study (the species was found at only four of more than 820 bat detector observation points in 2014; see Fig. 1) opens a question on the species regular presence in FVG.

Determinations of *T. teniotis* were based on characteristics of search echolocation calls (Fig. 2; Zbinden & Zingg 1986, Bayefsky-Anand et al. 2008, Barataud 2014, Dietz & Kiefer 2014). The parameters of recorded echolocation calls of *T. teniotis* were (average, ±standard deviation, minimum – maximum, number of samples):

- start frequency 20.3 kHz (±3.9 kHz, 15.3 – 30.6 kHz; n = 17),
- end frequency 12.1 kHz (±0.7 kHz, 11.4 – 14.1 kHz; n = 17),
- frequency of most energy 13.8 kHz (±0.9; 12.7 – 15.7 kHz; n = 17),
- pulse duration 16.1 ms (±2.6 ms, 12.0 – 21.0 ms; n = 17),
- interpulse interval 510.5 ms (±174.3 ms, 267 – 770 ms; n = 11).

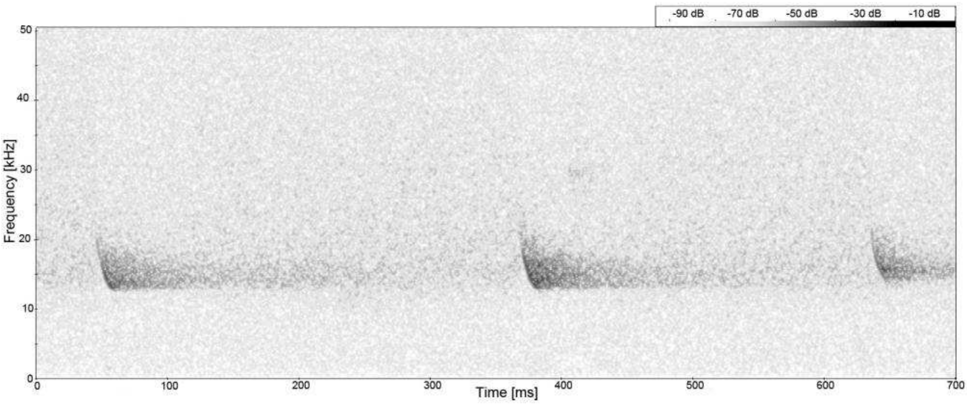

Figure 2. Spectrogram of echolocation calls of *Tadarida teniotis*, recorded at the largest pond in Laghetti delle Noghere in the night 17.–18.7.2014 (see Tab. 1).
Slika 2. Spektrogram eholokacijskih klicev vrste *Tadarida teniotis*, posnetih na bregu največjega jezera rezervata Laghetti delle Noghere v noči 17.–18.7.2014 (glej Tab. 1).

These characteristics are similar to the ones reported by Russo & Jones (2002), based on calls recorded in southern Italy. The calls can be discriminated from similar ones of *Nyctalus lasiopterus*, as the latter has calls of longer duration, with almost constant frequency and with typical *Nyctalus* alternation of two calls (Haquart & Disca 2007). Additionally, the two species can be discriminated by the feeding buzz: in *N. lasiopterus*, the feeding buzz is in the frequency part inaudible to human ear, while in *T. teniotis* feeding buzzes are in low frequency, in human audible sound range (Haquart & Disca 2007). The calls of *T. teniotis* could potentially be mixed also with *N. leisleri* male advertisement calls, but the latter are of longer duration and mostly emitted from a stationary point (Zingg 1990, Helversen & Helversen 1994, Russ 1999, Middleton et al. 2014).

Our observations present the first records of *T. teniotis* in FVG (Lapini & Dorigo 2011, Lapini et al. 2014), increasing the number of registered bats in the region to 30. As *T. teniotis* was known to occur in Italy (Russo & Jones 2002, Lanza 2012), with FVG lying within its European distribution range (Dietz & Kiefer, 2014), its occurrence in FVG is not surprising. Additionally, the species was recently recorded in Venetian portion of the Cansiglio area close to the FVG administrative borders (Cistrone et al. 2014). The status of the species presence, whether it is a common part of FVG fauna or only an occasional vagrant, remains to be ascertained with further studies.

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NAVODILA AVTORJEM

NATURA SLOVENIAE objavlja izvirne prispevke, ki imajo za ozadje terensko delo s področja biologije in/ali prispevajo k poznavanju favne in flore osrednje in jugovzhodne Evrope. Prispevki so lahko v obliki znanstvenih člankov, kratkih vesti ali terenskih notic.

Znanstveni članek je celovit opis izvirne raziskave in vključuje teoretično ozadje tematike, območje raziskav in metode uporabljene pri delu, podrobno predstavljene rezultate in diskusijo, sklepe ter pregled literature. Dolžina naj ne presega 20 strani.

Kratka znanstvena vest je izvirni prispevek, ki ne vsebuje podrobnega teoretičnega pregleda. Njen namen je seznaniti bralca z delnimi ali preliminarnimi rezultati raziskave. Dolžina naj ne presega petih strani.

Terenska notica je krajši prispevek o zanimivih favnističnih ali florističnih opažanjih in najdbah na področju Slovenije. Dolžina naj ne presega treh strani.

Vsi prispevki bodo recenzirani. Avtorji lahko v spremnem dopisu sami predlagajo recenzente, kljub temu pa urednik lahko izbere tudi kakšnega drugega recenzenta. Recenziran članek popravi avtor oz. avtorji sami. V primeru zavrnitve se originalne materiale skupaj z obrazložitvijo glavnega urednika vrne odgovornemu avtorju.

Prispevki, objavljeni v reviji Natura Sloveniae, ne smejo biti predhodno objavljeni ali sočasno predloženi in objavljeni v drugih revijah ali kongresnih publikacijah. Avtorji se s predložitvijo prispevkov strinjajo, da ob njihovi potrditvi, ti postanejo last revije.

Prispevke lahko oddate na naslov Natura Sloveniae, Večna pot 111, SI-1111 Ljubljana, Slovenija (telefon: (01) 423 33 70, fax: 273 390, E-mail: maja.zagmajster@bf.uni-lj.si).

FORMAT IN OBLIKA PRISPEVKA

Prispevki naj bodo napisani v programu Word for Windows, v pisavi "Times New Roman CE 12", z levo poravnavo in 3 cm robovi na A4 formatu. Med vrsticami naj bo dvojni razmak, med odstavki pa prazna vrstica. Naslov prispevka in naslovi posameznih poglavij naj bodo natisnjeni krepko v velikosti pisave 14. Latinska imena rodov in vrst morajo biti pisana ležeče. Uredniku je potrebno prispevek oddati v primerni elektronski obliki (disketa, CD, elektronska pošta) v Rich text (.rtf) ali Word document (.doc) formatu.

Naslov prispevka (v slovenskem in angleškem jeziku) mora biti informativen, jasen in kratek. Naslovu naj sledijo celotna imena avtorjev in njihovi naslovi (vključno z naslovi elektronske pošte).

Izvleček v slovenskem jeziku mora na kratko predstaviti namen, metode, rezultate in zaključke. Dolžina izvlečka naj ne presega 200 besed za znanstveni članek oziroma 100 besed za kratko znanstveno vest. Pod izvlečkom naj bodo ključne besede, ki predstavljajo področje raziskave. Njihovo število naj ne bo večje od 10. Sledi abstract in key words v angleškem jeziku, za katere velja enako kot za izvleček in ključne besede.

Glavnina prispevka znanstvenega članka in kratke znanstvene vesti je lahko pisana v slovenskem jeziku čeprav je bolj zaželjen angleški jezik. Prispevek, ki je pisan v slovenskem jeziku mora vsebovati obširnejši angleški povzetek - summary, prispevek pisan v angleškem jeziku pa obširnejši slovenski povzetek (200-500 besed). Terenska notica je v celoti napisana v angleškem jeziku, brez izvlečka, ključnih besed in povzetka. Pri oblikovanju besedil naj se avtorji zgledujejo po zadnjih številkah revije.

SLIKE IN TABELE

Skupno število slik in tabel v prispevku naj ne bo večje od 10, njihovo mesto naj bo v članku nedvoumno označeno. Posamezne tabele z legendami naj bodo na ločenih listih. Naslovi tabel naj bodo nad njimi, naslovi slik in fotografij pa pod njimi. Naslovi in legenda slik in tabel naj bodo v slovenskem in angleškem jeziku. Pri navajanju slik in tabel v tekstu uporabljajte okrajšave (npr. angl: Tab. 1 ali Tabs. 1-2, Fig. 1 ali Figs. 1-2 in slo.: Tab. 1 in Sl. 1).

NAVAJANJE LITERATURE

Navajanje literature v besedilu mora biti na ustreznem mestu. Kadar citiramo enega avtorja, pišemo Schultz (1987) ali (Schultz 1987), če sta avtorja dva (Parry & Brown 1959) in če je avtorjev več (Lubin et al. 1978). Kadar navajamo citat večih del hkrati, pišemo (Ward 1991, Pace 1992, Amman 1998). V primeru, ko citiramo več del istega avtorja objavljenih v istem letu, posamezno delo označimo s črkami (Lucas 1988a, b). Literatura naj bo urejena po abecednem redu.

Primeri:

- članke iz revij citiramo:

Schultz J.W. (1987): The origin of the spinning aparatures in spiders. Biol. Rev. 62: 123-134.

Parry D.A., Brown R.H.J. (1959): The hydraulic mechanism of the spider leg. J. Exp. Biol. 36: 654-657.

Lubin Y.D., Eberhard W.G., Montgomery G.G. (1978): Webs of Miagrammopes (Araneae: Araneaidae) in the neotropics. Psyche 85: 1-13.

Lucas S. (1988a): Spiders in Brasil. Toxicon 26: 759-766.

Lucas S. (1988b): Spiders and their silks. Discovery 25: 1-4.

- knjige, poglavja iz knjig, poročila, kongresne povzetke citiramo:

Foelix R.F. (1996): Biology of spiders, 2. edition. Harvard University Press, London, pp. 155-162.

Nentwig W., Heimer S. (1987): Ecological aspects of spider webs. In: Nentwig W. (Ed.), Ecophysiology of Spiders. Springer Verlag, Berlin, 211 pp.

Edmonds D.T. (1997): The contribution of atmospheric water vapour to the formation of a spider's capture web. In: Heimer S. (Ed.), Proceedings of the 17th European Colloquium of Arachnology. Oxford Press, London, pp. 35-46.

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All papers will be subject to peer review by one referee. Authors are invited to suggest the names of referees, although the editor reserves the right to elect an alternative referee to those suggested. The reviewed paper should be corrected by author or authors themselves. In the case of the rejection, the original materials will be sent back to the corresponding author with the editors explanation.

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FORMAT AND FORM OF ARTICLES
Papers should be written with Word for Windows using "Times New Roman CE" size 12 font, align left and margins of 3 cm on A4 pages. Double spacing should be used between lines and paragraphs should be separated with a single empty line. The title and chapters should be written bold in font size 14. The latin names of all genera and species must be written italic. All submissions should be sent to the editor in the appropriate electronic version on diskette, CD or via e-mail in Rich text format (.rtf) or Word document (.doc) format.

Title of paper should be informative, understandable, and concise. The title should be followed by the name(s) and full adress(es) of the author(s), including E-mail adresse(s).

Abstract must give concize information about the objectives, methods used, results and the conclusions. The abstract length should not exceed 200 words for »Scientific Papers« and 100 words for »Short Communications«. There should be no more than ten keywords which must accurately reflect the field of research covered in the paper. Field notice does not include abstract and keywords. Author(s) should check the last issue of Natura Sloveniae when preparing the manuscript.

ILLUSTRATIONS AND TABLES
Papers should not exceed a total of ten illustrations and/or tables, with their positon amongst the text clearly indicated by the author(s). Tables with their legends should be submitted on separate pages. Titles of tables should appear above them, and titles of illustrations and photographs below. Illustrations and tables should be cited shortly in the text (Tab. 1 or Tabs. 1-2, Fig. 1 or Figs. 1-2).

LITERATURE
References should be cited in the text as follows: a single author is cited, as Schultz (1987) or (Schultz 1987); two authors would be (Parry & Brown 1959); if a work of three or more authors is cited, (Lubin et al. 1978); and if the reference appears in several works, (Ward 1991, Pace 1992, Amman 1998). If several works by the same author published in the same year are cited, the individual works are indicated with the added letters a, b, c, etc. (Lucas 1988a, b). The literature should be arranged in alphabetical order.

Examples (use the the following forms):

- articles from journals:
Schultz J.W. (1987): The origin of the spinning aparatures in spiders. Biol. Rev. 62: 123-134.
Parry D.A., Brown R.H.J. (1959): The hydraulic mechanism of the spider leg. J. Exp. Biol. 36: 654-657.
Lubin Y.D., Eberhard W.G., Montgomery G.G. (1978): Webs of Miagrammopes (Araneae: Araneaidae) in the neotropics. Psyche 85: 1-13.
Lucas S. (1988a): Spiders in Brasil. Toxicon 26: 759-766.
Lucas S. (1988b): Spiders and their silks. Discovery 25: 1-4.

- for books, chapters from books, reports, and congress anthologies:
Foelix R.F. (1996): Biology of spiders, 2. edition. Harvard University Press, London, pp. 155-162.
Nentwig W., Heimer S. (1987): Ecological aspects of spider webs. In: Nentwig W. (Ed.), Ecophysiology of Spiders. Springer Verlag, Berlin, 211 pp.
Edmonds D.T. (1997): The contribution of atmospheric water vapour to the formation of a spider's capture web. In: Heimer S. (Ed.), Proceedings of the 17th European Colloquium of Arachnology. Oxford Press, London, pp. 35-46.