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Contribution to the knowledge of the butterfly fauna (Lepidoptera: Papilionoidea) of Central Slovenia

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Abstract. The southwestern Posavsko hills and northern Suha krajina are among the least studied areas regarding the butterfly fauna in Slovenia. To fill this knowledge gap, we selected all unpublished records of butterflies since 2014, in addition to the focused field surveys performed in the 2019–2022 period. We recorded a total of 105 butterfly species, presenting almost 60% of all species found in Slovenia. Among the species found, there are several habitat specialists of high conservation importance, e.g., *Leptidea morsei*, *Euphydryas aurinia*, *Parnassius mnemosyne*, *Phengaris arion*, *Carcharodus floccifera*, *Lycaena dispar*. Locations harbouring these species and those with the highest species richness are of great importance for preserving the diverse butterfly fauna of the region.

Key words: southwestern Posavsko hills, northern Suha krajina, faunistics, conservation, field surveys, species richness

Izvleček. Prispevek k poznavanju favne metuljev (Lepidoptera: Papilionoidea) centralne Slovenije – Jugoahodni del Posavskega hribovja in severni del Suhe krajine sta glede favne dnevnih metuljev v Sloveniji med najslabše raziskanimi območji. V ta namen smo med letoma 2019 in 2022 opravili serijo usmerjenih popisov, zraven pa so vključeni še neobjavljeni podatki od leta 2014 naprej. Skupaj smo zabeležili 105 vrst metuljev, kar pomeni skoraj 60 % vseh vrst dnevnih metuljev, najdenih v Sloveniji. Med najdenimi vrstami so bile tudi take, ki so pomembne z naravovarstvenega vidika, npr. *Leptidea morsei*, *Euphydryas aurinia*, *Parnassius mnemosyne*, *Phengaris arion*, *Carcharodus floccifera*, *Lycaena dispar*. Lokacije z omenjenimi vrstami, kot tudi tiste z največjo pestrostjo, so pomembne za ohranitev velike pestrosti metuljev te regije.

Ključne besede: jugoahodno Posavsko hribovje, severna Suha krajina, favnistika, naravovarstvo, terenski popisi, vrstna pestrost



Introduction

Among the least studied parts of Slovenia in terms of butterflies are the southwestern Posavsko hills and northern Suha krajina between the Krka and Sava Rivers in Central Slovenia. No extensive surveys of butterflies were undertaken in the region, with only a few records included in the Atlas of Butterflies of Slovenia and its supplement (Verovnik et al. 2012; Čelik 2013). Most of the past surveys and data collection were carried out during the designation of Natura 2000 network in order to outline the distribution species under the Habitat Directive (OJ EC 1992; Ur. l. RS 2004a) or under the Regulation on protected wild animal species (Ur. l. RS 2004b). Based on these surveys, Suha krajina and Mirenščica were recognised as areas of conservational importance for butterflies (Čelik et al. 2005) due to the presence of two species listed in Annex II of the Habitat Directive, and in Annex I and II of the Regulation on protected wild animal species (OJ EC 1992, Ur. l. RS. 2004a, 2004b), *Leptidea morsei* and *Euphydryas aurinia*, while previous data also highlighted Moravska Gora, where both mentioned species were also found (Verovnik et al. 2012). Due to their presence, these localities are still regularly surveyed, and the results of these surveys are included in this report. However, since only two qualifying species were recognised, these areas were not included in Natura 2000 (Ur. l. RS 2004a). Consequently, only small parts of the studied area are covered by the network, mostly towards the south near the Krka River (Krka s pritoki, SI3000338), around Trebnje (Trebnje, SI3000382; Vejar, SI30000056; Vrhtrebnje – Sv. Ana, SI3000057) and around Mirna (Mirna, SI3000059) (Ur. l. RS 2004a). It must be additionally noted that none of the existing Natura 2000 areas were designated for butterflies' species listed in Annex II of the Habitat Directive. The past surveys indicated a potential high butterfly diversity of the studied region especially due to presence of several specialist species uncommon in central Slovenia, e.g. *Lycaena dispar*, *Polyommatus thersites*, *Polyommatus dorylas*, *Parnassius mnemosyne*, *Pyrgus armoricanus*, *Carcharodus floccifera*, etc. (Čelik et al. 2005; Verovnik et al. 2012; Čelik 2013), some of which are also included in the Regulation on protected wild animal species (Ur. l. RS 2004b). With this in mind, a more extensive survey of the area was needed, focusing on wide coverage of the surveyed region and targeted search for rare or threatened species.

Materials and methods

Geographical description of the studied region

The surveyed region cannot be described as a well-defined unit, and is composed from several geographical/regional units: Dolenjsko podolje, Suha krajina with Dobrepolje and southwestern part of Posavsko hills. According to Perko (1998) and its new regionalisation of Slovenia, the area lies at the boundary between the Dinaric and Alpine macro-regions. The first is represented mainly by Dinaric plains, valley systems and corrosion plains in the south, while the second is composed mainly of Alpine hills in the north. These parts of Slovenia are known for their typical temperate continental climate (Ogrin 1996), with 1300–1800 mm of annual rainfall, while the average year temperatures are around 7–10 °C, depending on altitude and other factors (Vrtačnik & Bertalančič 2017).

Topographically, the studied region is not diverse as it consists mainly of hilly terrain between two river valleys, with some small valleys and basins where bigger towns are situated. It is mostly covered with hills which rarely rise above 600 m, with the highest being Obolno at 776 m just north of the Stična village. The hills north of Ivančna Gorica-Trebnje (A2) highway are generally slightly higher, while the hills south of the highway rarely exceed 500 m, with Trebni vrh being the highest at 581 m (Požar 2005). The largest part of the region consists of limestone and dolomite bedrock, with a few deposits of clays and silts in some basins and valleys (e.g., Ivančna Gorica) (Perko 1998). The predominant vegetation consists of beech, chestnut, oak, fir, European hornbeam and partly birch, while south-facing slopes are locally dominated by red pine (parts of Moravska Gora). Cultivation, settlements and pastures are concentrated around larger towns like Ivančna Gorica, Trebnje, Mirna and along the Krka River (Perko 1998). The particularly important characteristic of the region, however, are its still relatively widely preserved dry, and partially humid extensive grasslands, which provide important habitats for many butterfly species.

The approximate surveying borders in this study were set between the Krka River (Krka-Žužemberk) in the south, the line connecting Žužemberk-Mirna Peč-Mokronog towns in the east, Mokronog-Velika Preska-Šmartno pri Litiji towns in the north, and Šmartno pri Litiji-Prežganje-Polica-Krka towns in the west (Fig. 1).

Field work

The surveys of the area took place from 2014–2022, with the majority of research performed during the summer of 2019, March–November of 2020 and summer of 2022. During each survey, the entire area of the chosen locality was thoroughly checked, with all found butterfly species recorded. Records made prior to 2014 are not included, since they were already published in the Atlas of Butterflies of Slovenia or in its supplement (Verovnik et al. 2012; Čelik 2013). In total, 70 localities were surveyed throughout the region, however, most localities are concentrated in the areas where extensive grasslands abound (Fig. 1). The surveying was performed using a butterfly net and identification was done in the field. Butterflies were not collected, therefore genital dissection needed for separation of *Leptidea sinapis/juvernica* species complex was not carried out. The butterflies were determined using the standard butterfly guide (Tolman and Lewington 2008), while localities were selected based on our past surveys (Moravska Gora, Debeče, Vodice pri Gabrovki, Pusti Javor, Leskovec, Metnaj, Osredok nad Stično, Tlaka, Primskovo and Lisec; all the previously surveyed localities are included in the Atlas of Butterflies of Slovenia or in its supplement (Verovnik et al. 2012; Čelik 2013)), knowledge of the region, and from the inspection of satellite photos/maps. All surveys were performed during appropriate weather conditions (sunny, relatively light wind, temperatures above 15 °C) between 9:00–18:00.

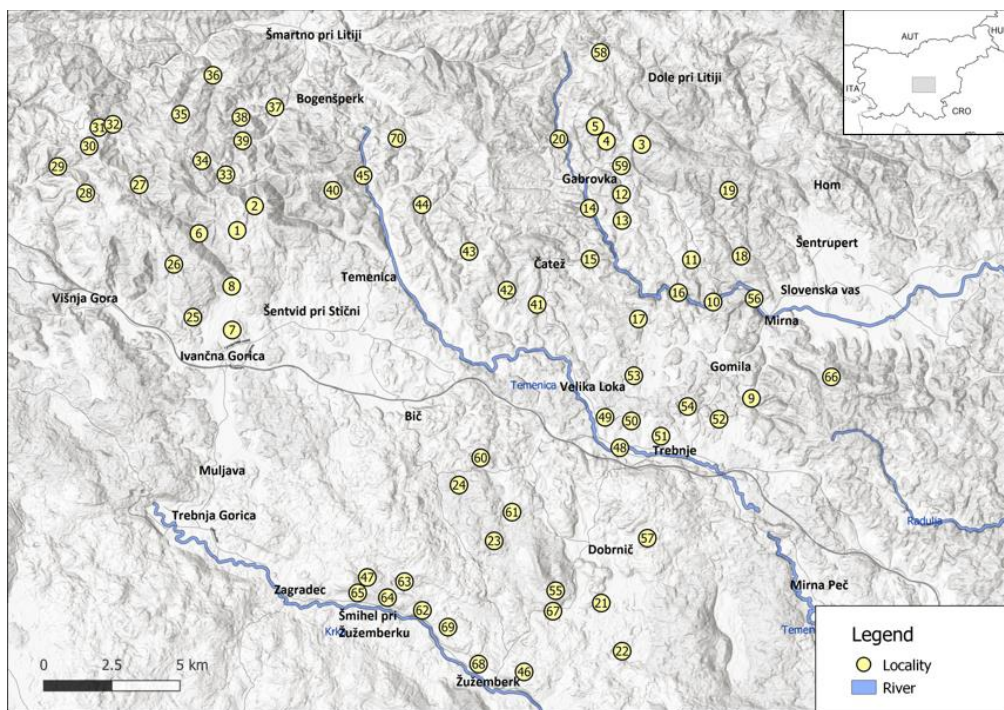


Figure 1. Map of the southwestern Posavsko hills and northern Suha krajina with the included localities surveyed between 2014 and 2022. Numbers refer to description of localities in Tab. 1. The position of the surveyed area within the country is shown with a grey square in the upper right corner.

Slika 1. Zemljevid severozahodnega dela Posavskega hribovja in severnega dela Suhe krajine z vključenimi lokacijami, pregledanimi med 2014 in 2022. Številke lokalitet so enake opisom lokalitet v Tab. 1. Položaj raziskovanega območja znotraj države je prikazan s sivim kvadratom zgoraj desno.

Results and discussion

General overview of localities and species

During the surveys, 44 localities were closely examined once, while 26 localities were surveyed at least twice. Most butterfly species were found at three localities at least, while nine species were found at two localities and eight species at a single one. During the surveying of the region, a total of 105 species or species complexes were found representing almost 60% of all species found in Slovenia (Verovnik 2019). Among these three species belonged to the family Papilionidae, 12 to Pieridae, 32 to Lycaenidae, a single one to Riodinidae, 45 to Nymphalidae, and 12 to Hesperidae. Species found at more than half of the surveyed localities could be considered common in the region and include: *Colias crocea*, *Gonepteryx rhamni*, *Pieris rapae*, *L. sinapis/juvernica*, *Polyommatus icarus*, *Coenonympha pamphilus*, *Maniola jurtina*, *Melanargia galathea*, and *Ochlodes sylvanus*. Unsurprisingly, these species are also widespread in other parts of Central Slovenia (Verovnik et al. 2012).

With addition of eight species recorded only in previous surveys (*Colias hyale*, *Pieris ergane*, *Lysandra coridon*, *Nymphalis antiopa*, *Euphydryas maturna*, *Limenitis populi*, *Fabriciana (Argynnis) niobe* and *Pyrgus alveus*) (Verovnik et al. 2012; Čelik 2013), a total of 113 have been recorded from this part of central Slovenia so far. This puts the region among the most diverse in continental Slovenia, comparable with the Haloze and Goričko regions further eastwards – both with 109 species recorded (Verovnik 2000; Verovnik 2003; Verovnik et al. 2012). This is still somewhat less diverse compared to the two main centres of butterfly diversity at the junction with the sub-Mediterranean region in the Vipava Valley and at Kraški rob closer to the coast, with more than 130 species recorded (Verovnik et al. 2012).

Among the species observed, 22 are included in the red list of butterflies of Slovenia (Ur. l. RS 2002), 15 in the European red list of butterflies (Van Swaay et al. 2010), eight in the Regulation on protected wild animal species (Ur. l. RS 2004b), and five in the Directive on the conservation of natural habitats and of wild fauna and flora (OJ EC 1992) (Tab. 3).

Most species-rich localities are (in order of most species found): Moravska Gora, Žužemberk, Brezovo and Vrh pri Križu, and Vrhovo pri Žužemberku (Tab. 1). It is not surprising that the localities Moravska Gora and Brezovo are relatively close to one another, which is also true for localities Vrh pri Križu, Vrhovo pri Žužemberku and Žužemberk. In the case of the Moravska Gora and Brezovo localities, they are located near the northern border of the surveyed area at a relatively high altitude, both above 550 m. Characteristic of both localities are warm and dry extensive grasslands, and open deciduous woods on calcareous bedrock, which are sometimes replaced by pines. The entire area has a strong karst outlook, which is additionally increased by the abundance of large satyrids (e.g. *Hipparchia fagi*). In the case of Moravska Gora, especially near the village road, small gardens and orchards are also abundant, which additionally enrich the flora of the area. This abundance of habitat types, specific geographical location, as well as the presence of still relatively preserved areas of extensive grasslands are the main reasons for the wide variety of butterfly species.

The main habitat characteristics of the localities Vrh pri Križu, Vrhovo pri Žužemberku and Žužemberk, on the other hand, are the combination of humid and dry extensive grasslands, as well as woodlands with clearings in different stages of overgrowth. Thus, many different habitat specialists can be found in the area (e.g. *L. dispar*, *Lycaena hippothoe* and *C. floccifera* characteristic for humid, and *Melitaea aurelia*, *M. britomartis* and *Brenthis hecate* characteristic for dry extensive grasslands). All three localities are situated at the southern edge of the surveyed area, near the Krka River, at altitudes around 300 m, and have at least some karst characteristics including smaller valleys, exposed rocky terrain, etc. Combination of the mentioned characteristics, which include dry and humid extensive grasslands, riparian vegetation near the Krka River, rocky outcrops, as well as orchards, forest edges, etc., is reflected in high species richness, which is characteristic for low altitude, karst, habitat-rich areas in Slovenia, e.g., Vipava Valley, areas around Dragonja/Sečovelje villages, etc. (Verovnik et al. 2012; Čelik 2013).

Table 1. The list of localities surveyed during the study, including the description of locality and its habitat, coordinates, altitude, and date(s) of surveys. Coordinates are given in a WGS-84 decimal degrees, latitude (Lat.) followed by longitude (Long.). Abbreviations of names on the given surveying date refer to: AP – Andrej Peternel, LŠ – Luka Šturm, RV – Rudi Verovnik and JZ – Jure Zaman.

Tabela 1. Seznam lokalitet, vzorčenih med študijo, skupaj z opisom lokalitete in habitata, koordinat, nadmorske višine in datumom/ov vzorčenj(a). Koordinate so podane v WGS-84-decimalnih stopnjah kot zemljepisna širina (Lat.) in zemljepisna dolžina (Long.). Okrajšave imen ob datumih posamičnih vzorčenj pripadajo: AP – Andrej Peternel, LŠ – Luka Šturm, RV – Rudi Verovnik in JZ – Jure Zaman.

No.	Name	Description	Habitat type	Coordinates (Lat, Long)	Altitude (m)	Date	No. of species
1	Grasslands on slopes 200 m E of Metnaji; N of Ivančna Gorica	Dry grasslands; forest edge	45.979046, 14.810992	540	31.05.2014 (RV); 18.7.2019 (AP, JZ)	13	
2	Grasslands 130 m W of Pristava nad Stično; N of Ivančna Gorica	Hay meadows; forest edge	45.987053, 14.819198	550	31.05.2014 (RV)	6	
3	Grasslands 300 m E and S of Brezovo: NE of Gabrovka	Dry extensive and intensive grasslands; forest edge	46.007416, 14.997887	620	13.5.2018, 2.5.2020, 1.5.2021, 11.8.2022 (RV); 21.07.2019 (AP, LŠ, JZ), 9.8.2022 (AP, LŠ)	51	
4	S slopes at Moravska Gora; N of Gabrovka	Dry grasslands; forest edge, road verges, open woods	46.008222, 14.985342	560	13.5.2018, 2.5.2020, 1.5. and 1.6. 2021, 11.8.2022 (RV); 21.07.2019 (AP, LŠ, JZ); 7.5.2020 (AP, JZ); 9. and 20.5.2021 (JZ), 9.8.2022 (AP, LŠ)	62	
5	Grasslands 300 m SE of Zgornje Vodice; N of Gabrovka	Hay meadows; forest edge	46.013036, 14.980054	660	13.5.2018, 2.5.2020, 1.5. and 30.5.2021 (RV)	21	
6	Meadows 800 m NW of Potok village, along Stiški potok stream; Gabrje pri Stični; N of Ivančna Gorica	Humid grasslands; forest edge	45.978070, 14.792910	420	16.6.2019 (AP, LŠ); 18.7.2019 (AP, JZ); 19.07.2019 (LŠ)	39	
7	Grasslands at the elementary school, S of Stična; N of Ivančna Gorica	Intensive grasslands; forest edge	45.946490, 14.808600	350	18.7.2019 (AP, JZ)	10	
8	Small river valley of Stiški potok, 50 m N of Gabrje pri Stični; N of Ivančna Gorica	Shrub and flowers along the stream; forest edge	45.960810, 14.808390	390	18.7.2019 (AP, JZ)	11	
9	Grasslands 300 m SE of Lanšprež manor, near Gomilščica stream; Gomila; N of Trebnje	Humid grasslands; forest edge	45.924140, 15.053820	270	19.7.2019 (AP, JZ); 27.10.2019, 7.3. and 3.5.2020 (JZ);	21	
10	Grasslands S, SE and E of Migolska Gora, around Mirenščica stream; N of Trebnje	Humid grasslands; forest edge	45.955660, 15.035740	290	19.7.2019 (AP, JZ); 6.8.2021, 3.7.2022 (JZ)	24	
11	Grasslands 450 m SW of Selo pri Mirni, near Homščica stream; N of Trebnje	Humid grasslands; forest edge	45.969480, 15.025430	350	19.7.2019 (AP, JZ)	5	

No.	Name	Description	Habitat type	Coordinates (Lat, Long)	Altitude (m)	Date	No. of species
12	Overgrowing grasslands	450 m S of Pretržje, near Gabrovščica stream; SE of Gabrovka	Partially overgrowing humid meadows; forest edge	45.990830, 14.992470	350	19.7.2019 (AP, JZ)	5
13	Grasslands and shrubs	450 m NE of Tlaka; S of Gabrovka	Dry grasslands; forest edge	45.982300, 14.992700	340	19.7.2019 (AP, JZ)	17
14	Grasslands beneath the ruins of Turn castle, near Turnska Cerknica stream; Gabrska Gora; SW of Gabrovka		Humid grasslands; forest edge	45.986280, 14.977260	330	19.7.2019 (AP, JZ)	7
15	Grasslands 50 m S of Okrog (Dule), near Dušica stream; S of Gabrovka		Humid grasslands; forest edge	45.969640, 14.977640	330	19.7.2019 (AP, JZ)	9
16	Grasslands 250 m S of Selska Gora, near Mirenščica stream; N of Trebnje		Humid grasslands; forest edge	45.958710, 15.019350	300	19.7.2019 (AP, JZ)	10
17	Forest clearing and grasslands 450 m NW of Mala Ševnica, near Cedilnica stream; N of Trebnje		Partially overgrown humid grasslands; forest edge	45.950120, 15.000450	300	19.7.2019 (AP, JZ)	11
18	Grasslands NW of Trstenik, 250 S of Srasle, along the Trstenik-Zabukovje road; Srasle; NE of Mirna		Humid grasslands; forest edge	45.970665, 15.048959	280	21.07.2019 (AP, LŠ, JZ)	11
19	Grasslands 350 m N of quarry at Gorenje Zabukovje, near stream Ločica; Zabukovje; NW of Mirna		Humid grasslands, forest edge	45.992150, 15.043090	360	21.07.2019 (AP, LŠ, JZ); 24.6.2020, 14.6.2021 (JZ)	24
20	Grasslands in a small valley 50 m E of Hohovica; NW of Gabrovka		Humid grasslands; shrubs	46.008900, 14.962910	360	21.07.2019 (AP, LŠ, JZ)	18
21	Grasslands 600 m S and SE of Korita; S of Trebnje		Intensive grasslands; forest edge	45.857172, 14.982919	250	22.07.2019 (LŠ)	8
22	Grasslands 400 m W of Podlipa; NE of Žužemberk		Humid grasslands; forest edge	45.841410, 14.992745	250	22.07.2019 (LŠ)	19
23	Grasslands and forest clearings 700 m N and NE of Volčja Jama; N of Žužemberk		Dry grasslands; forest edge and clearings	45.877523, 14.932309	340	22.07.2019 (LŠ)	19
24	Grasslands 600 m S of Babna Gora; W of Trebnje		Intensive grasslands; forest edge	45.895795, 14.915733	320	22.07.2019 (LŠ)	10
25	Grasslands and shrubs on slopes SW of Stična; N of Ivančna Gorica		Dry grasslands; forest edge, shrubs	45.950694, 14.790047	420	23.07.2019 (LŠ, JZ)	13
26	Grasslands 900 m NE of Velika Dobrava; NW of Ivančna Gorica		Intensive grasslands; forest edge	45.967970, 14.781077	540	23.07.2019 (LŠ, JZ)	21

No.	Name	Description	Habitat type	Coordinates (Lat, Long)	Altitude (m)	Date	No. of species
27	Grasslands 1100 m E of Leskovec, near Stiški potok stream; NW of Ivančna Gorica	Dry grasslands; forest edge	45.993935, 14.764731	540	23.07.2019 (LŠ, JZ)	18	
28	Grasslands and slopes 850 m W of Leskovec; NW of Ivančna Gorica	Dry grasslands; forest edge	45.991234, 14.739448	740	23.07.2019 (LŠ, JZ)	14	
29	Grasslands on slopes 700 m SW of Mali Vrh pri Prežganju, near Veliki potok stream; NE of Grosuplje	Dry and humid grasslands; forest edge	45.999935, 14.726270	480	23.07.2019 (LŠ, JZ)	15	
30	Gasslands and clearing 200 m S of Veliko Trebeljevo; SW of Litija	Intensive grasslands; forest edge	46.006583, 14.741094	540	23.07.2019 (LŠ, JZ)	10	
31	Grasslands on slopes 400 m E of Veliko Trebeljevo; SW of Litija	Dry grasslands; forest edge	46.012669, 14.745662	500	23.07.2019 (LŠ, JZ)	21	
32	Grasslands near Reka stream, 850 m E of Veliko Trebeljevo; SW of Litija	Intensive grasslands; forest edge	46.013711, 14.752331	380	23.07.2019 (LŠ, JZ)	16	
33	Grasslands and slopes 250 m W and SW of Debeče, near Bukovica stream; S of Litija	Humid and dry grasslands; forest edge	45.997272, 14.805665	530	23. and 24.07.2019 (LŠ, JZ)	14	
34	Grasslands and slopes at Osredek nad Stično; SW of Litija	Dry grasslands; forest edge	46.001805, 14.794284	620	24.07.2019 (LŠ, JZ)	17	
35	Grasslands and slopes in a small valley 400 m W of Jastrebnik; SW of Litija	Humid and dry grasslands; forest edge	46.016975, 14.784236	420	24.07.2019 (LŠ, JZ)	14	
36	Grasslands and slopes 200 m S of Volčja Jama; SW of Litija	Dry grasslands; forest edge	46.029719, 14.799543	340	24.07.2019 (LŠ, JZ)	13	
37	Grasslands and slopes at Podroje, near Koški potok stream; S of Litija	Humid and dry grasslands; forest edge	46.019302, 14.828849	300	24.07.2019 (LŠ, JZ)	30	
38	Grasslands and slopes 350 m S of Kot, near Koški potok stream; S of Litija	Humid and dry grasslands; forest edge	46.016018, 14.812797	330	24.07.2019 (LŠ, JZ)	22	
39	Clearings 1250 m SW of Vintarjevec, near Vintarjevski potok stream; S of Litija	Partially overgrowing clearings; forest edge	46.008348, 14.813535	340	24.07.2019 (LŠ, JZ)	11	
40	Grasslands on slopes 100 m NE of Bukovica (Cerovec); S of Litija	Dry grasslands; forest edge	45.992163, 14.856168	480	24.07.2019 (LŠ, JZ)	13	
41	Grasslands 900 m NW of Mačkovec; NW of Trebnje	Partially overgrowing humid grasslands; forest edge	45.954820, 14.952630	320	25.7.2019 (AP, JZ)	14	
42	Grasslands 750 m N of Dolga Njiva pri Šentlovrencu; NW of Trebnje	Humid extensive and intensive grasslands; forest edge	45.959520, 14.938300	330	25.7.2019 (AP, JZ)	14	

No.	Name	Description	Habitat type	Coordinates (Lat, Long)	Altitude (m)	Date	No. of species
43	Grasslands 150 m N of Primskovo, near Laniški potok stream; NW of Trebnje	Humid grasslands; forest edge	45.972150, 14.920530	340	25.7.2019 (AP, JZ)	20	
44	Grasslands on slopes W of Mišji dol; NE of Ivančna Gorica	Dry grasslands; forest edge	45.987440, 14.898270	380	25.7.2019 (AP, JZ)	14	
45	Grasslands at Pusti Javor, along Temenica-Prečna stream; S of Litija	Humid grasslands; forest edge	45.996970, 14.870488	380	25.7.2019 (AP, JZ)	29	
46	Grasslands on slopes 250 m E of Zafara; E of Žužemberk	Dry grasslands; forest edge	45.834630, 14.946490	310	26.7.2019 (AP, JZ)	12	
47	Grasslands on slopes 350 m N of Valična vas; NW of Žužemberk	Dry grasslands; forest edge	45.865560, 14.872430	400	26.7.2019 (AP, JZ)	15	
48	Grasslands around Štefan pri Trebnjem, also near Temenica-Prečna stream; W of Trebnje	Humid grasslands; shrub	45.907994, 14.991682	280	Mar.-Jun., Avg. 2020 (JZ)	22	
49	Grasslands between and N of Kamni Potok and Gorenja Nemška vas; W of Trebnje	Dry grasslands; forest edge	45.917945, 14.984703	300	Mar.-May 2020 (JZ)	31	
50	Grasslands around both Pekel/Studenec, mainly to the N; NW of Trebnje	Humid grasslands; forest edge	45.916776, 14.997149	300	Mar.-Jul., Nov. 2020, 8.5.2021 (JZ)	39	
51	Grasslands around both Trebnje/Praproče settlements	Humid grasslands; forest edge	45.911781, 15.011120	290	Mar.-Jun. 2020 (JZ)	27	
52	Grasslands 200 m E of Primštál; NE of Trebnje	Intensive grasslands; forest edge	45.917342, 15.038491	310	3.4. and 14.5.2020 (JZ)	7	
53	Grasslands at Blato, and near Blato pond; N of Trebnje	Intensive grasslands; forest edge and shrubs	45.931561, 14.998300	320	Apr., Nov. 2020 (JZ)	12	
54	Grasslands at Gorenje Medvedje selo, mostly to the N; N of Trebnje	Dry grasslands; forest edge	45.921505, 15.023672	310	Apr.-Jun. 2020 (JZ)	32	
55	Grasslands at the SE of Lisec; SW of Trebnje	Dry grasslands; forest edge and shrubs	45.861220, 14.961370	380	7.5.2020 (AP, JZ); 8.8.2021, 18.4., 16.10.2022 (JZ)	30	
56	Partially overgrown grasslands at Mirna pond; Mirna; NE of Trebnje	Intensive grasslands; riparian vegetation	45.956794, 15.055127	260	25.6.2020, 3.7.2022 (JZ)	3	
57	Grasslands 250 m W and N of Dolenji Vrh; S of Trebnje	Dry grasslands; forest edge	45.878407, 15.004673	450	12.7.2020 (JZ)	4	
58	Grasslands 170 m SE of Mala Goba; N of Gabrovka	Dry grasslands; forest edge	46.037143, 14.982466	700	1.5.2021 (RV)	5	
59	Grasslands at Gabrovka, E of the school	Intensive grasslands; forest edge	46.000162, 14.992439	420	1.5. and 21.6.2021 (RV)	28	

No.	Name	Description	Habitat type	Coordinates (Lat, Long)	Altitude (m)	Date	No. of species
60	Grasslands 600 m NW of Gorenje Selce; W of Trebnje	Humid grasslands; forest edge	45.904710, 14.925960	380	5.6.2022 (JZ)	27	
61	Grasslands 100 m NE of Dolenje Kamenje pri Dobrniču; SW of Trebnje	Dry grasslands; forest edge	45.886930, 14.940770	320	5.6.2022 (JZ)	19	
62	Grasslands 350 m SE of Vrh pri Križu; NW of Žužemberk	Humid grasslands; forest edge	45.854780, 14.898450	270	16.5. and 11.8. 2022 (RV), 5.6.2022 (JZ), 12.6.2022 (LŠ, JZ), 9.8.2022 (AP, LŠ)	51	
63	Grasslands 650 m NW of Vrh pri Križu; NW of Žužemberk	Dry grasslands; forest edge	45.864190, 14.889990	350	16.5. and 11.8.2022 (RV), 5.6.2022 (JZ)	31	
64	Small lake in an abandoned quarry 600 m E of Valična vas; NW of Žužemberk	Ruderal sandy areas; shrubland;	45.858940, 14.881950	300	20.5. and 11.8.2022 (RV), 5.6.2022 (JZ)	25	
65	Abandoned quarry 300 m W of Valična vas; NW of Žužemberk	Rocky and sandy slopes; open woods	45.860490, 14.867890	360	16.5.2022 (RV), 5.6.2022 (JZ)	11	
66	Grasslands 100 m N of Debenec; NE of Trebnje	Dry grasslands; forest clearings	45.931158, 15.091570	440	11.6. and 3.7.2022 (JZ)	20	
67	Grasslands 150 m W of Dobrava; NE of Žužemberk	Dry and humid grasslands; forest edge	45.854510, 14.960126	260	12.6.2022 (LŠ, JZ)	29	
68	Grasslands 250 m NW of Žužemberk	Dry and humid grasslands; forest edge	45.837185, 14.924976	270	12.6.2022 (LŠ, JZ), 9.8.2022 (AP, LŠ), 16., 31.10.2022 (JZ)	54	
69	Grasslands and forest clearings 600 m E of Vrhovo pri Žužemberku; NW of Žužemberk	Dry and humid grasslands; forest edge	45.849283, 14.910535	260	12.6.2022 (LŠ, JZ), 9.8.2022 (AP, LŠ)	46	
70	Grasslands at the E edge of Višnji Grm, near the main road; SE of Litija	Dry grasslands; forest edge	46.009140, 14.886415	460	1.6.2021 (RV)	6	

Table 2. The list and occurrence of butterfly species found during the 2014–2022 surveys in southwestern Posavsko hills and northern Suha krajina in Central Slovenia. The localities are indicated by numbers from 1 to 70 as in the list and description of localities.

Tabela 2. Seznam in pojavljanje vrst dnevnih metuljev, opaženih med popisi, opravljenimi v obdobju 2014–2022 na območju jugozahodnega dela Posavskega hribovja in severnega dela Suhe krajine v centralni Sloveniji. Lokacije so označene s številkami od 1 do 70 kot v seznamu in opisu lokacij.

Family/Species	Locality number(s)
Papilionidae	
<i>Iphiclides podalirius</i> (Linnaeus, 1758)	3, 4, 6, 10, 13, 19, 22, 25, 26, 27, 28, 30, 31, 32, 36, 37, 41, 44, 45, 48, 50, 53, 54, 55, 63, 66, 68
<i>Papilio machaon</i> Linnaeus, 1758	3, 4, 23, 26, 28, 31, 33, 35, 43, 48, 49, 50, 51, 52, 53, 54, 55, 61, 62, 66, 68
<i>Parnassius mnemosyne</i> (Linnaeus, 1758)	3, 49
Pieridae	
<i>Leptidea morsei</i> (Fenton, 1881)	3, 4, 23
<i>Leptidea sinapis</i> (Linnaeus, 1758) / <i>Leptidea juvernica</i> Williams, 1946	3, 4, 5, 6, 7, 9, 10, 19, 22, 23, 24, 25, 26, 27, 28, 29, 31, 32, 34, 35, 37, 38, 41, 42, 43, 44, 45, 47, 55, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69
<i>Colias alfacariensis</i> Ribbe, 1905	3, 4, 26, 37, 44, 45, 49, 53, 59, 62
<i>Colias crocea</i> (Fourcroy, 1785)	3, 4, 6, 9, 10, 11, 13, 15, 18, 21, 22, 24, 25, 27, 36, 37, 41, 42, 44, 45, 46, 47, 48, 49, 50, 51, 54, 55, 59, 60, 61, 62, 63, 67, 68, 69
<i>Gonepteryx rhamni</i> (Linnaeus, 1758)	3, 4, 5, 6, 8, 9, 12, 13, 17, 20, 23, 24, 26, 27, 28, 30, 31, 32, 33, 35, 37, 38, 39, 40, 43, 45, 55, 58, 59, 60, 61, 62, 63, 66, 67, 68, 69
<i>Anthocharis cardamines</i> (Linnaeus, 1758)	3, 4, 9, 48, 49, 50, 51, 54, 59
<i>Aporia crataegi</i> (Linnaeus, 1758)	50, 68, 69
<i>Pieris brassicae</i> (Linnaeus, 1758)	3, 6, 19, 45, 49, 50, 51, 54, 62, 64, 68
<i>Pieris mannii</i> (Mayer, 1851)	4, 10, 48, 55, 64, 65, 66, 68
<i>Pieris napi</i> (Linnaeus, 1758)	4, 7, 14, 16, 18, 20, 21, 25, 27, 36, 38, 45, 64
<i>Pieris rapae</i> (Linnaeus, 1758)	3, 4, 5, 6, 10, 11, 13, 14, 16, 18, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 31, 32, 34, 36, 37, 38, 39, 41, 42, 44, 45, 55, 59, 60, 67, 68, 69
<i>Pontia edusa</i> (Fabricius, 1777)	48, 68
Lycaenidae	
<i>Lycaena alciphron</i> (Rottemburg, 1775)	61
<i>Lycaena dispar</i> (Haworth, 1802)	9, 37, 49, 50, 51, 54, 60, 68
<i>Lycaena hippothoe</i> (Linnaeus, 1761)	6, 13, 15, 20, 37, 45, 48, 49, 51, 54, 60, 63, 68, 69
<i>Lycaena phlaeas</i> (Linnaeus, 1761)	3, 4, 9, 19, 37, 48, 49, 50, 51, 52, 54, 55, 59, 62, 64, 67, 68, 69
<i>Lycaena tityrus</i> (Poda, 1761)	1, 3, 4, 5, 6, 9, 13, 19, 22, 23, 25, 26, 27, 30, 34, 35, 36, 37, 38, 40, 49, 51, 54, 55, 59, 61, 62, 63, 64, 65, 68, 69
<i>Lycaena virgaureae</i> (Linnaeus, 1758)	19
<i>Callophrys rubi</i> (Linnaeus, 1758)	3, 4, 50, 51, 54, 55
<i>Favonius quercus</i> (Linnaeus, 1758)	66
<i>Thecla betulae</i> (Linnaeus, 1758)	50, 53, 55
<i>Satyrrium acaciae</i> (Fabricius, 1787)	4, 10, 68, 69
<i>Satyrrium ilicis</i> (Esper, 1779)	67, 68, 69
<i>Satyrrium spini</i> (Denis & Schiffermüller, 1775)	3, 62
<i>Satyrrium w-album</i> (Knoch, 1782)	20, 38, 39, 45

Family/Species	Locality number(s)
<i>Aricia agestis</i> (Denis & Schiffermüller, 1775)	2, 3, 4, 6, 20, 22, 23, 26, 27, 28, 31, 32, 33, 34, 40, 48, 51, 54, 62, 63, 67, 68, 69
<i>Aricia artaxerxes</i> (Fabricius, 1793)	4, 6, 22, 29, 33, 34, 62, 69
<i>Celastrina argiolus</i> (Linnaeus, 1758)	3, 4, 10, 48, 49, 50, 51, 53, 54, 55, 60, 61, 62, 63, 66, 67, 68, 69
<i>Cupido argiades</i> (Pallas, 1771)	3, 4, 5, 9, 10, 20, 23, 36, 37, 42, 43, 45, 46, 48, 49, 50, 53, 59, 62, 63, 64, 67, 68, 69
<i>Cupido minimus</i> (Fuessly, 1775)	2, 3, 4, 5, 10, 34, 59, 62, 64, 70
<i>Cyaniris semiargus</i> (Rottemburg, 1775)	4
<i>Glauopsyche alexis</i> (Poda, 1761)	4, 50
<i>Leptotes pirithous</i> (Linnaeus, 1767)	9
<i>Cacyreus marshalli</i> Butler, 1898	68
<i>Lysandra bellargus</i> (Rottemburg, 1775)	2, 3, 4, 23, 29, 45, 47, 55, 59, 62, 63, 64, 68, 69
<i>Phengaris arion</i> (Linnaeus, 1758)	4, 6, 15, 19, 20, 29, 31, 37, 40, 43
<i>Plebejus argyrognomon</i> (Bergsträsser, 1779)	6, 46, 49, 55, 62, 69
<i>Plebejus argus</i> (Linnaeus, 1758)	1, 3, 4, 13, 14, 19, 20, 26, 31, 33, 34, 35, 36, 37, 40, 57, 59, 62, 63, 68, 69
<i>Plebejus idas</i> (Linnaeus, 1761)	5, 6, 43, 46, 60, 62, 63
<i>Polyommatus dorylas</i> (Denis & Schiffermüller, 1775)	34, 37, 59, 62, 63, 64, 69
<i>Polyommatus icarus</i> (Rottemburg, 1775)	1, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 31, 32, 33, 34, 35, 36, 37, 38, 40, 41, 42, 43, 44, 46, 47, 48, 55, 59, 60, 61, 62, 63, 64, 66, 67, 68, 69
<i>Polyommatus thersites</i> (Cantener, 1835)	3, 5, 59
<i>Pseudophilotes vicrama</i> (Moore, 1865)	10, 51
<i>Scolitantides orion</i> (Pallas, 1771)	4, 55
Riodinidae	
<i>Hamearis lucina</i> (Linnaeus, 1758)	4, 10, 19, 31, 38, 43, 45, 59
Nymphalidae	
<i>Apatura ilia</i> (Denis and Schiffermüller, 1775)	24, 48, 56
<i>Apatura iris</i> (Linnaeus, 1758)	1, 4, 28, 57, 67
<i>Limnitis camilla</i> (Linnaeus, 1764)	6, 39
<i>Limnitis reducta</i> Staudinger, 1901	4, 6, 19, 42, 50, 54, 62, 64, 65
<i>Neptis rivularis</i> (Scopoli, 1763)	4, 37, 38, 54, 56
<i>Neptis sappho</i> (Pallas, 1771)	19, 50, 54
<i>Argynnis paphia</i> (Linnaeus, 1758)	1, 3, 4, 6, 8, 11, 16, 18, 19, 24, 26, 27, 30, 31, 33, 37, 38, 41, 43, 45, 46, 50, 60, 62, 64, 66, 67, 68, 69
<i>Boloria dia</i> (Linnaeus, 1767)	3, 4, 5, 6, 10, 13, 22, 24, 29, 31, 34, 36, 37, 44, 45, 47, 48, 49, 50, 51, 52, 54, 55, 58, 59, 60, 61, 62, 63, 65, 66, 67, 68, 69
<i>Boloria euphrosyne</i> (Linnaeus, 1758)	3, 4, 5, 55
<i>Brenthis daphne</i> (Bergsträsser, 1780)	4, 6, 8, 10, 17, 22, 39, 42, 43, 50, 51, 60, 63, 67, 68, 69
<i>Brenthis hecate</i> (Denis and Schiffermüller, 1775)	3, 62, 63, 68, 69
<i>Brenthis ino</i> (Rottemburg, 1775)	16, 29, 46, 47, 68, 69
<i>Speyeria aglaja</i> (Linnaeus, 1758)	3, 41, 45
<i>Issoria lathonia</i> (Linnaeus, 1758)	9, 17, 41, 42, 44, 48, 49, 50, 51, 53, 54, 60, 61, 62, 66, 67, 68, 69

Family/Species	Locality number(s)
<i>Fabriciana adippe</i> (Denis & Schiffermüller, 1775)	9, 16, 20, 23, 38, 45, 50, 62, 69
<i>Aglaïs io</i> (Linnaeus, 1758)	4, 6, 9, 17, 19, 23, 37, 46, 48, 49, 50, 51, 52
<i>Aglaïs urticae</i> (Linnaeus, 1758)	1, 4, 48, 49, 50, 52, 54, 55, 62, 69
<i>Arachnia levana</i> (Linnaeus, 1758)	6, 8, 9, 12, 13, 16, 17, 18, 32, 35, 37, 38, 39, 42, 43, 44, 45, 46, 49, 50, 51, 52, 54, 59, 62, 64
<i>Vanessa atalanta</i> (Linnaeus, 1758)	4, 5, 6, 9, 12, 25, 26, 27, 28, 39, 42, 43, 48, 49, 50, 53, 55, 64, 66, 68, 69
<i>Vanessa cardui</i> (Linnaeus, 1758)	3, 4, 6, 7, 9, 10, 17, 18, 20, 22, 23, 33, 34, 35, 37, 38, 40, 41, 44, 47, 49, 52, 54, 59, 60, 61, 62, 66, 67, 68, 69, 70
<i>Polygonia c-album</i> (Linnaeus, 1758)	1, 3, 5, 6, 33, 38, 39, 42, 45, 48, 49, 50, 54, 56, 60, 64, 68, 69
<i>Euphydryas aurinia</i> (Rottemburg, 1775)	3, 4, 62, 63, 69
<i>Nymphalis polychloros</i> (Linnaeus, 1758)	9, 49
<i>Melitaea athalia</i> (Rottemburg, 1775)	3, 4, 5, 6, 9, 21, 23, 25, 26, 31, 32, 36, 37, 38, 39, 40, 43, 44, 45, 47, 50, 51, 53, 55, 59, 60, 61, 62, 63, 64, 65, 67, 68, 69, 70
<i>Melitaea aurelia</i> Nickerl, 1850	22, 43, 62, 68
<i>Melitaea britomartis</i> Assmann, 1847	62, 63, 68
<i>Melitaea cinxia</i> (Linnaeus, 1758)	2, 3, 4, 5, 6, 62, 63
<i>Melitaea diamina</i> (Lang, 1789)	6
<i>Melitaea didyma</i> (Esper, 1778)	3, 4, 7, 10, 18, 35, 36, 37, 50, 51, 55, 59, 60, 61, 62, 63, 64, 67, 68, 69
<i>Melitaea phoebe</i> (Denis & Schiffermüller, 1775)	2, 3, 5, 49, 51, 53, 55, 59, 60, 62, 63, 65
<i>Melitaea trivia</i> (Denis & Schiffermüller, 1775)	49, 50, 51, 54, 60, 67, 68
<i>Aphantopus hyperantus</i> (Linnaeus, 1758)	1, 3, 4, 6, 8, 10, 11, 13, 19, 20, 21, 22, 26, 27, 30, 31, 32, 35, 37, 38, 41, 42, 43, 45, 57
<i>Brintesia circe</i> (Fabricius, 1775)	26, 65, 67, 68
<i>Coenonympha arcania</i> (Linnaeus, 1761)	3, 4, 6, 51, 54, 59, 60, 61, 62, 63, 64, 65, 67, 68, 69
<i>Coenonympha glycerion</i> (Borkhausen, 1788)	1, 3, 4, 6, 50, 54, 59, 60, 61, 62, 63, 67, 68, 69, 70
<i>Coenonympha pamphilus</i> (Linnaeus, 1758)	1, 3, 4, 5, 6, 7, 9, 10, 15, 16, 18, 20, 21, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 37, 38, 41, 42, 43, 45, 47, 48, 49, 50, 55, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70
<i>Erebia aethiops</i> (Esper, 1777)	3, 4, 6, 10, 19, 27, 29, 34, 38, 45
<i>Hipparchia fagi</i> (Scopoli, 1763)	3, 4, 43, 47, 55
<i>Lasiommata maera</i> (Linnaeus, 1758)	4
<i>Lasiommata megera</i> (Linnaeus, 1767)	4, 25, 48, 49, 50, 51, 53, 54, 55, 66, 68
<i>Lopinga achine</i> (Scopoli, 1763)	3, 19, 68, 69
<i>Maniola jurtina</i> (Linnaeus, 1758)	1, 2, 3, 4, 5, 6, 7, 9, 10, 12, 13, 14, 15, 16, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 40, 41, 43, 44, 45, 46, 47, 51, 54, 59, 60, 61, 62, 63, 65, 66, 67, 68, 69, 70
<i>Melanargia galathea</i> (Linnaeus, 1758)	3, 4, 6, 7, 8, 10, 13, 14, 15, 19, 20, 22, 23, 25, 26, 27, 28, 29, 30, 31, 32, 34, 35, 38, 40, 46, 47, 50, 60, 61, 62, 63, 66, 67, 68, 69
<i>Minois dryas</i> (Scopoli, 1763)	3, 4, 19, 29, 31, 45, 46, 47, 57, 62, 64, 68, 69
<i>Pararge aegeria</i> (Linnaeus, 1758)	3, 4, 5, 6, 8, 19, 45, 49, 50, 51, 54, 55, 68

Family/Species	Locality number(s)
Hesperiidae	
<i>Heteropterus morpheus</i> (Pallas, 1771)	1, 3, 4, 6, 7, 8, 10, 13, 14, 15, 17, 19, 20, 22, 23, 26, 27, 28, 30, 31, 32, 33, 34, 37, 38, 39, 40, 41, 43, 44, 45, 47, 50
<i>Carterocephalus palaemon</i> (Pallas, 1771)	54, 63
<i>Hesperia comma</i> (Linnaeus, 1758)	3, 4, 33, 36, 55, 62, 63, 64, 68, 69
<i>Ochlodes sylvanus</i> (Esper, 1777)	1, 3, 4, 6, 8, 9, 10, 13, 16, 17, 18, 22, 23, 26, 27, 28, 29, 30, 31, 32, 32, 33, 34, 35, 37, 38, 39, 40, 41, 42, 43, 45, 47, 50, 62, 66, 67, 68, 69
<i>Thymelicus lineola</i> (Ochsenheimer, 1808)	3, 4, 10, 17, 19, 60, 62, 64, 67, 68, 69
<i>Thymelicus sylvestris</i> (Poda, 1761)	6, 7, 13, 17, 20, 22, 50, 62, 66, 67, 68, 69
<i>Carcharodus alceae</i> (Esper, 1780)	50, 51, 55, 60, 64, 66, 68
<i>Carcharodus floccifera</i> (Zeller, 1847)	49, 54, 62, 68, 69
<i>Erynnis tages</i> (Linnaeus, 1758)	3, 4, 5, 6, 8, 13, 15, 19, 22, 26, 29, 31, 37, 40, 44, 45, 49, 50, 53, 54, 55, 58, 59, 62, 63
<i>Pyrgus armoricanus</i> (Oberthür, 1910)	5, 37, 49, 59, 60, 61, 62, 64, 68, 69
<i>Pyrgus malvae</i> (Linnaeus, 1758)	32, 48, 49, 50, 51, 54, 67
<i>Spialia sertorius</i> (Hoffmannsegg, 1804)	4, 54, 62

Table 3. The list of butterfly species included in the Red list of butterflies of Slovenia (Ur. l. RS 2002), European red list of butterflies (Van Swaay et al. 2010), Regulation on protected wild animal species (Ur. l. RS 2004b) and/or Council directive on the conservation of natural habitats and of wild fauna and flora (Council Directive 92/43/EEC 1992).

Tabela 3. Seznam vrst dnevnih metuljev, vključenih na Rdeči seznam metuljev Slovenije (Ur. l. RS 2002), Evropski rdeči seznam metuljev (Van Swaay et al. 2010), Uredbo o zavarovanih prostoživečih živalskih vrstah (Ur. l. RS 2004b) in/ali na Direktivo Sveta o ohranjanju naravnih habitatov ter prostoživečih živalskih in rastlinskih vrst (Council Directive 92/43/EEC 1992).

Species	Inclusion in the Red list of butterflies of Slovenia (Ur. l. RS 2002)	Inclusion in the European red list of butterflies (Van Swaay et al. 2010):	Inclusion in the Regulation on protected wild animal species (Ur. l. RS 2004b)
<i>Parnassius mnemosyne</i> *	Vulnerable	Near threatened	×
<i>Pieris mannii</i>	Vulnerable	Least concerned	
<i>Lycaena alciphron</i>	Vulnerable	Near threatened	
<i>Lycaena hippothoe</i>	Vulnerable	Near threatened	
<i>Lycaena dispar</i> *	Vulnerable	Least concerned	×
<i>Leptidea morsei</i>	Vulnerable	Endangered	×
<i>Plebejus argyrognomon</i>	Vulnerable	Least concerned	
<i>Plebejus idas</i>	Vulnerable	Least concerned	
<i>Pseudophilotes vicrama</i>	Vulnerable	Near threatened	
<i>Scolitantides orion</i>	Vulnerable	Near threatened	
<i>Apatura ilia</i>	Vulnerable	Least concerned	
<i>Euphydryas aurinia</i> *	Vulnerable	Least concerned	×
<i>Melitaea aurelia</i>	Vulnerable	Near threatened	
<i>Melitaea britomartis</i>	Vulnerable	Near threatened	
<i>Melitaea diamina</i>	Vulnerable	Near threatened	
<i>Melitaea trivia</i>	Vulnerable	Near threatened	
<i>Carcharodus alceae</i>	Vulnerable	Least concerned	
<i>Pyrgus armoricanus</i>	Vulnerable	Least concerned	
<i>Phengaris arion</i> *	Vulnerable	Endangered	×
<i>Spialia sertorius</i>	Vulnerable	Least concerned	
<i>Carcharodus floccifera</i>	Endangered	Near threatened	×
<i>Polyommatus thersites</i>	Endangered	Least concerned	×
<i>Polyommatus dorylas</i>	Least concerned	Near threatened	
<i>Hipparchia fagi</i>	Least concerned	Near threatened	
<i>Lopinga achine</i> *	Least concerned	Vulnerable	×

* Species included in the Council Directive on the conservation of natural habitats and of wild fauna and flora (Council Directive 92/43/EEC 1992).

* Vrsta vključena na Direktivo Sveta o ohranjanju naravnih habitatov ter prostoživečih živalskih in rastlinskih vrst (Council Directive 92/43/EEC 1992).

Comments to selected species

Leptidea morsei (Fenton, 1881) (fam. Pieridae)

The isolated occurrence of the species at Gabrovka has been discovered during surveys carried out for the designation of Natura 2000 sites (Čelik et al. 2005) and the species has been monitored regularly at this location in the past years, with the results published in this article. The butterfly has been observed regularly, although in fluctuating numbers on Moravska Gora and its vicinity, where the distribution of its hostplant *Lathyrus niger* (L., 1753) Bernh., 1800 remains stable as well. We found *L. morsei* at a new locality at Volčja Jama village north of Žužemberk, where a single male of the second generation was observed in a clearing north of the village on 22.7.2019. The hostplant was also found at the location, occurring on south-facing slopes with sparse oak woods near the village. This suggests that the species is more common in the region than previously thought, as it was now also confirmed in northern Suha krajina, and not only in the vicinity of Moravska Gora in the southwestern parts of Posavsko hills. Consequently, additional surveys should be performed in these parts to consolidate the finding.

Cacyreus marshalli Butler, 1898 (fam. Lycaenidae)

This known allochthonous butterfly species occurs throughout the Mediterranean and was first discovered in Slovenia in 2008 (Verovnik et al. 2011). Despite its known dispersal potential, the only noteworthy range extension in the past few years in Slovenia was in the Soča Valley where it reached Bovec town (Verovnik et al. 2012; Verovnik, pers. obs.). There are only two records from central Slovenia, first from Kranj in 2010, where adults were observed inside a house where pelargoniums were kept over winter (Verovnik et al. 2011), and the second from Žirovski Vrh in the Poljanska Valley, where the butterfly was spotted sitting on a pelargonium plant in September 2020 (Tina Belej, pers. obs.). Its presence on a dry grassland near Žužemberk on 31.10.2022 was therefore unexpected. Given that it was observed also near Ljubljana at Pijava Gorica on 1.11.2022 (Šturm, pers. obs.) it is possible that the species had spread from the Primorska region during the late October heatwave (ARSO 2022). It is, however, unlikely that larvae or adults would have survived the harsh winters outdoors in Central Slovenia, for otherwise it would have been observed more regularly here in the past decade. It would be worth surveying the urban areas in the vicinity of the finds in the next autumn to check whether local populations have been established.

Aricia artaxerxes (Fabricius, 1793) (fam. Lycaenidae)

This species has been considered an exclusively Alpine species in Slovenia in the past (Carnelutti 1992). However, the surveys carried out in the last few decades have confirmed its much wider distribution including the Dinaric Mts in the south and even the sub-Pannonian region in the north east (Verovnik et al. 2012). It is, however, sparsely recorded from Central Slovenia with notable concentrations of records southwest of Mt Kum in northern Posavje (Verovnik, pers. obs.) and on the Sava River gravels north of Ljubljana (Verovnik, pers. obs.). We found the species at eight new localities from different parts of the surveyed areas, indicating its wider distribution in the region (Fig. 2). It is linked to unfertilized, flower-rich, dry, calcareous grasslands with abundance of sunrose (*Helianthemum* sp.), a likely hostplant of the species. Such grasslands are becoming increasingly rare and fragmented in Slovenia, and the species should therefore be considered threatened in lowlands, including the studied region.

Phengaris arion (Linnaeus, 1758) (fam. Lycaenidae)

This emblematic species is one of the most threatened butterflies in Europe (van Swaay et al. 2010) and is considered vulnerable in Slovenia (Ur. l. RS 2002). From the studied region it is only known from a historical record from Trebnje but was/is also present in the neighbouring regions to the north in the Posavje and Zasavje regions (Verovnik et al. 2012). We recorded the species at 10 localities, mostly in the northern part of the surveyed region (Fig. 2). This is somewhat surprising given the past survey efforts, however, most of the previous surveys of Natura 2000 species were done in late spring/early summer, thus outside the main flight period of the species (Verovnik et al. 2012). In the surveyed region *P. arion* utilizes different types of dry grasslands, also in the early stages of abandonment and overgrowing, and is highly sensitive to excessive fertilization and multiple mowing regimes (Van Swaay et al. 2012). Abandonment of mowing on steep south-facing slopes is possibly the main feature of most of the localities populated by the species in the region, therefore some sort of management will be required in the near future to sustain the existing habitat network.

Melitaea diamina (Lang, 1798) (fam. Nymphalidae)

This is a predominantly humid grassland species, although found also in dry, calcareous grasslands in western Slovenia (Verovnik et al. 2012). The species is listed as vulnerable in Slovenia (Ur. l. RS 2002) due to decline in suitable habitat, in particularly humid meadows and mires, which have mostly been turned into intensive grasslands with drainage, seeding and fertilization. The same trend is evident in the studied region where the species was found at several localities in the northern part during surveys at the beginning of the century (Verovnik et al. 2012). Many of these localities were revisited during our field work, but only a single population was reconfirmed in a small valley north of Ivančna Gorica at Potok settlement. Targeted surveys during first generation maximum might confirm a survivor of some additional populations, but in general, the humid grasslands deteriorated most severely in the studied region over the last two decades. They may still provide suitable habitat for some less sensitive hygrophilous specialist such as *Brenthis ino*, *L. dispar* and *L. hippothoe*, which are still widespread in the region, but further intensification could eliminate these species as well.

Hipparchia fagi (Scopoli, 1763) (fam. Nymphalidae)

This is a typical thermophilous shrubland and woodland species with sparse records from central Slovenia (Verovnik et al. 2012). From the studied region it was historically known only from Šentlovrenc near Trebnje (collection in the Slovenian Museum of Natural History). We recorded the species commonly on Moravska Gora above Gabrovka town along woodland edges, as well as in orchards and vineyards. Elsewhere, only single specimens were observed at Primskovo, which is quite near the historical record, on southern slopes of Mt Lisec, and north of Valična vas in a complex of dry grasslands. These new finds are likely a result of recent late summer surveys that were absent in the past, as the species is known from neighbouring regions (Verovnik et al. 2012), being particularly widespread in the Haloze region further northeast (Verovnik 2003).

Carcharodus alceae (Esper, 1780) (Hesperiidae)

Despite utilizing severely modified ruderal habitats including urban areas and intensive farmlands, the species is surprisingly rare in Central Slovenia, its strongholds being the sub-Pannonian eastern part of the country and the Primorska region in the west (Verovnik et al. 2012). In the studied region it was recorded only from a single locality near Gabrovka (Verovnik, pers. obs.), so addition of six new localities is significant. These are mainly concentrated in southern and eastern parts of the region (Fig. 2). It has been found in different habitats including a ruderal area near Valična vas in the south.

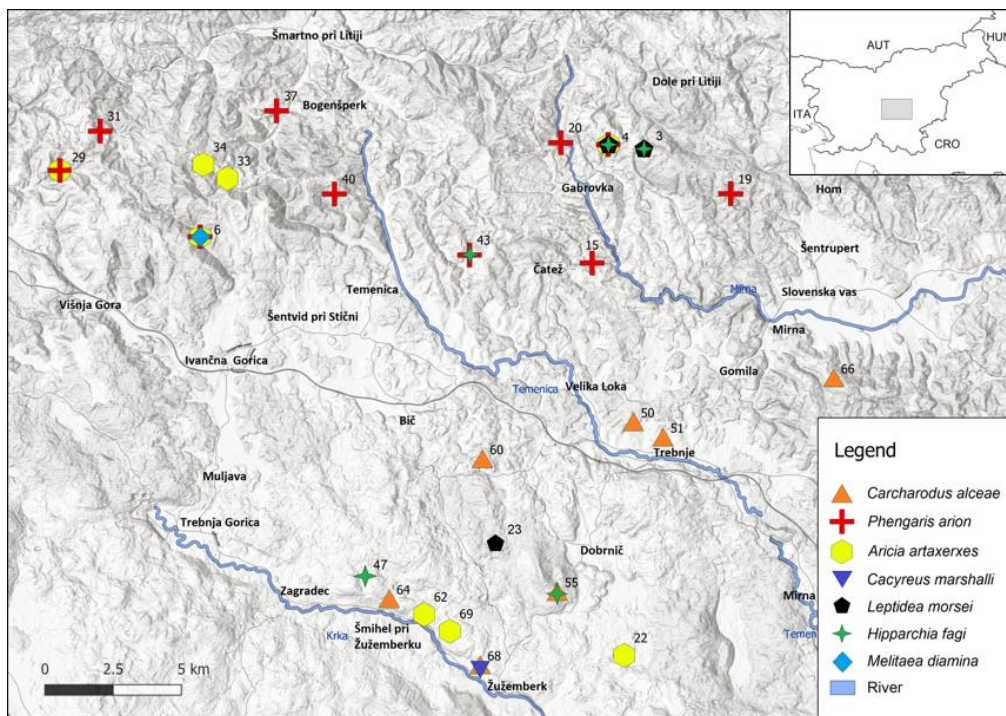


Figure 2. Distribution of *Leptidea morsei*, *Hipparchia fagi*, *Cacyreus marshalli*, *Melitaea diamina*, *Carcharodus alceae*, *Phengaris arion* and *Aricia artaxerxes* in the surveyed area of the southwestern Posavsko hills and northern Suha krajina. Numbers refer to localities listed in Tab. 1. The position of the surveyed area within the country is shown with a grey square in the upper right corner.

Slika 2. Razširjenost vrst *Leptidea morsei*, *Hipparchia fagi*, *Cacyreus marshalli*, *Melitaea diamina*, *Carcharodus alceae*, *Phengaris arion* in *Aricia artaxerxes* na območju jugozahodnega Posavskega hribovja in severne Suhe krajine. Številke označujejo lokacije, ki so navedene v Tab. 1. Položaj raziskovanega območja znotraj države je prikazan s črnim/sivim kvadratom zgoraj desno.

Concluding remarks

Several additional rare or rarely observed species include those with more sparsely seen adults such as *Thecla betulae*, *Favonius quercus*, *Satyrrium ilicis*, *Satyrrium acaciae*, *Satyrrium w-album*, and thermophilous species *Scolitantides orion*, *Pseudophilotes vicrama*, *P. thersites*, *Limenitis reducta*, and *Melitaea trivia*. Also noteworthy is the widespread occurrence of *Aphantopus hyperantus* and *Heteropterus morpheus*, both being only rarely recorded in the region in the past, as well as the observation of *B. hecate* on five localities, despite being thought to have almost disappeared from Central Slovenia (Verovnik et al. 2012). *Leptotes pirithous*, a known migratory species, has been observed once during the surveys.

Given the long list of butterfly species, the abundance of records of species of conservation concern, as well as local hot spots of butterfly diversity, the central Slovenia or, to be more precise, the southwestern Posavsko hills and northern Suha krajina, is grossly underrepresented within Natura 2000 network of Slovenia, or any other form of legally protected area. As this is unlikely to change, local initiatives are needed to preserve the most important localities, which would provide core areas for threatened species to survive. Although flower-rich, dry, calcareous grasslands still abound, in particular around Gabrovka and just north of the Krka Valley, both abandonment with overgrowing as well as intensification through pasturing and fertilisation in these areas are evident. These processes will inevitably lead to the decline of habitat specialist butterfly species that we were still able to record during our surveys. The situation is even worse for humid grasslands, as only small fragments are left, scattered mostly along small tributaries of major streams. Whether these are sufficient for maintaining local populations of threatened species remains to be studied through additional surveys. Land owners and local communities should be targeted to ensure maintaining or even enlarging the existing humid grassland areas, while the preservation of such habitats should be one of the ecological priorities of the country.

Povzetek

V članku predstavljamo popise dnevnih metuljev na območju centralne Slovenije (jugozahodni del Posavskega hribovja in severni del Suhe krajine), ki so potekali med letoma 2014 in 2022. Območje je bilo izbrano zaradi majhnega števila predhodnih terenskih podatkov, kjer znaten delež zajemajo pomembnejše najdbe pred letom 1990 (Verovnik et al. 2012). Metulje smo lovili z metuljnico in jih določevali na terenu s pomočjo ustrezne literature (Tolman & Lewington 2008). Posamezne lokacije vzorčenja smo izbrali na podlagi ohranjenosti habitatov, dostopnosti in predhodnih raziskav (Verovnik et al. 2012; Čelik 2013).

Na izbranem območju nam je v tem času uspelo zabeležiti 105 vrst metuljev, kar pomeni 60 % vseh najdenih vrst v Sloveniji (Verovnik et al. 2012). Večina vrst je bila najdena na vsaj treh lokacijah, medtem ko je bilo devet vrst najdenih na dveh in osem vrst na eni sami lokaciji. Vrste, ki smo jih našli na vsaj polovici lokacij, lahko štejemo med pogoste, med njimi pa so: *Colias crocea*, *Gonepteryx rhamni*, *Pieris rapae*, *Leptidea sinapis/juvernica*, *Polyommatus icarus*, *Coenonympha pamphilus*, *Maniola jurtina*, *Melanargia galathea*, in *Ochlodes sylvanus*. Te vrste so sicer pogoste tudi drugod v osrednji Sloveniji (Verovnik et al. 2012). Med najdenimi vrstami je bilo 22 takih, ki so vključene na rdeči seznam metuljev Slovenije (Ur. l. RS 2002), 15 takih, ki so vključene na seznam ogroženih metuljev v Evropi (Van Swaay et al. 2010), osem, ki so vključene v Uredbo o zavarovanih prosto živečih živalskih vrstah (Ur. l. RS 2004b), in pet takih, ki so vključene v Direktivo o ohranjanju naravnih habitatov ter prosto živečih živalskih in rastlinskih vrst (OJ EC 1992) (Tab. 3).

Največ vrst smo našli na lokacijah Moravska Gora, Žužemberk, Brezovo in Vrh pri Križu ter na lokaciji Vrhovo pri Žužemberku (Tab. 1). Lokaciji Brezovo in Moravska Gora sta blizu druga drugi na severnem delu območja, lokacije Vrh pri Križu, Vrhovo pri Žužemberku in Žužemberk pa ležijo na južnem robu območja prav tako blizu druga drugi. Med popisi nismo zabeležili osmih vrst, ki so bile predhodno na območju že najdene, smo pa nekaj vrst na območju zabeležili prvič (npr. *Cacyreus marshalli* in *Leptotes pirithous*). Za območje so precej pomembne tudi najdbe vrst *Leptidea morsei*, *Hipparchia fagi*, *Cacyreus marshalli* in *Melitaea diamina* ter še posebej vrste *Phengaris arion*, *Carcharodus alcea* in *Aricia artaxerxes*, ki smo jih našli na vsaj sedmih lokacijah (Sl. 2). Območje je glede na število najdenih vrst med najbolj pestrimi v Sloveniji, a ga podobno kot drugje v državi ogrožata zaraščanje ekstenzivnih travnikov in intenzivno pašništvo predvsem na suhih travnikih. Najbolj ogrožene so vrste, vezane na vlažne travnike, ki se fragmentirano pojavljajo le še ob manjših potokih v stranskih dolinah. Ker je celotno območje izredno slabo pokrito z območji, vključenimi v Natura 2000 (Ur. l. RS 2004a), velikemu številu bolj specializiranih vrst grozi izumrtje. Če želimo ohraniti pestrost tega dela države, bo zato treba opravljati tarčno usmerjene popise izbranih lokacij, predvsem pa k ohranjanju določenih habitatov (npr. vlažnih travnikov) spodbujati lokalno prebivalstvo in državo.

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First confirmation of variegated molehopper *Xya variegata* (Latreille, 1809) (Orthoptera: Tridactylidae) occurring in Slovenia

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Abstract. The occurrence of the variegated molehopper *Xya variegata* in Slovenia is confirmed unambiguously for the first time, based on observations of adults and larvae on 24. 3. 2023 and 2. 6. 2023 on the banks of a gravel pit along the Mura River, east of Petišovci in the Prekmurje region, northeastern Slovenia. Thus, the previously doubtful inclusion of the species in the checklist of Slovenian Orthoptera is now justified. Further research is needed to improve knowledge of its distribution and biology. A detailed assessment of the threat status and planning of conservation measures for this threatened and ecologically highly specialised grasshopper species should also be carried out.

Key words: grasshoppers, Caelifera, *Xya*, distribution, threat status, Slovenia

Izvelek. Prva potrditev pojavljanja pisane krtovke *Xya variegata* (Latreille, 1809) (Orthoptera: Tridactylidae) v Sloveniji – Pojavljanje pisane krtovke *Xya variegata* v Sloveniji je bilo prvič nedvoumno potrjeno z opazovanjem odraslih osebkov in ličink dne 24. 3. 2023 in 2. 6. 2023 na obrežju gramoznice ob reki Muri, vzhodno od Petišovcev v Prekmurju, severovzhodna Slovenija. S tem je doslej dvomljiva uvrstitev vrste na seznam kobilic Slovenije upravičena. Za izboljšanje znanja o razširjenosti in biologiji vrste so potrebne nadaljnje raziskave, tako kot tudi ocena stopnje ogroženosti in načrtovanje ohranitvenih ukrepov za to ogroženo, ekološko zelo specializirano vrsto kobilic.

Gljučne besede: kobilice, kratkotipalčnice, *Xya*, razširjenost, ogroženost, Slovenija

Introduction

The genus *Xya* is represented in Central Europe by two species, viz. Pfaendler's molehopper *X. pfaendleri* (Harz, 1970) and colourful molehopper *X. variegata* (Latreille, 1809). Both are only a few millimetres in size, their colouration is dark brown to black, with varying pattern of light markings. With their very peculiar appearance, they somewhat resemble tiny mole crickets. They are ecologically highly specialised grasshopper species with modified forelegs for digging typical small sand galleries and tunnels on the banks of various types of standing waters and rivers. With some experience, the colourful molehopper is rather easily distinguished from its



congener by a different pattern and more pronounced whitish markings on the thorax, terga, and legs. The lateral lobes of the pronotum have a characteristic wide whitish margin ventrally, whereas in Pfaendler's molehopper the pronotum is uniformly black with a coppery sheen and a very small light pronotum marking usually restricted to its posterior ventrolateral margin only (Zechner 2017a, 2017b; Bellmann et al. 2019; Iorio et al. 2019).

While Pfaendler's molehopper is more common in Slovenia and is currently known from nearly 40 localities in the northeastern and southeastern parts of the country (M. Bedjanič, unpubl.), the occurrence of the colourful molehopper in Slovenia has been considered dubious and has not been unambiguously confirmed so far (e.g. Gomboc et al. 2000, 2006). The presence of the species in western Slovenia, without concrete faunistic data or specimens in collections, was indicated in the monograph *Fauna of Orthopteroidea in Slovenia* by Us (1992) as »... In Slovenia they are in Primorska region«. It is important to note that the manuscript for the mentioned monograph was submitted just before the author's death in 1976 and was published posthumously a decade and a half later (Us 1992). In his brief description of the species under the old name *Tridactylus variegatus*, the characters of both mentioned *Xya* species can be recognized, so it is likely that the description of *X. pfaendleri* by K. Harz in 1970 (Harz 1970) was not known to the author at the time the manuscript was being prepared.

Based on the general statement mentioning the occurrence of the colourful molehopper in the Primorska region (Us 1992), it was included in the first Red List of endangered Orthopteroidea in Slovenia as »Insufficiently known« (Matvejev 1992). The statement by Us (1992) was repeated in Gomboc (2003), and subsequently the species was also included in the checklist of Orthoptera in Slovenia (Gomboc & Šegula 2014). However, in the recent comprehensive reviews of the grasshopper fauna of e.g. Vipavska dolina and Slovenian Istria in western Slovenia, the colourful molehopper was not listed (Gomboc 2013, 2019), with searches in other parts of Slovenia in the past not yielding any results either.

Material and methods

With the specific aim of studying the distribution and phenology of *Xya* grasshoppers, I visited some gravel pits in the Prekmurje region in spring 2023, including the Lakoš gravel pit (WGS84 Lat./Long.: 46.532140 °N, 16.418997 °E; alt. 162 m) along the Mura River, 1.6 km east of Petišovci, very close to the Croatian border. The gravel pit covers about 14.7 ha, it is filled with groundwater and has been abandoned a few years ago after the cessation of commercial gravel extraction that had started app. two decades ago. In its northern and northeastern portions, the banks are sparsely vegetated, with extensive areas of bare sandy and gravelly ground and southern exposure, providing an ideal habitat for molehoppers (Fig. 1).



Figure 1. Lakoš gravel pit along the Mura River near Petišovci in Prekmurje region, where the variegated molehopper *Xya variegata* was observed in late March and early June 2023: (a) 24. 3. 2023, (b) 2. 6. 2023 (photo: M. Bedjanič).

Slika 1. Gramoznica Lakoš ob reki Muri v bližini Petišovcev v Prekmurju, kjer je bila pisana krtovka *Xya variegata* opazovana konec marca in v začetku junija 2023: (a) 24. 3. 2023, (b) 2. 6. 2023 (foto: M. Bedjanič).

The locality was visited twice, on the afternoon of 24. 3. 2023 when the weather was partly cloudy with a pleasant temperature of 23 °C, and on 2. 6. 2023 in the afternoon when it was mostly sunny and windy, at 25 °C. On both occasions, the northeastern banks of the gravel pit were examined for molehoppers by careful visual inspection of suitable patches, aided by Pentax Papilio II binoculars (8.5 × 21, macro focusing distance 50 cm).

Results and discussion

The targeted survey for the presence of *Xya* grasshoppers at Lakoš gravel pit on 24. 3. 2023 soon revealed signs of molehoppers' presence in the form of typical small sand galleries. Only a moment later, to the great surprise and excitement of the observer, the first individual of *X. variegata* was sighted and photographed. Syntopically, *X. pfaendleri* was also observed. In total, I observed 5 adult individuals and 5 larvae of the colourful molehopper and 30 adult individuals and 20 larvae of Pfaendler's molehopper. I revisited the Lakoš gravel pit on 2. 6. 2023. Colonies of both *X. variegata* and *X. pfaendleri* were sighted in the northeastern part of the gravel pit. Individuals of both species, larvae and adults, shared the same patches of suitable habitat, with no apparent interactions or aggression (Figs. 2, 3).



Figure 2. Variegated molehopper *Xya variegata* – adult individual at Lakoš gravel pit near Petišovci, on 2. 6. 2023 (photo: M. Bedjanič).

Slika 2. Pisana krtovka *Xya variegata* – odrasel osebek pri gramoznici Lakoš v bližini Petišovcev, dne 2. 6. 2023 (foto: M. Bedjanič).



Figure 3. Syntopic occurrence of variegated molehopper *Xya variegata* and Pfaendler's molehopper *X. pfaendleri* at Lakoš gravel pit near Petišovci on 2. 6. 2023 - larva of *X. variegata* (left) and two adult individuals of *X. pfaendleri* (right) (photo: M. Bedjanič).

Slika 3. Sintopično pojavljanje pisane krtočke *Xya variegata* in pritlikave krtočke *X. pfaendleri* v gramoznici Lakoš v bližini Petišovcev dne 2. 6. 2023 – ličinka *Xya variegata* (levo) in dva odrasla osebka *X. pfaendleri* (desno) (foto: M. Bedjanič).

In total, I observed between 50 and 100 adult individuals and larvae of the colourful molehopper, as well as 50–100 adult individuals and larvae of Pfaendler's molehopper. Of the other orthopterans, a few undetermined Tetrigidae individuals and numerous larvae and adults of the marsh cricket *Pteronemobius heydenii* (Fischer, 1853) were recorded. For *X. variegata*, these are the first confirmed faunistic records from Slovenia (Fig. 4). Thus, the previously doubtful inclusion of the species in the checklist of Slovenian Orthoptera is now justified.

Based on the known European range of the colourful molehopper (Harz 1975; Hochkirch et al. 2016a; Bellmann et al. 2019; Iorio et al. 2019), its occurrence in Slovenia was expected. The new records from northeastern Slovenia are not extremely surprising, as the species has already been recorded in neighbouring countries on the eastern outskirts of the Pannonian Lowlands. In Austria, *X. variegata* was found for the first time at around the turn of the millennium (Berg et al. 2000). Since then, supplementary records have been added. The species is largely restricted to the Austrian Pannonian region, with two additional isolated sites in the Lafnitz River valley in Styria and Southern Burgenland (Russ 2006; Zechner 2017b). According to Skejo et al. (2018), it is known with certainty in Croatia from two localities in Hrvatsko Zagorje. Scattered old records from the former Yugoslavia and the Balkan Peninsula (e.g. Us 1938, 1964; Us & Matvejev 1967) should be revised, as Pfaendler's molehopper, which occurs in eastern and southeastern Europe and further to the east, was described only in 1970 (Harz 1970). Additionally, in parts of eastern and southeastern Europe, both species are sympatric and occasionally syntopic (e.g. Harz 1975; Berg et al. 2000; Russ 2006; Zechner 2017b). Records from Slovenia (Gomboc et al. 2000; M. Bedjanič, unpubl.) and elsewhere (e.g. Harz 1970, 1975; Pavićević et al. 2014; Zehner et al. 2017a; Ivković et al. 2018; Puskás et al. 2018; Čato & Zagorac 2021) suggest that Pfaendler's molehopper is the more common of the two species in the lowlands of the wider Pannonian region.

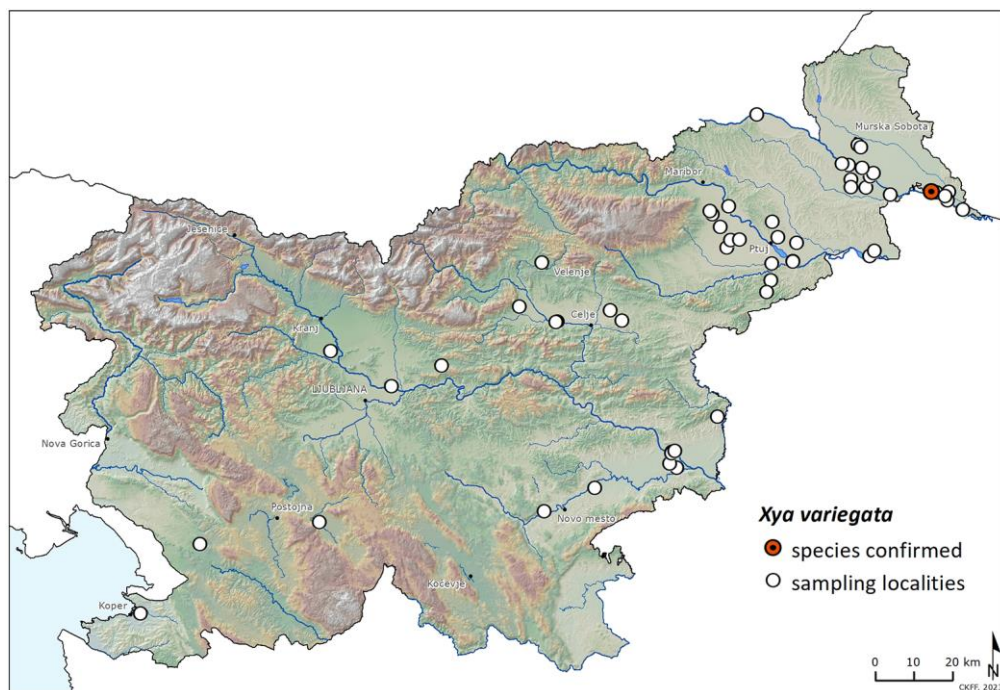


Figure 4. Distribution map of variegated molehopper *Xya variegata* in Slovenia, with white circles indicating the localities visited by the author between September 2021 and June 2023, at which the species was not recorded despite the targeted search.

Slika 4. Zemljevid razširjenosti pisane krtočke *Xya variegata* v Sloveniji. Beli krožci ponazarjajo lokalitete, ki jih je avtor obiskal med septembrom 2021 in junijem 2023 in kjer vrsta kljub ciljnemu iskanju ni bila zabeležena.

Due to its wide distribution from North Africa and Mediterranean Europe to South-East Asia and locally abundant occurrences in some parts of southern Europe, the colourful molehopper is listed as a Least Concern (LC) species in the European Red List of Grasshoppers, Crickets and Bush-crickets (Hochkirch et al. 2016b). However, regional differences and generally decreasing population trend are noted (Hochkirch et al. 2016a). For example, it is Extinct (EX) in Switzerland (Hochkirch 2016a), in the whole of Austria it is considered Data Deficient (DD) (Zechner 2017b), while in Styria it has recently been assessed as a Critically Endangered (CR) species (Zechner et al. 2021).

Hitherto the only known locality of *X. variegata* in Slovenia is located within the Natura 2000 site Mura (SI3000215) and the transboundary Mura-Drava-Danube UNESCO Biosphere Reserve, so at least formally some degree of the species' habitat protection and appropriate management should be ensured. However, due to the lack of the formal legal status of this tiny grasshopper species as highly threatened regionally and in Slovenia, conservation efforts confronting potential threats may prove to be difficult. Although further targeted fieldwork and research is needed for a detailed assessment of its threat status and planning of conservation measures, it is certain that *X. variegata* will be listed among endangered species in a badly needed update of the *Red List of Threatened Animal Species* in Slovenia.

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Addition to the knowledge on the moth fauna (Insecta: Lepidoptera) of Bosnia and Herzegovina and Croatia

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Abstract. Additions to the moth fauna of Bosnia and Herzegovina and Croatia are given. We report on first observations of five species and on reconfirmation of one species after eight decades. In Croatia, we recorded the species *Eublemma cochylioides* (Guenée, 1852) for the first time, while *Eublemma himmighoffeni* (Millière, 1867) has been confirmed in the country after 85 years. We report on the first observation of five moth species for Bosnia and Herzegovina: *Triodia adriaticus* (Osthelder, 1931), *Eumera regina* Staudinger, 1892, *Dryobotodes monochroma* (Esper, 1790), *Lithophane lapidea* (Hübner, [1808]) and *Nycteola columbana* (Turner, 1925). Even though these records could be expected due to species general distributions, they fill the knowledge of moth diversity of both countries and the wider region.

Key words: Hepialidae, Geometridae, Erebidae, Nolidae, Noctuidae, distribution, diversity

Izvleček. Prispevek k favni nočnih metuljev (Insecta: Lepidoptera) Bosne in Hercegovine in Hrvaške – V prispevku podajamo nove podatke o nočnih metuljih v Bosni in Hercegovini ter na Hrvaškem, s prvimi opažanji petih vrst in ponovno potrditvijo ene vrste po več kot osem desetletjih. Na Hrvaškem smo prvič zabeležili vrsto *Eublemma cochylioides* (Guenée, 1852), medtem ko je bila *Eublemma himmighoffeni* (Millière, 1867) ponovno najdena po 85 letih. V Bosni in Hercegovini smo našli pet novih vrst za državo: *Triodia adriaticus* (Osthelder, 1931), *Eumera regina* Staudinger, 1892, *Dryobotodes monochroma* (Esper, 1790), *Lithophane lapidea* (Hübner, [1808]) in *Nycteola columbana* (Turner, 1925). Čeprav je bilo te vrste mogoče pričakovati glede na njihovo splošno razširjenost, naši podatki dopolnjujejo poznavanje raznolikosti nočnih metuljev v obeh državah in v regiji.

Gljučne besede: Hepialidae, Geometridae, Erebidae, Nolidae, Noctuidae, razširjenost, raznovrstnost

Introduction

In the beginning of the 20th century, an impressive work was published that covered the previously unknown moth fauna of Bosnia and Herzegovina (Rebel 1904a) and which today serves as a landmark for all who research the butterfly and moth fauna of the country. Afterwards, only a few papers dealing with the moths of Bosnia and Herzegovina were published



(Schawerda 1918; Stauder 1925, 1926, 1929, 1930, 1933), most of which have been consolidated in the revision of the list (Lelo 2004). Still, in comparison with the neighbouring countries, the moth diversity of Bosnia and Herzegovina is far from sufficient (Plant & Jakšić 2018) and records of additional species of almost all moth families are expected.

In Croatia the moth fauna, especially Macroheterocera, has been studied in greater detail, and for the larger families published and unpublished checklists exist (Kučinić 1997; Koren 2012; Mihoci 2012; Gumhalter 2019) rendering it easier to put any records in the comparative perspective.

During the recent years, several new and/or interesting moth species have been recorded in Bosnia and Herzegovina (Hanjalić & Lelo 2015; Koren & Kulijer 2020; Koren & Martinović 2020; Beshkov & Nahirnić-Beshkova 2021; Koren et al. 2021, 2022a), as well as in Croatia (Mrnjavčić Vojvoda et al. 2014; Koren & Gomboc 2015; Koren & Kulijer 2020).

In this work the records of additional six species are presented, five new to Bosnia and Herzegovina and one new to the fauna of Croatia, with one reconfirmation of the species after over eight decades.

Materials and methods

This report covers our observations from the 2020–2022 period in Bosnia and Herzegovina and Croatia (Tab. 1).

The study in Bosnia and Herzegovina was mainly conducted on the Klek peninsula and the nearby mainland, while the study in Croatia was conducted within the Klek settlement and the mainland south of the border with Bosnia and Herzegovina. Two main light-trapping methods were used. The main method applied was the pyramid-shaped collecting tent comprising a metal frame and two 15W UV lamps (604 nm) connected to a 12 V battery and covered with a white canvas. Six traps were used, distanced about ten meters apart. The second method implied the usage of two 6W 12V portable heath moth traps with actinic UV-A lamps (350–400 nm) which were set in the dusk and left on site and collected the following morning. Three portable heath moth traps were used per locality and night. In addition, in Klek settlement, Croatia, a 100W mercury light bulb put on a terrace was used to attract moths.

The android application and digital platform Biologer were used to record field data during this research (Popović et al. 2020). The specimens were identified and are stored in the collection of T. Koren. For each record, the exact locality, coordinates, altitude, and dates are provided.

Table 1. The list of localities with methods used and new records of moth species in Bosnia and Herzegovina and Croatia. Abbreviations: DK – Dejan Kuljer, TK – Toni Koren. Coordinates are in WGS84 decimal degrees.

Tabela 1. Seznam lokalitet z uporabljenimi metodami in novimi podatki za nočne metulje Bosne in Hercegovine in Hrvatske. Okrajšave: DK – Dejan Kuljer, TK – Toni Koren. Koordinate so v WGS84 decimalnih stopinjah.

No.	Location	Method	Date (Observer)	Species
1	House at Opuće settlement, Neum, BIH; 42.927186° N, 17.572877° E, 40 m a.s.l.	portable heath moth traps	1.10.2021 (DK)	<i>Triodia adriaticus</i>
2	Opuće settlement, northern part, Neum, BIH; 42.928529° N, 17.572879° E, 35 m a.s.l.	portable heath moth traps	16.10.2021 (DK) 19.10.2021 (DK)	<i>Dryobotodes monochroma</i> <i>Lithophane lapidea</i>
3	Konštar locality, Neum city, BIH; 42.930888° N, 17.658310° E, 175 m a.s.l.	portable heath moth traps	14.9.2020 (DK)	<i>Eumera regina</i> <i>Nycteola columbana</i>
4	Gradina locality, Neum city, BIH; 42.932013° N, 17.684761° E, 200 m a.s.l.	portable heath moth traps	16.9.2020 (DK)	<i>Eumera regina</i>
5	Klek settlement, CRO; 42.946881° N, 17.56341° E, 81 m a.s.l.	mercury light bulb	9.10.2022 (DK)	<i>Eublemma cochylionides</i>
6	Slopes on the eastern side of the bay, grasslands, and overgrown agricultural land, Zaton, Dubrovnik, CRO; 42.696625° N, 18.048319° E, 55 m a.s.l.	pyramid-shaped tents	27.5.2021 (TK)	<i>Eublemma himmighoffeni</i>

Results and discussion

In total, the records of seven moth species are presented, five being recorded for the first time in Bosnia and Herzegovina, one in Croatia and one rediscovered in Croatia after 85 years. The species were registered at six different localities (Fig. 1).

The species *Triodia adriaticus* (Osthelder, 1931) (fam. Hepialidae) was found for the first time in Bosnia and Herzegovina, Opuće settlement (Loc. 1; Tab. 1, Fig. 1). This species inhabits parts of south-eastern Europe, from Istria in Croatia, across the Adriatic coastline to Macedonia, Albania (Beshkov 1994), Ionian Sea coast, Korfu and Peloponnesus in Greece (de Freina and Witt 1990). This species is usually numerous in favourable habitats and can be attracted to light sources in high numbers. No previous records of this species exist for Bosnia and Herzegovina, but its occurrence was expected due to the probably continuous distribution along the Adriatic coastline (Koren 2020).

The species *Eumera regina* Staudinger, 1892 (fam. Geometridae) was found for the first time for Bosnia and Herzegovina, at two different localities, Konštar (Loc. 3; Tab. 1, Fig. 1) and Gradina (Loc. 4; Tab. 1, Fig. 1). This is a unique and striking Geometridae moth that cannot be confused with any other species due to the forewing terminal area being yellowish pink with two white dots (Fig. 2a) (Skou & Sihvonen 2015). Within Europe, the distribution of this species is restricted to the Balkan Peninsula and ranges from Dalmatia (Croatia) to Greece (Skou & Sihvonen 2015). No previous records of this species exist for Bosnia and Herzegovina, but its

occurrence was expected due to recent records of *E. regina* in the Neretva River Delta (Koren, unpubl.), just several kilometres west of the localities where the species was found in Bosnia and Herzegovina. It was recorded in a habitat typical of this species in the region, karst grasslands surrounded by maquis (Fig. 2b).

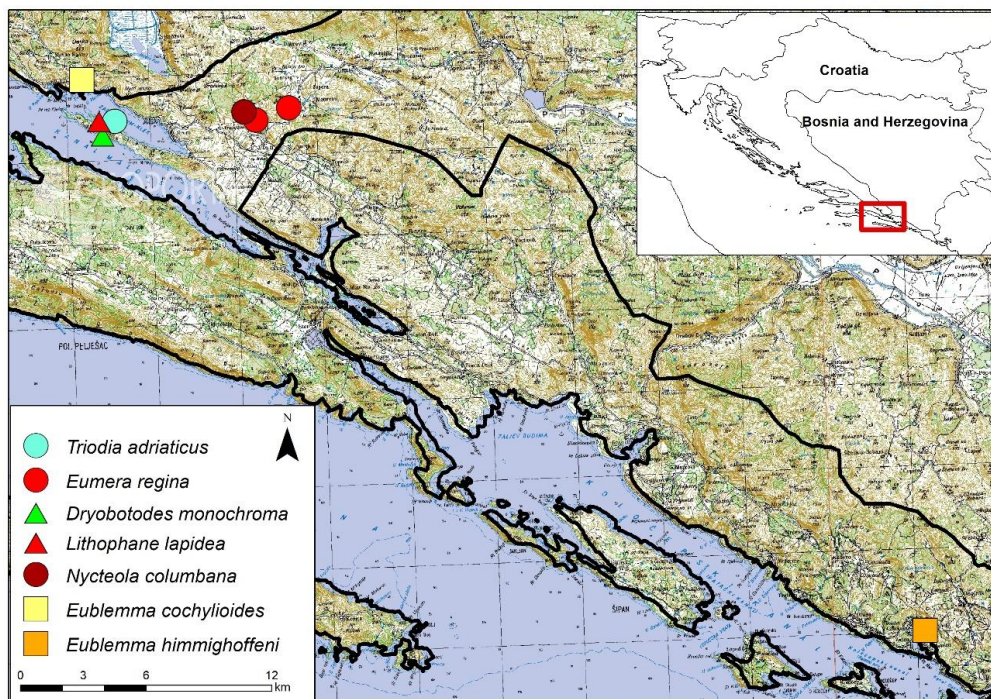


Figure 1. Distribution of the newly recorded moth species in Bosnia and Herzegovina & Croatia.

Slika 1. Razširjenost novo zabeleženih vrst nočnih metuljev v Bosni in Hercegovini in na Hrvaškem.

The species *Dryobotodes monochroma* (Esper, 1790) (fam. Noctuidae) was found for the first time in Bosnia and Herzegovina (Rebel 1904a; Lelo 2004), recorded on two different dates at Opuće settlement (Loc. 2; Tab. 1, Fig. 1). This is a Holo-Ponto-Mediterranean species with its northern distribution limit in Central Europe (Ronkay et al. 2001). The map presented in the Noctuidae Europaeae series (Ronkay et al. 2001) is misleading, as it includes the whole Balkan Peninsula and its countries. For Croatia and Bosnia and Herzegovina, this does not hold true. In Croatia, this species is, according to the newly gathered data (Koren, unpubl.) and historical records (Rebel 1912; Schwingenschuss & Wagner 1926; Stauder 1926), present only on the Mediterranean coastline, while in Bosnia and Herzegovina there have been no records of this species so far (Rebel 1904a; Lelo 2004). Thus, the presence of this species in the Mediterranean part of Bosnia and Herzegovina was expected. The identification was confirmed by the examination of male genital structures in order to distinguish it from the very similar *Dryobotodes servadeii* Parenzan, 1982 (Ronkay et al. 2001).

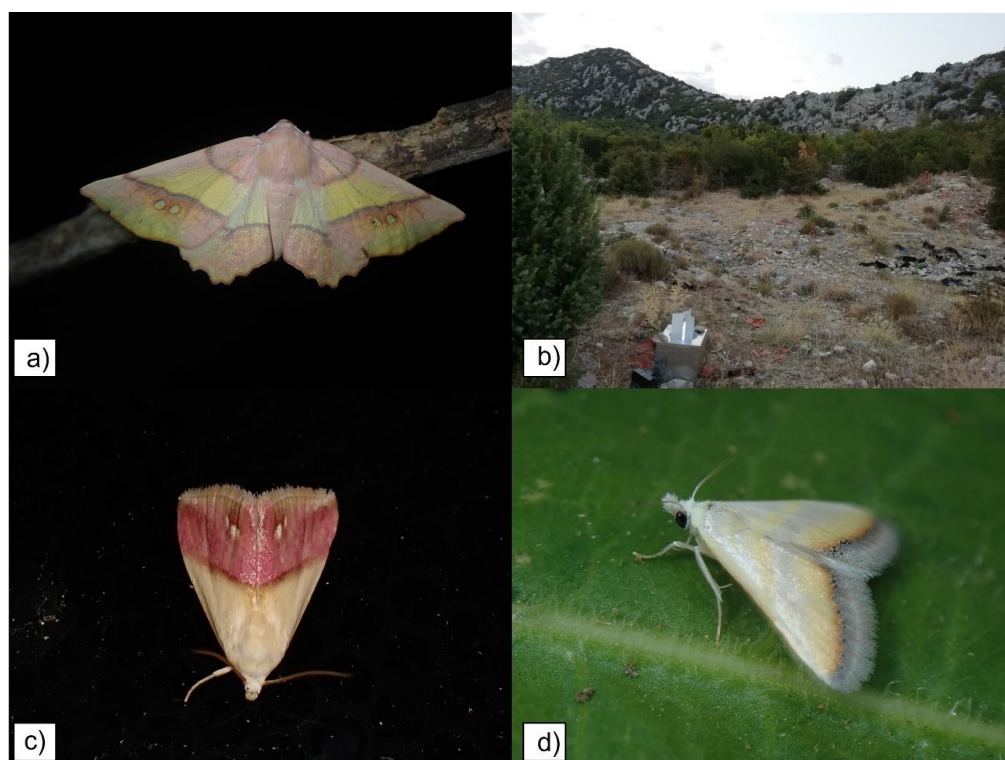


Figure 2. Photos of three moth species, found in Bosnia and Herzegovina and Croatia: a) *Eumera regina* from Gradina, b) habitat of *E. regina* at Gradina, c) *Eublemma cochylioides* from Klek settlement, d) *Eublemma himmighoffeni* from Zaton. For the localities, see Tab. 1. Photo: T. Koren (a, d), D. Kulijer (b, c).

Slika 2. Fotografije trih vrst noćnih metuljev, najdenih v Bosni in Hercegovini in na Hrvaskem: a) *Eumera regina* z lokalitete Gradina, b) habitat vrste *E. regina* na lokaliteti Gradina, c) *Eublemma cochylioides* iz naselja Klek, d) *Eublemma himmighoffeni* z lokacije Zaton. Za lokalitete glej Tab. 1. Foto: T. Koren (a, d), D. Kulijer (b, c).

The second species of the family Noctuidae, *Lithophane lapidea* (Hübner, [1808]), was recorded at the second locality near Opuće settlement (Loc. 2; Tab. 1, Fig. 1), which is the first observation for Bosnia and Herzegovina. This is a Ponto-Mediterranean species in Europe occurring in France, northern and central Italy and across the Balkan Peninsula (Ronkay et al. 2001). In neighbouring Croatia, it is a fairly common species along the Adriatic coastline from Istria in the north (Koren 2022) down to the southern part of the country. Thus, the presence in the Mediterranean part of Bosnia and Herzegovina was expected.

The species *Nycteola columbana* (Turner, 1925) (fam. Nolidae) was found at Konštar locality (Loc. 3; Tab. 1, Fig. 1) for the first time in Bosnia and Herzegovina (Rebel 1904b; Lelo 2004). This is an Eurasian species, distributed in southern parts of Europe, northern Africa and the Middle East (Fibiger et al. 2009). It is very similar to other members of the genus *Nycteola* and the correct identification was confirmed by examining the genital structures (Fibiger et al. 2009).

The species *Eublemma cochylioides* (Guenée, 1852) (fam. Erebidae) (Fig. 2c) was found for the first time in Croatia at Klek settlement (Loc. 5; Tab. 1, Fig. 1). This is a variable species with the forewing colour ranging from yellow to pink. Especially notable are the specimens with the half of the forewing coloured yellow and half pink as is the case with the specimen from Klek (Fig. 2c). This individual was observed and photographed only when reaching a mercury bulb positioned at the external side of the house. Due to the unique appearance, its identification was possible even without catching the individual.

The species *E. cochylioides* is a tropical species with disjunct distribution in Europe, Africa, Middle East to SE Asia, all to Australia (Fibiger et al. 2010). Recently, the spreading of this species has been noted in northern Europe and recorded up to Great Britain (Hatton et al. 2022). This species inhabits open, steppe-like habitats. Adults fly from September to November. Larvae feed on different Asteraceae species (Fibiger et al. 2010). This is not only the first record in Croatia, but also the northernmost record along the Adriatic coast. While the migrating behaviour is known in this species (Hatton et al. 2022), it is possible that it was just overlooked during previous surveys and is indeed native to the area.

The second species of the Erebidae family, *Eublemma himmighoffeni* (Millière, 1867) (Fig. 2d), was found at Zaton in Croatia (Loc. 6; Tab. 1, Fig. 1). This is a small and easily recognizable member of the genus *Eublemma* due to its forewing colouration. For this species, only one reliable record exists in the literature for Croatia, Gruž (Gravosa) in Dubrovnik city (Schwingschuss & Wagner 1926). Stauder (1927) mentioned the presence of this species in Dalmatia, but without exact locations. The second record of the species, also from Gruž, is available on the web portal lepiforum.de with the following data: Dalmatia, Gravosa - Zaton, 1.–8.10.1936 H. Fabigan (Lepiforum e.V. 2021). While the new record from Croatia reported herewith is not far from the previously known area of this species around Dubrovnik, it represents the first confirmed record of the species in the country after 85 years.

The known flight period of this species is from the end of June till the end of August (Fibiger et al. 2010) and up to mid-September (Beshkov 1994), but our record from Croatia shows that this species is active even earlier, at the end of May. It inhabits dry grassland habitats near the coast (Fibiger et al. 2010), which concurs with our observations (Tab. 1).

Conclusions

Many species are being recorded in the Mediterranean part of the Bosnia and Herzegovina region, mostly the Neum and Klek peninsula areas. Here, the political border of Croatia is discontinued, with part of the coastline and the sea belonging to Bosnia and Herzegovina. Thus, it is the hotspot for recording Mediterranean species in the country, such as the ones presented in this work, that have not been recorded in the country so far. It is most likely that many of these species are present also within the mainland Herzegovina, as is the case with Mediterranean butterfly species (Lelo 2008; Koren et al. 2019; Koren et al. 2022b), but this should be investigated with additional surveys.

The Klek Peninsula and the small territory around Neum are the only parts of Bosnia and Herzegovina with characteristic Eumediterranean and maritime habitats and therefore highly valuable for the overall biodiversity of the country. For several true Mediterranean plant species and habitat types, this is the sole area where they occur on the territory of Bosnia and Herzegovina (Kutleša & Lakušić 1964; Maslo & Milanović 2022). Due to the restricted range in the country, tourism development and related urbanization and construction of infrastructure, Mediterranean habitats and the species that inhabit them are under significant and growing threat.

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The first record of the Monkey goby *Neogobius fluviatilis* (Pallas, 1814) (Pisces: Gobiidae) in Slovenia

Prva opisana najdba rečnega glavoča *Neogobius fluviatilis* (Pallas, 1814) (Pisces: Gobiidae) v Sloveniji

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The first confirmed presence of the Monkey goby fish species, *Neogobius fluviatilis* (Pallas, 1814) in Slovenia has been recorded in August 2021. During regular Fisheries Research Institute of Slovenia surveys, nine individuals were caught in Ledava River within Murska šuma near the town Pince (Lat: 46.500556, Lon: 16.531944). Ledava River is lowland watercourse with minimal discharge of 0,145 m³/s recorded at Čentiba station in 2003 (ARSO 2022).

The Monkey goby species can be distinguished from related species by the length of the first branched ray in the secondary dorsal fin (Kotelat & Freyhoff 2007). The first branched ray is twice as long as the penultimate ray. In 2022, specimens from Ledava River were also genetically confirmed at the Chair of Genetics, Animal Biotechnology and Immunology at

Biotechnical Faculty, University of Ljubljana (Sušnik S., pers. comm.). In a 100 m long river transect with an average water depth of 0.7 m and wetted width of 5 m, the specimens were caught using the electrofishing backpack sampling method. Specimens measured from 39 to 65 mm in total length, while it is reported that Monkey goby can reach from 100 mm to 200 mm in length (Kotelat & Freyhoff 2007; Placha et al. 2010; Grabowska 2011; Staszny et al. 2022). In the Ledava River, Monkey gobies were found in runs, hidden under stones and rocks, which represented the dominant substrate fraction (60%) of the riverbed. This is rather surprising, as the species is considered to spend most of its time on sandy substrates (Kotelat & Freyhoff 2007). However, the recent book on invasive animal species in Hungary suggest that monkey gobies actually prefer stony bottoms, and their presence on sandy bottoms is a consequence of competition with sister species (Staszny et al. 2022). Monkey goby lives up to 5 years and it spawns for the first time in the second year (Smirnov 1986; Kotelat & Freyhoff 2007). Females can spawn a few times per season. Adhesive eggs are deposited on stones, shells and/or aquatic plants. During the spawning season, from April to July, locally until September, males have a completely black body with yellow fin-margins (Kotelat & Freyhoff 2007). The male guards the nest aggressively and takes care of the offspring until it hatches (Pinchuk et al. 2003). Gobies are generalists, as well as omnivores and mostly feed on benthic invertebrates (Kotelat & Freyhoff 2007). Larger specimens can become piscivorous and feed on smaller fish or fish fry.



Figure 1. Monkey goby (*Neogobius fluviatilis*) from Ledava River (photo: L. Mrzelj).

Slika 1. Rečni glavoč (*Neogobius fluviatilis*) iz reke Ledave (foto: L. Mrzelj).

The Monkey goby belongs to the Ponto-Caspian goby group. The initial distribution area of the species is Eastern Europe (Povž 2016); the Black, Azov, Marmara Sea Basins and the Caspian Lake. These goby species have already been recorded in the 90s of the 20th Century spreading across Northern and Western Europe (Povž 2016). The increased expansion range of the species is strongly attributed to a large human contribution. The Ponto-Caspian gobies expansions are accelerated due to watercourse transportation industry and habitat degradation. Gobies can spread over long distances in waterbodies via ship transportation (Anheit et al. 1998). Consequently, some authors describe their range expansion as invasive (Kotelat & Freyhoff 2007). In 1970, the Monkey goby was introduced into the Lake Balaton in Hungary (Kotelat & Freyhoff 2007). In 2006, Veenvliet and Veenvliet described that the species has dispersed along the Danube River, reaching Croatia. In 2022, the species was recorded in Drava and Mura River systems (Rauch 2022) from where it could successfully reach lower stretches of the Ledava River. Until today, the presence of two Ponto-Caspian goby species was confirmed in Slovenia; the Monkey goby in Ledava River in 2021 and the Bighead goby in Sava River near Obrežje in 2016 (Povž 2016). »Monkey goby« occurrence for Sava River including tributaries Sora, Ljubljanka, Mirna, Krka, Kolpa and Savinja (Simonović et al. 2015) cannot be considered as reliable, since there is no reference or field data, which could confirm the recorded find. Therefore, Ledava River can be considered as the first recorded find of Monkey gobies in Slovenia. Considering Ponto-Caspian gobies expansion trends, we can expect an increase of species finds and records of more specimens in Slovenia in the near future.

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Confirmation of the alpine salamander *Salamandra atra* (Laurenti, 1768) on Slovenian side of the Gorjanci Mountains

Potrditev planinskega močerada *Salamandra atra* (Laurenti, 1768) na slovenski strani Gorjancev

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The alpine salamander (*Salamandra atra*) lives in Slovenia mostly above the forest border. However, it can also be found as low as 500 m a. s. l. (Vek et al. 2019). Observations in the Julian Alps, Karavanke Mountains, Kamniško-Savinjske Alps,

Trnovska planota plateau and along Dinaric mountains towards Mt. Snežnik are common (Vek et al. 2019). Therefore, *S. atra* has Alpine and Dinaric distribution in Slovenia (IUCN 2023, Fig. 1). A seemingly disjunct population of *S. atra* lives also in the Gorjanci Mountains, situated in Southeastern Slovenia (Vogrin 1997), where one animal was found on 23. 5. 1994 in the virgin beech forest Gorjanci - Trdinov vrh (lat. 45.800600, long. 15.450350, 1050 m a. s. l.) by the last author of this notice. Additionally, there are two sites of the species near the state border on the Croatian side of the Gorjanci Mountains (Croatian name Žumberak Mountains); first in the Tomaševička pit (870 m a. s. l.; Kletečki 1990) and second in the Kuta virgin forest (800-900 m a. s. l.; Jeran et al. 2011). It seems that the species is rare in that area (Jeran et al. 2011).

On 29. 10. 2022, a team of speleologists of the Šaleški jamarski klub Podlasica Topolšica Speleoclub accompanied speleologists from the Kostanjevica na Krki Speleoclub during their visit of the Gorjanc Cave (lat. 45.800597, long. 15.450349, 760 m a. s. l., Fig. 1), a several hundred-metre-long and deep



Figure 1. Distribution of the alpine salamander (*Salamandra atra*) in Slovenia and its neighbouring countries and its records in the Gorjanci Mountains. General distribution according to IUCN (2023), Croatian sites in the Gorjanci Mountains according to Jeran et al. (2011). Map was prepared by Ali Šalamun.

Slika 1. Razširjenost planinskega močerada (*Salamandra atra*) v Sloveniji in sosednjih državah ter najdišča na Gorjancih. Splošna razširjenost glede na IUCN (2023), najdišča na hrvaški strani Gorjancev glede na Jeran et al. (2011). Karto je izdelal Ali Šalamun.

cave, with approximately 1.7×2 m wide entrance (Fig. 2a). At a depth of 30 m, on the ledge of the entrance pit, they photographed a salamander, which was later determined as *S. atra* (Fig. 2b).

The Gorjanc Cave is just 750 m afar from the closest site of *S. atra* in the Kuta virgin forest, 2 km from the Tomaševička pit and 11 km from the Gorjanci virgin forest (Fig. 1). It is situated at the lowest but still quite similar altitude and in similar environment of a beach forest than the other sites. This indicates a possible *S. atra* continuous area along the peaks of the Gorjanci Mountains connected with the old-growth beech forests. To the best of our knowledge, the population of *S. atra* in the Gorjanci Mountains is approximately 60 km East – NorthEast away from the closest sites on Mt. Snežnik (Fig. 1). However, we do not exclude a possibility of additional findings of the species between these two areas, as there are enough higher-altitude beech forests, which may be a suitable habitat for this species. It is interesting to note that the first Croatian observation is also from a cave (Kletečki 1990), and only intense focused research by Jeran et al. (2011) contributed to additional observations. Therefore, we assume that focused surveys could contribute also to further sightings of *S. atra* also on the Slovenian side of the Gorjanci Mountains.

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Figure 2. The entrance pit of the Gorjanc Cave (left) and the alpine salamander *Salamandra atra* found approximately 30 m below the entrance (right; photo: Matjaž Čuk).

Slika 2. Vhodno brezno jame Gorjanc (levo) in planinski močerad *Salamandra atra* najden približno 30 m pod vhomod (desno; foto: Matjaž Čuk).

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[ARSO] Agencija Republike Slovenije za okolje. 2022. Podnebne značilnosti oktobra 2022. Ljubljana (SI): Agencija Republike Slovenije za okolje, Ministrstvo za okolje, podnebje in energijo. https://meteo.arso.gov.si/met/sl/climate/current/climate_month/ [accessed on 26.11.2022]

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